MATERIALS SCIENCE MA(S)TERS

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Teacher Guides

Part 2

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MATERIALS SCIENCE MASTERS

UNIVERSITY OF SILESIA IN KATOWICE

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SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

NON-METALLIC MATERIALS

Code: NMM

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Co-funded by the European Union

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to the subject Non-metallic materials; History and distribution of materials – history of development of materials and technologies, distribution of construction materials, considerations for material selection (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture is to acquaint students with the history and classification of materials, i.e. the history of development of materials and technologies, the classification of construction materials, the characteristics of individual material groups (metals, ceramics, plastics and composites) and considerations for material selection such as material characteristics, production technology, material and production costs, ecological aspects of using the selected material etc.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 1 – Distribution of materials

6. Additional notes

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Topics 2

1. The subject of the lecture

CERAMICS/ Division and properties of ceramics – definition of ceramics, basic division of ceramics, properties of ceramics, composition of ceramic materials; Types and use of ceramic materials – traditional and progressive ceramics; Technology for the preparation of ceramic products – preparation and treatment of ceramic raw materials, shaping and drying, firing (sintering) (6 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture is to acquaint students with division and properties of ceramics – definition of ceramics, basic division of ceramics, properties of ceramics, composition of ceramic materials; types and use of ceramic materials – traditional and progressive ceramics; technology for the preparation of ceramic products – preparation and treatment of ceramic raw materials, shaping and drying, firing (sintering).

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be continued for three more classes.

In the first week, students will learn about division and properties of ceramics – definition of ceramics, basic division of ceramics, properties of ceramics, composition of ceramic materials.

In the second week, students will learn about types and use of ceramic materials – traditional and progressive ceramics.

In the third week, students will learn about technology for the preparation of ceramic products – preparation and treatment of ceramic raw materials, shaping and drying, firing (sintering).

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 2 – Ceramics

6. Additional notes

The topics will be covered in the next three lectures.

Topics 3

1. The subject of the lecture

GLASS/ Classification and properties of glass - definition of glass, basic classification of glass, properties of glass; Types and use of glass, basic glass raw materials; Technology of preparation of glass and glass products – treatment of raw materials and preparation of the glass stem, melting, shaping and cooling, finishing the operation (6 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture is to acquaint students with classification and properties of glass – definition of glass, basic classification of glass, properties of glass; types and use of glass, basic glass raw materials; technology of preparation of glass and glass products – treatment of raw materials and preparation of the glass stem, melting, shaping and cooling, finishing the operation.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be continued for three more classes.

In the first week, students will learn about classification and properties of glass – definition of glass, basic classification of glass, properties of glass.

In the second week, students will learn about types and use of glass, basic glass raw materials.

In the third week, students will learn about technology of preparation of glass and glass products – treatment of raw materials and preparation of the glass stem, melting, shaping and cooling, finishing the operation.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 3 – Glass

6. Additional notes

The topics will be covered in the next three lectures.

Topics 4

1. The subject of the lecture

PLASTICS/ Classification and properties of plastics - definition of plastics, basic classification of plastics, properties of plastics; Types and use of plastics – thermoplastics, reactive plastics, elastomers; excipients; Plastics processing technology (6 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture is to acquaint students with classification and properties of plastics – definition of plastics, basic classification of plastics, properties of plastics; types and use of plastics – thermoplastics, reactive plastics, elastomers; excipients; plastics processing technology.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be continued for three more classes.

In the first week, students will learn about classification and properties of plastics – definition of plastics, basic classification of plastics, properties of plastics.

In the second week, students will learn about types and use of plastics – thermoplastics, reactive plastics, elastomers.

In the third week, students will learn about plastics processing technology.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 4 – Plastics

6. Additional notes

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The topics will be covered in the next three lectures.

Topics 5

1. The subject of the lecture

COMPOSITES/ Classification and properties of composites – definition of composites, basic classification of composites, properties of composites; Types and use of composites – composites with plastic, metal, ceramic matrix; Composites production technology (6 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture is to acquaint students with classification and properties of composites – definition of composites, basic classification of composites, properties of composites; types and use of composites – composites with plastic, metal, ceramic matrix; composites production technology.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be continued for three more classes.

In the first week, students will learn about classification and properties of composites – definition of composites, basic classification of composites, properties of composites.

In the second week, students will learn about types and use of composites – composites with plastic, metal, ceramic matrix.

In the third week, students will learn about composites production technology.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 5 – Composites

6. Additional notes

Co-funded by the European Union

The topics will be covered in the next three lectures.

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercises of *Non-metallic materials*

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the introduction to the laboratory exercises for the subject Non-metallic materials, the evaluation method, exam requirements, etc.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- no equipment or materials

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 6 – Chemical laboratory

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 2

1. The subject of the laboratory classes

Transmission of water vapour and liquid water through the fabric

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with transmission of water vapour and liquid water through the fabric. The goal of the laboratory exercise is to explore the mechanisms by which water vapor and liquid water pass through fabrics, focusing on their physical and chemical properties that influence permeability. It also aims to highlight the implications of these processes for fabric performance in applications like clothing, technical textiles, and environmental protection.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- analytical balances,
- exiccator,
- textile samples

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 3

1. The subject of the laboratory classes

Identification of textile fibres

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with identification of textile fibres. The goal of the laboratory exercise is to provide an understanding of the methods and techniques used to identify different types of textile fibers, including natural, synthetic, and blended varieties. It emphasizes the importance of accurate fiber identification for quality control, product development, and compliance with industry standards.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- fibre samples,
- lighter, beakers,
- optical microscope, microscope slides and coverslips

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 4

1. The subject of the laboratory classes

Determination of ceramic water absorption

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with determination of ceramic water absorption. The goal of the laboratory exercise is to explain the methods for measuring water absorption in ceramic materials, highlighting its importance in assessing material porosity and performance. It focuses on the implications of water absorption for durability, structural integrity, and suitability for various applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- water bath,
- analytical balance,
- ceramic samples,
- distilled water

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 5

1. The subject of the laboratory classes

Testing of soils for ceramic production

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with testing of soils for ceramic production. The goal of the laboratory exercise is to discuss the methods used to test soil properties relevant to ceramic production, such as plasticity, mineral composition, and impurities. It highlights the importance of these tests in ensuring the quality, workability, and performance of ceramic products.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- beakers
- sieves,
- analytical balance,
- soil sample, distilled water

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 6

1. The subject of the laboratory classes

Determination of water hardness

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with determination of water hardness. The goal of the laboratory exercise is to explain the methods for determining water hardness by measuring the concentration of calcium and magnesium ions. It emphasizes the significance of understanding water hardness for industrial processes, domestic use, and its impact on equipment and product quality.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- boiler,
- titration flask, volumetric flasks,
- burette,
- analytical balance

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 7

1. The subject of the laboratory classes

Determination of the acetic acid content of vinegar – visual method

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with determination of the acetic acid content of vinegar by visual method. The goal of the laboratory exercise is to demonstrate the visual titration method for determining the acetic acid content in vinegar, using acid-base reactions and indicators. It highlights the importance of this analysis in ensuring product quality, compliance with food standards, and understanding vinegar's chemical properties.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- automatic burrete,
- phenolphtalein and methyl orange solution,
- oxalic acid, calcium chloride

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 8

1. The subject of the laboratory classes

Determination of the acetic acid content of vinegar – potentiometric method

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with determination of the acetic acid content of vinegar by potentiometric method. The goal of the laboratory exercise is to explain the potentiometric method for determining the acetic acid content in vinegar, utilizing pH measurements and titration curves. It emphasizes the precision and reliability of this method for quality control and compliance with food industry standards.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- pH meter,
- automatic burrete,
- phenolphtalein and methyl orange solution,
- oxalic acid, calcium chloride

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 9

1. The subject of the laboratory classes

Red plant dyes as pH indicators

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with red plant dyes as pH indicators. The goal of the laboratory exercise is to explore the use of red plant dyes as natural pH indicators, demonstrating their color changes across different pH levels. It highlights the scientific principles behind their functionality and their potential applications in eco-friendly and sustainable chemical testing.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test tube set,
- glass rod,
- knife, beaker,
- sulphuric acid, sodium hydroxide solution

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 10

1. The subject of the laboratory classes

Refractometry

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with refractometry. The goal of the laboratory exercise is to introduce refractometry as a technique for measuring the refractive index of substances, providing insights into their composition and purity. It emphasizes the application of this method in fields such as chemistry, food science, and material analysis for quality control and research purposes.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- Abbe refractometer,
- analytical balance,
- Gay-Lussac pycnometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 11

1. The subject of the laboratory classes

Conductivity of electrolytes

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with conductivity of electrolytes. The goal of the laboratory exercise is to examine the electrical conductivity of electrolyte solutions, focusing on the factors that influence ion mobility and conductivity levels. It highlights the importance of understanding electrolyte behavior in applications such as batteries, water quality analysis, and industrial processes.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- conductometer,
- conductivity electrodes,
- beakers,
- electromagnetic stirrer, thermometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 12

1. The subject of the laboratory classes

Phase equilibria of multicomponent systems – two-component system of sparingly soluble liquids

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with phase equilibria of multicomponent systems – two-component system of sparingly soluble liquids. The goal of the laboratory exercise is to explore the phase equilibria of multicomponent systems, specifically focusing on two-component systems of sparingly soluble liquids. It examines the principles governing phase separation, solubility limits, and the formation of phase diagrams to understand the behavior of such mixtures under different conditions.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test tubes with stoppers,
- thermometer,
- stirrer,
- water bath

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter 7 – Laboratory exercises

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 13

1. The subject of the laboratory classes

Semester thesis presentations

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to present topics from the field of non-metallic materials which the students have developed during the semester.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- no equipment or materials

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Markovičová, L.: *Non-metallic materials*. EDIS, Žilina 2021. 150 s.

- chapter according to the selected topic

7. Additional notes

Assessment according to the syllabus Non-metallic materials.

8. Optional information

Co-funded by the European Union

Exercise instructions are described in detail in the recommended literature.

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Content preparation: Project Team of Materials Science Ma(s)ters, Afyon Kocatepe University

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

SELECTED CHAPTERS FROM PHASE TRANSFORMATIONS

Code: SCPT

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to phase transformations

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to introduce to the subject Selected chapters from phase transformations, characteristics of states of matters, and a fundamental classification of phase transformation from the point of view of mechanism, thermodynamics and kinetics.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.

6. Additional notes

NO

Topics 2

1. The subject of the lecture

Thermodynamics fundamentals in phase transformations

2. Thematic scope of the lecture (abstract, maximum 500 words)

The given topic deals with the characteristics of elementary thermodynamic quantities such as Gibbs free energy (free enthalpy of the system G), enthalpy and entropy of the system. Subsequently, the relationship between the mentioned thermodynamic quantities is discussed and the influence of temperature and pressure on the thermodynamics of phase transformations is introduced. Subsequently, phase transformations from a thermodynamic point of view will be divided into phase transformations I and II. kind - the so-called Ehrenfest distribution of phase transitions. After mastering the basics of thermodynamics, students will expand their knowledge of the thermodynamics of single-component and binary systems. In the case of binary systems, concepts such as phase and lever rule, the emergence and formation of binary equilibrium diagrams and the characteristics of the basic so-called non-variant reactions - peritectic, eutectic, eutectoid and pretitectoid crystallization of binary alloys with perfect or limited solubility in the solid state.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for three more classes.

In the first week, issues related to elementary thermodynamic quantities such as Gibbs free energy (free enthalpy of the system G), enthalpy and entropy of the system. Subsequently, the relationship between the mentioned thermodynamic quantities is discussed and the influence of temperature and pressure on the thermodynamics of phase transformations is introduced.

In the second week, Students will learn about the fundamentals and classification of thermodynamics of phase transformations, I. and II. of the kind – Ehrenfest classification of phase transformation will be discussed.

In the third week, further aspects of the thermodynamics of single-component and binary systems are discussed. In the case of binary systems, concepts such as phase and lever rule, the establishment and formation of binary equilibrium diagrams and the characteristics of the basic so-called non-variant reactions - peritectic, eutectic, eutectoid and pretitectoid crystallization of binary alloys with perfect or limited solubility in the solid state will be discussed.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.

Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

6. Additional notes

Topics 3

1. The subject of the lecture

Fundamentals of kinetics in phase transformations

2. Thematic scope of the lecture (abstract, maximum 500 words)

First, the relationship between thermodynamics and phase transformation kinetics will be presented. Subsequently, the kinetics of phase transformations will be discussed. Kinetic processes during phase transformations are the nucleation of the crystallization nucleus, the growth of the crystallization nucleus, and the very speed of the phase change - crystallization. The nucleation of the nucleus has several aspects, the formation of a solid phase nucleus in the melt or of the solid phase in the solid phase, which can be homogeneous or heterogeneous - the relationship between the activation energy of the phase transformation and the critical radius of the crystallization nucleus. The growth of the crystallization nucleus will be discussed concerning the temperature and pressure of the phase change as well as the influence of the phase change mechanism, i.e. diffusion and shear mechanism. The crystallization rate itself is then given by the superposition of the transformation mechanism and the rate of heat removal from the interphase interface. The mentioned facts will be presented using the so-called S-curves of the rate of nucleation, growth and crystallization of alloys.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for three more classes.

In the first week, the relationship between thermodynamics and phase transformation kinetics will be presented. Subsequently, the kinetics of phase transformations will be discussed.

In the second week, problems of homogenous and heterogenous nucleation will be discussed.

In the third week, further aspects of the kinetics such nucleus growth and crystallization rate as a function of temperature and pressure will be discussed.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

6. Additional notes

The topics will be covered in the next three lectures.

Topics 4

1. The subject of the lecture

Crystallization and polymorphic transformations

2. Thematic scope of the lecture (abstract, maximum 500 words)

In order, the fourth topic entitled "Crystallization and polymorphic transformations" will be focused on primary crystallization and polymorphic transformations taking place during the cooling of metal alloys. Concepts such as polymorphic transformation, examples of allotropic metals and the relationship of polymorphic transformations to the mechanical properties of alloys will be clarified.

Subsequently, concepts related to the breakdown of a supersaturated solid solution - segregation, natural and artificial ageing of the material - will be questioned.

Examples of artificial ageing will be presented in the Al-Cu binary system, where individual stages of the hardening process will be described, such as the formation of Guinier-Preston zones I. and II. species, the formation of a transient precipitate and a stable precipitate.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for three more classes.

In the first week, issues related to primary crystallization and polymorphic transformation will be presented with an accent on the allotropic modification of metal alloys with examples.

In the second week, the problems of segregation, and natural and artificial ageing will be discussed.

In the third week, an example of artificial ageing in a binary Al-Cu system is presented.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

6. Additional notes

The topics will be covered in the next three lectures.

Topics 5

1. The subject of the lecture

The phase transformations at heating and cooling of the steel

2. Thematic scope of the lecture (abstract, maximum 500 words)

The mentioned topic consists of three thematic units, which will be discussed at individual lectures. The first part will be devoted to the phase transformation during steel heating, called austenitization. We will focus in more detail on the formation of austenite and its basic characteristics (influence of grain size, chemical composition, etc.). Subsequently, we will analyze the austenitization of hypo eutectoid, eutectoid and hypereutectoid steel. At the next meeting, there will be characteristic phase transformations during the cooling of homogeneous austenite with full or partial participation of diffusion - pearlitic and bainitic transformation. The last part will be devoted to phase transformations of austenite without the participation of diffusion, the so-called shear transformations - massive transformations and martensitic transformation in steels.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for three more classes.

In the first week, the problems of the austenitization of steels will be discussed.

In the second week, phase transformations of homogenous austenite such as pearlitic and bainite transformation will be explained.

In the third week, phase transformation without diffusion presence – massive and martensitic transformation in steels will be presented.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

6. Additional notes

The topics will be covered in the next three lectures.

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to matters of state

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 1 and also cover case examples for calculation matter of state for engineering application. Calculation of atomic and mass percentages. Introduction to the calculation of the density of materials.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **2 reports**, each for **2 points**. **The sum of points achieved is 4.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Thermodynamics in single-component and binary systems

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 2 and also cover applying the Hume-Rothery and Hägg rules in the determination of solid solutions. Based on provided calculation determining the interstitial or substitutional solid solutions, intermediary phases.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **2 reports**, each for **2 points**. **The sum of points achieved is 4.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

The kinetics of phase transformation – crystallography

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 3 and also cover the calculation of lattice parameters of metals. Relation between the atomic radii and the lattice parameters, calculation of octahedral and tetrahedral spaces in metal lattices. Application of knowledge from crystallography concerning the deformation of crystal lattices during phase transformations.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with

a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **1 report**, each for **2 points**. **The sum of points achieved is 2.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Phase transformations during cooling of homogenous austenite – part I.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 4. and also cover the application of the T-T-T diagram (also known as the isothermal-transformation diagram) at austenite cooling and the explanation of pearlitic transformations and the relation of transformation temperatures to the chemical composition of steels. Pearlitic transformation during the cooling of homogeneous austenite is the only transformation that is 100% diffuse. That is, it takes place in the entire volume of steel and the entire proportion of austenite is transformed during the so-called eutectoid temperature to pearlite. Depending on the temperature of undercooling, it is possible to modulate the resulting microstructure of the steel, from coarse-grained pearlite to fine-grained. The given knowledge will be applied in the calculation and graphical interpretation of the kinetic curves of the cooling of hypereutectoid, eutectoid and hypo-eutectoid steel.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Phase transformations during cooling of homogenous austenite – part II.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 5. and also cover the application of the C-C-T (continuous – cooling - transformation) diagram at austenite cooling and an explanation of bainite and martensite transformation. The bainitic transformation is partly diffuse, and the martensitic transformation is realized only by a shear mechanism. For both transformations, the formation of the so-called residual austenite significantly affects the resulting mechanical properties of the steel. The given knowledge will be applied in the calculation and graphical interpretation of the kinetic curves of the cooling of hypereutectoid, eutectoid and hypo-eutectoid steel.

The students will implement the knowledge gained from the topics of exercises 1 to 5 when solving a semester project focused on thermodynamic and kinetic analysis of heat treatment procedures of selected steels and possible optimization of existing heat treatment methods.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of state of matters and classification of phase transformations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.

- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes, i.e.</u>

- The main topic will be implemented during 5 classes in the form of a project task, in which students will design the heat-treatment process. The semester project will be handed in at the end of the semester and evaluated according to the criteria specified in the relevant syllabus; the maximum number of 30 points is for the semester project. During the mentioned 5 weeks, it is possible to consult with the teacher about problems arising during the solution of the project.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third edition.* CRC Press, Taylor & Francis Group, 2009.
- Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.
- Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
- Kittel, Charles: *Introduction to Solid State Physics – Eighth Edition*. John Wiley & Sons, Inc., 2005.
- Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – after completing the semestral project students receive a maximum of 30 points
- The topics will be covered in the 5 classes with the teacher consultations on demand.

8. Optional information

NO

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS‘ GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

GENERAL CHEMISTRY FOR TECHNICIANS

Code: GCT

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1.	**The subject of the lecture**
	BASIC LAWS AND DEFINITIONS OF GENERAL CHEMISTRY AND ATOMIC STRUCTURE OF SUBSTANCES
2.	**Thematic scope of the lecture (abstract, maximum 500 words)**
	The lectures of Topics 1 aim to the explaining and understanding the basic laws, general chemistry basic terms and quantities and the essence of the chemical properties of materials. They contain description and explanation of: - law of conservation of mass, law of conservation of energy, - law of equivalency of mass and energy and proportionality between energy and mass of the same material object - basic terms and quantities (system, isolated system, matter, substance, pure substance, atom, molecule, chemical element, chemical compound, chemical formula, atomic mass unit, relative atomic and molecular masses, amount of substance, molar mass) - structure of atom – elementary particles, nucleus and nuclear binding energy, electron shell of atom – previous models and the present model based on principles of quantum mechanics (wave function ψ, definition of orbital, quantum numbers) - Rules of the building-up of the electron shell (building-up principle, Pauli exclusion principle, Hund's rule - electron configuration of the elements, valence orbitals, valence electrons – relations to the chemical properties of elements.
3.	**Learning outcomes**
	Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Basic laws and definitions of General chemistry and atomic structure of substances.*
4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**
	assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification** problem methods – **discussion/debate** Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**
	Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 1, , chapter 2, chapter 7.
6.	**Additional notes**
	The topics will be covered in 2 one-hour lectures.

Topics 2

1. The subject of the lecture

PERIODIC RELATIONSHIPS AMONG THE ELEMENTS AND TYPES OF CHEMICAL BONDS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 2 aim to the explaining and understanding of periodic relations among chemical elements and nature of chemical bonding. They contain description and explanation of:

- periodic table of elements and its relationship to electron structure of atoms, periodic law, characteristics of periods and groups,
- nature and mechanism of the covalent bond, differences between polar and nonpolar covalent bond,
- nature and mechanism of ionic bond,
- bonding in metals – band theory, relation of metallic bond to the electrical conductivity of materials,
- intermolecular forces, hydrogen bond,
- relationship between type of chemical bond and physical properties of materials.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Periodic relationships among the elements and types of chemical bonds*.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 8, chapter 9, chapter 10, chapter 11.

6. Additional notes

The topics will be covered in 2 one-hour lectures.

Topics 3

1. The subject of the lecture

STATES OF MATTER

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 3 aim to the explaining and understanding of basic properties of substances in individual states of matter. They contain description and explanation of:

- nature of the solid state - crystalline and amorphous substances, types of crystals according to the type of chemical bonds, polymorphism, isomorphism, disorders of crystal lattices
- nature of the liquid state - surface tension, dynamic and kinematic viscosity,
- nature of gaseous state – ideal and real gases, laws for ideal gases, equation of state for ideal and real gas, critical state,
- conversions of the matter states – evaporation and condensation, melting and solidification, sublimation and desublimation.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the *States of matter.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 5, chapter 11.

6. Additional notes

The topics will be covered in 2 one-hour lectures.

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Topics 4

1. The subject of the lecture

THERMODYNAMICS AND KINETICS OF CHEMICAL REACTIONS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 4 aim to the explaining and understanding of the basic principles of chemical thermodynamics and reactions kinetics. They contain description and explanation of:

- classification of chemical reaction in inorganic chemistry,
- the main state functions - internal energy, enthalpy, entropy, Gibbs free energy, their nature, definitions and relationships between them,
- conditions of spontaneity of chemical processes,
- definition and expression of reaction rate,
- dependence of reaction rate on the concentration of reaction species and on temperature, activation energy
- nature and definition of the catalysts, dependence of reaction rate on the presence of catalysts,
- kinetics of chemical equilibrium,
- equilibrium constant, Le Chatelier principle of moving equilibrium.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Thermodynamics and kinetics of chemical reactions*.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 6, chapter 13, chapter 14.

6. Additional notes

The topics will be covered in 3 one-hour lectures.

Topics 5

1. The subject of the lecture

HOMOGENOUS SYSTEMS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 5 aim to the explaining and understanding of various types of solutions with an emphasis on aqueous solutions. They contain description and explanation of:
- classification of solutions
- liquid solutions - types of solvents, nature of dissolution, solubility and its dependence on temperature
- nature of electrolytes, degree of ionization, weak and strong electrolytes,
- definition of pH,
- acids, bases - Bronsted and Lewis theory,
- acid-base indicators.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Homogeneous systems,*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 12, chapter 15

6. Additional notes

The topics will be covered in 2 one-hour lectures.

Topics 6

1.	**The subject of the lecture**

HETEROGENEOUS SYSTEMS

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

The lectures of Topics 6 aim to the explaining and understanding of processes in heterogeneous systems especially those related to reactions of the metals in conductive aqueous environments. they contain description and explanation of:

- Gibbs phase rule,
- phases, components, independent intensive variables (degrees of freedom) for 1, 2, 3 – component systems
- Oxidation-reduction reactions, oxidation number,
- reactions of metals in water and acidic and basic solutions, electrode potential,
- bases of electrochemistry - electrode reactions, nature of galvanic cell,
- electrolysis, Faraday's laws.

3.	**Learning outcomes**

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Heterogeneous systems*.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3, chapter 19

6.	**Additional notes**

The topics will be covered in 2 one-hour lectures.

Course content – laboratory classes

Topics 1 Lab 1

1. The subject of the laboratory classes

ELECTROLYSIS AND GALVANIC PLATING

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of oxidation-reduction processes and electrochemistry will be verified. The student will perform galvanic plating (Cu) of the steel sample and calculate the current yield of this process. During laboratory classes, students will work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Electrolysis and galvanic plating*. Students are able to work in a group, sharing tasks and working together analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Electrolysis and galvanic plating*, including critical analysis, synthesis and conclusions.

4. Necessary equipment

electrolyzer,
DC voltage source

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- introduction to the laboratory classes – instruction on laboratory order and safety at work,

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**
	Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 19
7.	**Additional notes**
	- ASSESSMENT Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.
8.	**Optional information**
	Lab 1 is 3-hours due to instruction on laboratory order and safety at work. Exercise manuals will be available.

Topics 2 Lab 2

1. The subject of the laboratory classes

CONDUCTOMETRY

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of electrolytes and their typical properties will be verified. The student will perform determination of solution molarity by measuring specific conductivity of chlorides containing solutions and using a calibration graph. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Conductometry*. Students are able to work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Conductometry* including critical analysis, synthesis and conclusions.

4. Necessary equipment

digital conductometer
thermometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 3 Lab 3

1. The subject of the laboratory classes

QUALITATIVE, INDICATIVE ANALYSIS OF LOW ALLOY STEELS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of solutions and chemical properties of metals will be verified. The student will perform dissolution of low alloy steel scobs in nitric acid solution and indicative verification of additive elements presence by simple color/appearance changes. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Qualitative indicative analysis of low alloy steels*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Qualitative indicative analysis of low alloy steels* including critical analysis, synthesis and conclusions.

4. Necessary equipment

-

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 12, chapter 20

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

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Topics 4 Lab 4

1. The subject of the laboratory classes

DETERMINATION OF HCO_3^- AND Ca^{2+}+ Mg^{2+} CONCENTRATION IN DRINKING AND UTILITY WATERS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of electrolytes acid/base properties will be verified. The student will perform determination of HCO_3^- and Ca^{2+}+ Mg^{2+} concentration (i.e. temporary and total hardness of waters) using acid-base and chelatometric titrations. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Determination of HCO_3^- and Ca^{2+}+ Mg^{2+} concentration in waters*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of HCO_3^- and Ca^{2+}+ Mg^{2+} concentration in waters* including critical analysis, synthesis and conclusions.

4. Necessary equipment

titration apparatus

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 5 Lab 5

1. The subject of the laboratory classes

PYCNOMETRIC DETERMINATION OF THE DENSITY OF LIQUIDS AND SOLIDS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of typical properties of solid and liquid states of matter will be verified. The student will perform determination of density of differently concentrated sodium chloride solutions and metals (e.g. nickel, zinc) by pycnometric method. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Pycnometric determination of the density of liquids and solids*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Pycnometric determination of the density of liquids and solids* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Pycnometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 11

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 6 Lab 6

1. The subject of the laboratory classes

REFRACTOMETRY

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of physical properties of liquids will be verified. The student will perform determination of wt. % of ethanol in water solution by measurement of the refractive index of ethanol calibration solutions and using a calibration graph. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Refractometry*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Refractometry* including critical analysis, synthesis and conclusions.

4. Necessary equipment

refractometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,

- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 11

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Co-funded by the European Union

Course content – theoretical classes

Topics 1

1. The subject of the theoretical classes

NOMENCLATURE OF INORGANIC COMPOUNDS

2. Thematic scope of the theoretical classes (abstract, maximum 500 words)

Students will obtain knowledge and skills in nomenclature of binary inorganic compounds, acids and salts. They will be able to create of chemical formulas according names of the compounds and names of compounds according the chemical formulas.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to use *Nomenclature of inorganic compounds* independently and correctly.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, flipped classroom**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- student's work in couples

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 1

6. Additional notes

- ASSESSMENT
According to Syllabus General Chemistry for technitians.

7. Optional information

-

Topics 2

1. The subject of the theoretical classes

MOLAR MASS, AMOUNT OF SUBSTANCE, MASS OF SUBSTANCE AND THEIR RELATIONS

2. Thematic scope of the theoretical classes (abstract, maximum 500 words)

Students will obtain knowledge and skills in basic quantities in general chemistry. They will be able to perform calculations related to molar mass, amount of substance, mass of substance.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to perform calculations in *Molar mass, amount of substance, mass of substance and their relations.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, flipped classroom**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- student's work in couples

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 1

6. Additional notes

- ASSESSMENT
According to Syllabus General Chemistry for technitians.

7. Optional information

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Topics 3

1. The subject of the theoretical classes

STOICHIOMETRIC CALCULATIONS FROM CHEMICAL FORMULAS AND CHEMICAL EQUATIONS

2. Thematic scope of the theoretical classes (abstract, maximum 500 words)

Students will obtain knowledge and skills in basic laws and rules used for calculations from chemical formulas and equations. They will be able to perform stoichiometric calculations from chemical formulas and chemical equations.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to perform *Stoichiometric calculations from chemical formulas and chemical equations.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, flipped classroom**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- student's work in couples

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3

6. Additional notes

- ASSESSMENT
According to Syllabus General Chemistry for technitians.

7. Optional information

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Topics 4

1. The subject of the theoretical classes

METHODS OF EXPRESSION OF THE COMPOSITION OF SOLUTIONS

2. Thematic scope of the theoretical classes (abstract, maximum 500 words)

Students will obtain knowledge and skills in methods and ways for expression of composition of solutions. They will be able to perform calculations related composition of solution - amount of solvent, solute, solution, molarity, mass and volume fractions.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to use correctly *Methods of expression of the composition of solutions* and calculate needed amounts of substances in solution according them.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, flipped classroom**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- student's work in couples

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 1

6. Additional notes

- ASSESSMENT
According to Syllabus General Chemistry for technitians.

7. Optional information

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

MATERIALS FOR BIOMEDICAL ENGINEERING

Code: MBE

Course content – lecture

Topics 1

1. The subject of the lecture

BASIC TERMS IN BIOMEDICAL ENGINEERING

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture of Topics 1 aim to define biomedical engineering terms such as:

- biocompatibility,
- biofunctionality,
- functional requirements for biomaterials,
- biomaterial,
- biodegradation,
- bioactive material,
- loading, shear,
- stress, strain,
- strength,
- material fatigue,
- creep,
- degradation.
- classification of biomaterials.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Basic laws and definitions in the field of biomaterials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6. Additional notes

The topics will be covered in 1 two-hour lecture.

Topics 2

1. The subject of the lecture

INTERNAL STRUCTURE OF MATERIALS AND CHEMICAL BONDING OF MATERIALS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topics 2 lecture is to define the internal structure of materials and the chemical bonding of materials. They contain description and explanation of:

- the periodic table of the elements and its relation to the electronic structure of atoms, the periodic law, characteristics of periods and groups,
- nature and mechanism of covalent bonding, differences between polar and non-polar covalent bonding,
- the nature and mechanism of ionic bonding,
- bonding in metals - band theory, relationship of metallic bonding to electrical conductivity of materials,
- intermolecular forces, hydrogen bonding,
- relationship between type of chemical bonding and physical properties of materials,
- magnetic properties of substances,
- characterization of metal biomaterials.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Periodic relationships among the elements and types of chemical bonds*.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**
Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8
Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 3

1. The subject of the lecture

CORROSION CHARACTERISTICS OF BIOMATERIALS AND STAINLESS STEELS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topics 3 lecture is to define corrosion, corrosion characteristics of biomaterials and to describe stainless steels. Include description and explanation:

- corrosion - definition, types of corrosion,
- electrode, equilibrium, standard,
- corrosion rate,
- current density,
- forms of corrosion of biomaterials,
- stainless steels - definition, distribution, properties,
- stainless ferritic steels,
- martensitic stainless steels,
- austenitic stainless steels,
- duplex stainless steels - ferritic-austenitic, martensitic-austenitic,
- stainless precipitation (dispersion) hardened steels.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and analyse problems related to the type of Corrosion attack and assess the suitability of the applied stainless steel.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 4

1.	The subject of the lecture
	COBALT ALLOYS, TITANIUM AND TITANIUM ALLOYS. METAL MATERIALS WITH SHAPE MEMORY.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topics 4 lecture is to define cobalt alloys, titanium and titanium alloys, metallic materials with shape memory. Include description and explanation:

- characteristics of cobalt and the distribution of cobalt alloys and their chemical composition,
- processing of cobalt alloys,
- microstructure of cobalt alloys and its effect on the properties of cobalt alloys,
- characteristics of titanium and its properties,
- basic distribution of titanium alloys according to equilibrium structure,
- distribution of titanium alloys depending on processing,
- microstructure of titanium alloys,
- applications of titanium alloys in biomedicine,
- definition of shape memory phenomenon,
- Ti-Ni alloys with shape memory,
- influence of the structure of Ti-Ni alloys on shape memory parameters.

3. Learning outcomes

They can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and distinguish the microstructure of cobalt alloys and titanium alloys. Be able to assess the effect of heat treatment on the *Microstructure of cobalt alloys and titanium alloys.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 5

1.	The subject of the lecture

CERAMICS AND BIOACTIVE GLASSES. CARBON.

2.	Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topics 5 lecture is to define ceramics as a biomaterial, bioactive glasses and carbon. Include description and explanation:

- basic definitions and properties of ceramics,
- oxide ceramics,
- calcium phosphate ceramics,
- dental ceramics,
- bioactive glasses - definition, composition, properties, uses,
- carbon - occurrence, properties, structure,
- graphite, diamond - comparison of properties,
- nanotechnology - fullerenes, nanotubes, nanofoams,
- carbon fibres.

3.	Learning outcomes

They can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate it, draw conclusions, formulate and solve problems related to ceramic materials and bioactive glasses. Knows the production, properties, types and applications of carbon fibres.

4.	Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5.	Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6.	Additional notes

The topics will be covered in 2 two-hour lecture.

Topics 6

1. The subject of the lecture

AEROGELS. POLYMERS. BONE CEMENTS.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of Topics 6 is to define aerogels and polymers, their properties, composition and applications. It includes description and explanation:

- aerogels - definition, composition,
- methods of preparing aerogels - sol-gel phase, supercritical drying,
- structure, properties and applications of aerogels,
- polymers - basic concepts, distribution and structure of polymers,
- physical properties of polymers,
- constructional polyreactions,
- natural and synthetic polymers - most commonly used polymers and their properties,
- bone cements - types, composition, properties, preparation, degradation, applications.

3. Learning outcomes

They can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to aerogels, polymers and bone cements. The student is able to assess the selection of appropriate polymer material for biomedical applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8

6. Additional notes

The topics will be covered in 2 two-hour lecture.

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

MECHANICAL TESTS - TENSILE TEST, BENDING IMPACT TEST

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the basic concepts and the process of mechanical testing of materials. The student will perform mechanical tests (tensile test and impact test) of different materials, evaluate the results and indicate the suitability of use. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the lab report.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to mechanical testing (tensile and impact testing). Students can work in a group, divide tasks and analyse results and draw conclusions together. They can produce a theoretical introduction and a description of the final results to laboratories on mechanical testing, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various materials,
- tearing machine,
- Charpy hammer,
- precision (sliding) gauge.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation/assimilation methods - reading,
set of practical methods - laboratory exercise/experiment; observation

(a) Laboratory sessions shall be conducted using special research equipment
b) In laboratory lessons, pupils carry out an experiment and carry it out independently.
c) During laboratory lessons, pupils work in groups, dividing tasks and collaborating to draw up a plan of work, analyse the results and draw conclusions.

The lessons take place in the following order: introduction to laboratory lessons - instruction on laboratory rules and safety at work, discussion (checking the students' knowledge) on the theoretical basis and the procedure for carrying out the experiment - familiarisation with the research equipment in the laboratory, students in groups, students perform a selected experiment, during the experiment, students make observations, record observations and results of the experiment, completion of the experiment and formulation of preliminary conclusions.

Students independently prepare a final report.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Kuhn, H. - Medlin, D.: ASM Handbook, Volume 8: Mechanical Testing and Evaluation, ASM International, 2000, 998 p.
- Kyriakos, K.: Mechanical Testing of Engineering Materials, Univ Readers, 2017. •ASM Handbook, Volume 10: Materials Characterization ASM International, 2019, 807 p.
- international standards STN EN 10002-1, STN EN 10045-1

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 2

1. The subject of the laboratory classes

MECHANICAL TESTS - HARDNESS MEASUREMENT

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During the laboratory lessons, students will learn the theoretical knowledge of the basic concepts and procedures for measuring the hardness of materials. The student will measure the hardness of different methodologies (Brinell, Vickers, Rockwell, Poldi hammer) of materials, evaluate the results and indicate the suitability of use. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the measurement of hardness by different methods. Students are able to work in a group, divide tasks and analyse results and draw conclusions together. They can produce a theoretical introduction and a description of the final results for a laboratory on mechanical testing, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples,
- hardener Brinell,
- hardener Vickers,
- hardener Rockwell,
- Poldi hammer,
- hardness tables.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Kuhn, H. - Medlin, D.: ASM Handbook, Volume 8: Mechanical Testing and Evaluation, ASM International, 2000, 998 p.
- Kyriakos, K.: Mechanical Testing of Engineering Materials, Univ Readers, 2017. •ASM Handbook, Volume 10: Materials Characterization ASM International, 2019, 807 p.
- international standards STN EN 10002-1, STN EN 10045-1

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 3

1. The subject of the laboratory classes

METHODS OF STUDYING THE STRUCTURE - MICROSTRUCTURE OF IRON AND CARBON ALLOYS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During the laboratory sessions, students will learn the theoretical knowledge of ways to evaluate the microstructure of materials and will be able to define the microstructures of iron-carbon alloys. The student will schematically describe the microstructures of steels and white cast irons. During the laboratory exercises, pupils will work in groups, divide the tasks and work together to develop a plan of work, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the microstructure of iron-carbon alloys. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can create a theoretical introduction and description of the final results for the microstructure assessment laboratory, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples,
- optical microscope.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Kuhn, H. - Medlin, D.: ASM Handbook, Volume 8: Mechanical Testing and Evaluation, ASM International, 2000, 998 p.
- Kyriakos, K.: Mechanical Testing of Engineering Materials, Univ Readers, 2017,
- ASM Handbook, Volume 10: Materials Characterization ASM International, 2019, 807 p.
- international standards STN EN 10002-1, STN EN 10045-1

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 4

1. The subject of the laboratory classes

Ti AND Ni ALLOYS – ASSESSMENT OF DENDRICITY

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory exercises, students will learn theoretical knowledge about the properties of titanium, about the distribution and properties of titanium alloys and their structure. The student can calculate the dendritic nature of titanium alloys and compare it depending on the conditions of the processing plant. During the laboratory exercises, students will work in groups, divide tasks and jointly develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the dendritic characters of titanium alloys. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can create a theoretical introduction and description of the final results for the dendricity assessment laboratory, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples,
- optical microscope,
- ruler,
- photographs of the microstructure of titanium alloys.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 5

1. The subject of the laboratory classes

DISSOLVING A SOLID

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory exercises, students will learn theoretical knowledge about the rate of dissolution of solid substances. During the laboratory exercises, students will work in groups, divide tasks and jointly develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the conditions of dissolution of solid substances. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can create a theoretical introduction and description of the final results for the solid dissolution rate laboratory, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples,
- digital conductomer,
- stirrer,
- perforated pipes.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 6

1. The subject of the laboratory classes

CHEMICAL RESISTANCE OF GLASS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory exercises, students will learn theoretical knowledge about the rate of types of glasses and their chemical resistance. The student can calculate the consumption of the titrant and based on the calculation, determine the glass resistance class. During the laboratory exercises, students will work in groups, divide tasks and jointly develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the chemical resistance of glass. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can create a theoretical introduction and description of the final results for the chemical resistance of glass laboratory, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- water bath,
- measuring flask,
- pipette,
- titration flask,
- glass powder.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Petrucci, R. - Herring, F. – Madura, J. – Bissonnette, C. 2016. General Chemistry: Principles and Modern Applications. 11th Edition, ISBN 978-01-338-9731-9, chapter 3

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 7

1. The subject of the laboratory classes

MEASUREMENT OF HEAT CAPACITY OF MATERIALS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory exercises, students will learn theoretical knowledge about thermal energy exchange between two or more samples with different temperatures. The student can calculate the heat capacity of the calorimeter and the heat capacity of the sample, based on the calculation, he can determine the material of the test sample. During the laboratory exercises, students will work in groups, divide tasks and jointly develop a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the heat capacity of various materials. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can create a theoretical introduction and description of the final results for the measurement of the heat capacity of materials laboratory, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- calorimeter,
- thermometer,
- samples of various materials.
- cooker,
- beakers.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 8

1. The subject of the laboratory classes

ELECROLYSIS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of oxidation-reduction processes and electrochemistry will be verified. The student will perform galvanic plating (Cu) of the steel sample and calculate the current yield of this process. During laboratory classes, students will work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to Electrolysis and galvanic plating. Students are able to work in a group, sharing tasks and working together analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Electrolysis and galvanic plating*, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- electrolyzer,
- DC voltage source.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 9

1. The subject of the laboratory classes

CORROSION PROPERTIES OF STAINLESS STEELS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the field of corrosion and stainless steels will be verified. The student will perform exposure immersion tests of a stainless steel sample. During laboratory classes, students will work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to weight loss and corrosion rate. Students are able to work in a group, sharing tasks and working together analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on the corrosion properties of stainless steels, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- steel samples,
- beaker.
- glass rod,
- Insulated wires,
- Analytical balance.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 10

1. The subject of the laboratory classes

IDENTIFICATION OF POLYMERS – FLAME TEST AND PYROLYTIC TEST

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the field of the polymers – basic concepts, division, structure of polymers will be verified. The student will perform polymer identification tests and identifies the tested samples. During laboratory classes, students will work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to the identification of unknown polymer samples based on their flame behavior. Students are able to work in a group, sharing tasks and working together analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on the identification of polymers in flame and pyrolysis plating, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- burner,
- test tubes.
- Litmus paper,
- Polymer samples.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

PROPERTIES, PROCESSING AND USING OF PLASTICS

Code: PPUP

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

CHEMICAL COMPOSITION, POLYMER STRUCTURE AND MOLECULAR WEIGHT DISTRIBUTION

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topic 1 lecture is to introduce the historical development of polymeric materials, to define the basic concepts of polymer chemistry such as: monomer, polymer, basic building unit, structural unit, building unit, polymerization degree, polydispersity, molecular weight, distribution curves. The relationship between the chemical composition and structure of polymers and their physical-mechanical properties will be explained.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to basic laws and definitions in the field of macromolecular chemistry, composition and properties of polymers..

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 1 two-hour lecture.

Topics 2

1. The subject of the lecture

CONSTRUCTION REACTIONS OF POLYMERS. ADITIVES AND PROCESSING METHODS.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of topic 2 is to define the building chemical reactions that lead to the formation of macromolecules. These reactions are called building polyreactions and are polymerization, polysdition and polycondensation. Students are introduced to additives that are added to polymer blends in order to improve their processing properties. Processing technologies common to plastics processing such as injection molding, extrusion, rolling, blow molding, dip molding, etc. will be reviewed.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to polymer construction reactions, selection of suitable additives and processing technology.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 3

1. The subject of the lecture

CLASSIFICATION OF POLYMERS. PROPERTIES AND USES OF POLYMERS.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of Topics 3 is to define the classification of polymers, to clarify the influence of chemical composition and structure on the properties of polymers. Based on the defined properties of polymers, the appropriate structural use of plastics is then selected. Students will learn in detail about the production, types, properties, processing and use of common as well as special types of thermoplastics, reactoplastics and elastomers.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and analyse problems related to the selection of a specific plastic for normal or special use.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 4

1. The subject of the lecture

COMPOSITE MATERIALS.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the Topics 4 lecture is to characterize individual types of polymer composite materials and to specify the most important factors affecting their properties and technological production procedures. The greatest attention will be paid to fibrous composites, which are the most widely used in industrial practice.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and analyse problems related to the polymer composite materials, their properties, structure, production and use.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 3 two-hour lecture.

Topics 5

1. The subject of the lecture

PLASTICS PROCESSING.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of the lecture Topics 5 is to define the division of polymer processing technologies. The production of products from polymers has some specifics that must be taken into account when designing technological procedures. The diversity of polymer properties, depending on the chemical nature of the polymer and its physical state, requires variability in production procedures and polymer processing conditions.

3. Learning outcomes

They can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate it, draw conclusions, formulate and solve problems related to the choice of polymer processing technology with regard to their properties and future use.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 2 two-hour lecture.

Topics 6

1. The subject of the lecture

NANOCOMPOSITES. RECYCLING.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of Topic 6 is to define polymer nanocomposites, which represent a new class of materials. We prepare them by mixing nano-fillers into the polymer matrix, the nano-filler must have at least one dimension in the nanometer range. Nanocomposites are materials with significantly better properties at a lower filler content than in polymer composites, where a filler with dimensions in the micro-scale was used. The possibilities of reusing plastics - recycling, which plastics can be recycled and which cannot, will be explained.

3. Learning outcomes

They can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the properties and possibilities of production and use of nanocomposites. The student can assess the possibilities and methods of recycling polymer waste.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

6. Additional notes

The topics will be covered in 2 two-hour lecture.

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

IDENTIFICATION OF POLYMERS ON THE BASIS OF THEIR DENSITY

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the identification of polymers on the basis of their density will be verified. The student will identify different polymers based on their density, evaluate the results and indicate the suitability of use. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the lab report.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to identification of polymers on the basis of their density. Students can work in a group, divide tasks and analyse results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Identification of polymers on the basis of their density, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- pycnometer,
- analytical balances.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation/assimilation methods - reading,
set of practical methods - laboratory exercise/experiment; observation

(a) Laboratory sessions shall be conducted using special research equipment
b) In laboratory lessons, pupils carry out an experiment and carry it out independently.
c) During laboratory lessons, pupils work in groups, dividing tasks and collaborating to draw up a plan of work, analyse the results and draw conclusions.

The lessons take place in the following order: introduction to laboratory lessons - instruction on laboratory rules and safety at work, discussion (checking the students' knowledge) on the theoretical basis and the procedure for carrying out the experiment - familiarisation with the research equipment in the laboratory, students in groups, students perform a selected experiment, during the experiment, students make observations, record observations and results of the experiment, completion of the experiment and formulation of preliminary conclusions.

Students independently prepare a final report.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 2

1. The subject of the laboratory classes

POLYMER IDENTIFICATION – FLAME TEST

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the identification of polymers based on their behaviour in flame will be verified. The student will identify different polymers based on their behaviour in flame (colour of flame, pH, smoke, condensate), evaluate the results and indicate the suitability of use. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the identification of polymers based on their behaviour in flame. Students are able to work in a group, divide tasks and analyse results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Polymer identification, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- test tubes,
- burner,
- litmus test.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 3

1. The subject of the laboratory classes

POLYMER IDENTIFICATION - PYROLYSIS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the identification of polymers based on their behaviour in flame during pyrolysis will be verified. The student will identify different polymers based on their behaviour in flame during pyrolysis (colour of flame, pH, smoke, condensate), evaluate the results and indicate the suitability of use. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the identification of polymers. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Polymer identification, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- test tubes,
- burner,
- litmus test.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 4

1. The subject of the laboratory classes

DETERMINATION OF THE SOLIDIFICATION CURVE

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of crystalline and amorphous polymers will be verified. The determines the solidification curve of two unknown polymers and determines the crystalline and amorphous polymer based on the curve. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the structure of polymers. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Determination of the solidification curve, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- test tubes,
- oil bath,
- thermometer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Carraher, Ch. E. Jr.: Introduction to polymer chemistry, Florida Atlantic University, USA, 2006, 503 s. ISBN 0-8493-7047-7

A.K. van der Vegt: From polymer to plastics, publisher: VSSD, 2005, 268p., ISBN-13 978-9071301629

international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 5

1. The subject of the laboratory classes

DETERMINATION OF THE FIRE CHARCTERISTICS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the chemical composition of polymers on their flammability will be verified. The determines the change in mass and burning rate of polymers in horizontal and vertical arrangement. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the flammability of polymers. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Determination of the fire characteristics, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- burner,
- ruler,
- analytical balances.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 6

1. The subject of the laboratory classes

VISCOSITY

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the effect of temperature on the flow of polymers will be verified. The determines the change in the flow rate of the polymer when the temperature changes, which has a significant impact on the injection of polymers. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to good injection molding of polymers. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Viscosity, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- water bath,
- test samples of various polymers,
- stopwatch,
- thermometer,
- viscosimeter.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 7

1. The subject of the laboratory classes

MECHANICAL PROPERTIES OF POLYMERS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the influence of aging on the mechanical properties of polymers will be verified. The determines the change in strength, ductility and impact strength after 3 months of aging in a UV chamber, which has a significant impact on the life of polymers. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the influence of UV aging on polymer properties. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Mechanical properties of polymers, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- ripper,
- accurate gauge,
- Charpy hammer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6.	Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7.	Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 4 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8.	Optional information

Exercise manuals will be available.

Topics 8

1. The subject of the laboratory classes

DETERMINATION OF RECYCLATE PROPERTIES

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of polymer recycling methods will be verified. The determines the content of volatile substances, the size of the recyclate particles, the bulk weight and the shape of the recyclate particles. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the influence of the properties of the recyclate on its reprocessing. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Determination of recyclate properties, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- recycled material,
- sieves,
- scales,
- microscope,
- measuring cylinder,
- beakers.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 9

1. The subject of the laboratory classes

DETERMINATION OF MELTING POINT

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of influence of structure of polymers on their melting point will be verified. The melting temperature of the unknown polymer is determined, the type of polymers and its temperature range of use are determined from the table based on the measured temperature. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the influence of the purity of the polymer on its melting point. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Determination of melting point, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- Koffler block.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,

- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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7. Additional notes

- ASSESSMENT

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8. Optional information

Exercise manuals will be available.

Topics 10

1. The subject of the laboratory classes

CHEMICAL RESISTANCEOF POLYMERS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of influence of structure of polymers on their chemical resistance will be verified. Samples of unknown polymers are immersed in selective solvents and the change in weight, colour and solubility of the samples is monitored. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the influence of the chemical composition of the polymer on its chemical resistance. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Chemical resistance of polymers, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- burner,
- test tubes.
- test samples of various polymers.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 11

1. The subject of the laboratory classes

CORROSION OF POLYMERS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of effect of polymer corrosion on their appearance, surface quality, weight and dimensions will be verified. The test sample is exposed to an aggressive environment under the prescribed conditions and the inducted changes are determined. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the impact of an aggressive environment on the corrosion resistance of plastics. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Corrosion of polymers, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of various polymers,
- analytical balances,
- micrometer,
- thermostat.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,

- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 12

1. The subject of the laboratory classes

DETERMINATION OF CHEMICAL RESISTANCE OF PVC

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of the influence of temperature and oxidation instability of polymers on their processability will be verified. Degradation of PVC takes place by heating it in a test tube, while the low molecular weight product (HCl) is split off. HCl is detected using an acid-base indicator. During the laboratory exercises, students will work in groups, divide the tasks and work together to develop a work plan, analyse the results and draw conclusions. The completed experiment will be the basis for the laboratory report.

3. Learning outcomes

Students will be able to use information from the literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the thermal degradation of PVC during its processing. Students are able to work in a group, divide tasks and analyze the results and draw conclusions together. They can prepare a theoretical introduction and final results description to the laboratories on Determination of chemical resistance of PVC, including critical analysis, synthesis and conclusions.

4. Necessary equipment, materials, etc

- test samples of PVC,
- oil bath,
- test tube,
- thermometer,
- litmus paper.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

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international standards STN EN ISO

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 3 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

CORROSION AND SURFACE TREATMENTS

Code: CST

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1.	**The subject of the lecture**

INTRODUCTION TO CORROSION – BASIC DEFINITIONS AND MECHANISMS

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

The lectures of Topics 1 aim to the explaining and understanding the historical and economic aspects of corrosion and basic definitions, concepts and mechanisms related to corrosion processes:

- explanation and definition of corrosion, corrosive materials and corrosive environments;
- historical aspects of corrosion and corrosion protection – early observations, ancient civilizations, industrial revolution;
- economic aspects of corrosion and corrosion protection – direct and indirect costs, health and safety costs, environmental costs, importance of corrosion protection (maintenance savings, operational efficiency, environmental and safety benefits) ;
- chemical and electrochemical corrosion - the essence, differences, environments where occur;
- explanation of the basic mechanism of corrosion - oxidation, reduction, anodic (polarization) and cathodic (depolarization) reactions, coupled reactions.

3.	**Learning outcomes**

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to The historical and economic aspects of corrosion and basic definitions, concepts and mechanisms related to corrosion processes.*

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5.	Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6.	Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 2

1. The subject of the lecture

THERMODYNAMICS OF CORROSION PROCESSES

2. Thematic scope of the lecture (abstract, maximum 500 words)

Several thermodynamic functions are important in understanding and analyzing corrosion processes. These functions help explain the underlying thermodynamic principles that govern the reactions involved in corrosion. The lectures of Topics 2 aim to the explaining and understanding these basic thermodynamic functions important in corrosion processes:

- electrochemical potential (E) - which helps determine the direction and extent of electron flow between the anodic and cathodic reactions. Pourbaix E – pH diagrams, explanation and construction;
- standard electrode potential (E°) which is a measure of the tendency of a half-reaction to occur at a standard condition. The standard electrode potential can provide insights into which metal is more likely to corrode (lower E°) and which is more likely to act as a cathode in a corrosion cell (higher E°);
- enthalpy (H), which represents the total energy change during a process at constant pressure. The enthalpy change of a corrosion reaction indicates whether the reaction is exothermic or endothermic;
- entropy (S) which is a measure of the disorder or randomness in a system. Corrosion processes often involve changes in the arrangement of atoms and molecules as metals corrode and form various products. Changes in entropy influence the overall thermodynamics of corrosion reactions;
- Gibbs energy (ΔG) which indicates whether a reaction is spontaneous or non-spontaneous under given conditions (for corrosion processes, a negative ΔG suggests that the corrosion reaction is thermodynamically favorable, meaning the metal tends to corrode in the given environment).

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *The basic thermodynamic functions important in corrosion processes.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 3

1. The subject of the lecture

KINETICS OF ELECTROCHEMICAL CORROSION

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 3 aim to the explaining and understanding of the kinetics of electrochemical corrosion (the study of the rates at which oxidation and reduction reactions occur at the electrode surfaces in a corrosion cell). They contain description and explanation of the following items:

- corrosion rate, derivation of corrosion rate from Faradays laws;
- relation between corrosion rate and current density;
- anodic and cathodic coupled reactions, polarization curves, explanation of corrosion potential and corrosion current density;
- polarisation curve of real corrosion process, immunity and activity regions;
- polarization curves of passivating metals – passivity, passive current density, transpassivity, pitting potential, repassivation potential;
- factors affecting corrosion rate – presence of passive surface films, diffusion processes.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *The kinetics of electrochemical corrosion.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.
POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6. Additional notes

The topics will be covered in 2 and half two-hour lectures (5 hours).

Topics 4

1. The subject of the lecture

MAIN FACTORS AFFECTING CORROSION PROPERTIES OF METALS AND ALLOYS. CORROSION TYPES.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 4 aim to the explaining and understanding of main internal and external factors affecting corrosion properties of metals and alloys and bring characteristics of individual types (forms) of corrosion. They contain description and explanation of:

- internal factors of corrosion resistance related to the composition, structure, and properties - alloy chemical composition, microstructure, grain boundaries corrosion can preferentially occur along them), precipitates and inclusions with different electrochemical potentials and compositions, crystallographic orientation of grains, phase transformations, hardness, grain size, residual stresses, defects and dislocations;
- internal factors related to the surface finish and roughness;
- external factors related to corrosive environment - concentration of aggressive ions or substances, pH, temperature, presence of inhibitors;
- overview of most common corrosion types – general corrosion, galvanic corrosion, pitting and crevice corrosion, intergranular corrosion, selective corrosion attack.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Main factors affecting corrosion properties of metals and alloys and with individual types of corrosion.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 5

1. The subject of the lecture

CORROSION IN VARIOUS ENVIRONMENTS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 5 aim to the explaining and understanding of the main corrosion principles and mechanisms in various environments and under mechanical stresses. They contain description and explanation of:

- corrosion in acid, neutral and alkaline electrolytes;
- corrosion in waters – pure and natural water, sea water, effect of water temperature;
- atmospheric corrosion – electrochemical principle, kinetics, classification of atmospheres according to aggressiveness, practical use of knowledge of the dominant factors of atmospheric corrosion;
- corrosion in soils – soil as corrosion environment, aggressiveness of soils, soil corrosion protection;
- Effect of mechanical stress on corrosive properties of alloys - corrosive cracking, corrosion fatigue.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Corrosion in various environments and under mechanical stresses.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.
POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6. Additional notes

The topics will be covered in 2 one-hour lectures.

Topics 6

1. The subject of the lecture

PREPARATION OF THE METAL SURFACES BEFORE THE EXPOSURE IN A CORROSIVE ENVIRONMENT

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 6 aim to the explaining and understanding of preparation of the metal surfaces before the exposure in a corrosive environment. They contain description and explanation of:

- mechanical and chemical cleaning of the surfaces;
- mechanical surface treatment – grinding, polishing;
- chemical and electrochemical treatment – pickling, passivation, electrochemical polishing
- non-metallic polymer (polyurethane, epoxy, acrylic) and ceramics (alumina and zirconia based) protective coatings and their properties;
- metal coatings and methods of their application;
- corrosion protection by adjusting the environment by inhibitors.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Preparation of the metal surfaces before the exposure in a corrosive environment*.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**
problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.
POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

6. Additional notes

The topics will be covered in 2 and half two-hour lectures (5 hours).

Course content – laboratory classes

Topics 1 Lab 1

1. The subject of the laboratory classes

INTRODUCTION TO THE LABORATORY EXCERCISES

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The first laboratory class is focused on instruction on laboratory order and safety at work; familiarization with the exposure and electrochemical methods of the corrosion resistance testing and familiarization with the device for electrochemical testing - detailed explanation of measurement procedure.

During this laboratory class, students' theoretical knowledge of the basic mechanism and thermodynamics of electrochemical corrosion will be verified. Students will work in a group, sharing tasks and working together to try out the procedure for an electrochemical potentiodynamic tests on a test metallic specimens, analyze the results and draw conclusions.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Exposure and electrochemical corrosion testing.* Students are able to work in a group, sharing tasks and working together analyze the results and draw conclusions.

4. Necessary equipment

Corrosion measuring system with conventional three-electrode cell system with a calomel reference electrode (SCE) and platinum auxiliary electrode (Pt)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- introduction to the laboratory classes – instruction on laboratory order and safety at work,

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment.

The first laboratory class is without preparation of the final report.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

7. Additional notes

- ASSESSMENT

The first laboratory class is without evaluation by points.

8. Optional information

Device manual will be available.

Topics 2 Lab 2

1. The subject of the laboratory classes

DETERMINATION OF CORROSION RESISTANCE OF CHOSEN METAL/ALLOY BY EXPOSURE CORROSION TEST

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of kinetics and types of electrochemical corrosion will be verified. The student will perform a rapid exposure corrosion test of a metal/alloy in an aggressive acid solution at the room temperature. The test will be performed on three parallel specimens of the rectangular shape, weight losses, corrosion rates will be determined and the average corrosion rate will be calculated. The student will evaluate macroscopically the corrosion damage of the samples. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Determination of corrosion resistance by exposure corrosion test*. Students are able to work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of corrosion resistance by exposure corrosion test* including critical analysis, synthesis and conclusions.

4. Necessary equipment

digital scale (± 0.001 g)
thermometer

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 6 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 3 Lab 3

1. The subject of the laboratory classes

DETERMINATION OF CORROSION RESISTANCE OF CHOSEN NON-PASSIVATING METAL/ALLOY BY POTENTIODYNAMIC POLARIZATION METHOD

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of corrosion thermodynamics, kinetics and polarization curves of non-passivating metals will be verified. The student will perform potentiodynamic polarization test on three parallel specimens (the same metal and the same surface treatment) in 0.5 M NaCl solution. The obtained polarization curves will be evaluated by Tafel analysis (EC LAB software) for determination of corrosion potential, corrosion current density and corrosion rate. The standard deviations of these potentiodynamic parameters will be determined. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Determination of corrosion resistance by potentiodynamic polarization method*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of corrosion resistance by potentiodynamic polarization method* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Corrosion measuring system, with conventional three-electrode cell system with a calomel reference electrode (SCE) and platinum auxiliary electrode (Pt)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 6 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 4 Lab 4

1. The subject of the laboratory classes

DETERMINATION OF A STAINLESS STEEL PASSIVE SURFACE FILM QUALITY BY ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY (EIS)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of corrosion properties of passivating metals/alloys will be verified. The student will perform EIS test on three parallel AISI 304 specimens with the same surface treatment in 0.5 M NaCl solution. The obtained Nyquist curves will be evaluated by EC LAB software for determination of polarization resistance. The standard deviations of the obtained polarization resistances will be determined. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Determination of a stainless steel passive surface film quality EIS method* Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of a stainless steel passive surface film quality EIS method* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Corrosion measuring system, with conventional three-electrode cell system with a calomel reference electrode (SCE) and platinum auxiliary electrode (Pt)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.
c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 6 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 5 Lab 5

1. The subject of the laboratory classes

ELECTROCHEMICAL POLISHING OF STAINLESS STEEL AND EVALUATION OF THE QUALITY OF PREPARED SURFACE BY CYCLIC POTENTIODYNAMIC METHOD

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of corrosion properties and surface treatments of stainless steels will be verified. The student will perform electrochemical polishing in mixture of HNO_3 and HF on three AISI 316L rectangular specimens. The prepared polished surfaces will be consequently tested by cyclic potentiodynamic polarization method. The representative curve will be selected and the pitting and repassivation potentials will be determined. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Electrochemical polishing of stainless steel and Evaluation of the quality of prepared surface by cyclic potentiodynamic method*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Electrochemical polishing of stainless steel and Evaluation of the quality of prepared surface by cyclic potentiodynamic method* including critical analysis, synthesis and conclusions.

4. Necessary equipment

electrolyzer
source
Corrosion measuring system, with conventional three-electrode cell system with a calomel reference electrode (SCE) and platinum auxiliary electrode (Pt)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

7. Additional notes

- ASSESSMENT
Report related to this laboratory exercise is evaluated (max. 6 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 6 Lab 6

1. The subject of the laboratory classes

ANODIC OXIDATION OF ALUMINUM ALLOY AND EVALUATION OF THE QUALITY OF PREPARED SURFACE BY POTENTIODYNAMIC POLARIZATION METHOD

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of anodic oxidation and corrosion properties of aluminium alloys will be verified. The student will perform anodic oxidation of three specimens of the same Al alloy by electrolysis in H_2SO_4 solution. The quality of obtained surface will be evaluated by potentiodynamic polarization method (0.5 M NaCl solution). Representative polarization curve will be evaluated by Tafel analysis (EC LAB software) for determination of corrosion potential, corrosion current density and corrosion rate. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Anodic oxidation of aluminum alloy AND Evaluation of the quality of prepared surface by potentiodynamic polarization method*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Anodic oxidation of aluminum alloy AND Evaluation of the quality of prepared surface by potentiodynamic polarization method* including critical analysis, synthesis and conclusions.

4. Necessary equipment

electrolyzer
source
Corrosion measuring system, with conventional three-electrode cell system with a calomel reference electrode (SCE) and platinum auxiliary electrode (Pt)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment
b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 6 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

PROJECT STUDY

Code: PS

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – exercises

Topics 1

1.	**The subject of the exercises**
	INNTRODUCTION TO PROJECT STUDY
2.	**Thematic scope of the exercises (abstract, maximum 500 words)**
	Defining the objectives and outputs of the project study. Students will perform a short oral introduction (curriculum vitae) in English. Each student will be assigned the project study topic according to the Diploma thesis.
3.	**Learning outcomes**
	Students can use information from literature and other available sources, interpret and critically evaluate them. Student will understand the assigned project study topic and its processing procedure.
4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**
	assimilation methods/providing - **reading**, activating methods: **peer learning, flipped classroom** a) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other. Classes are held in the following order: - teachers clarification of unclear matters - student's work with the teacher's accompaniment,
5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**
	PAUR, J. - DONIČ, T.: Flow of material in manufacturing enterprise: textbook of technical English for technicians, managers, PhD students, undergraduates and self-learners. Žilina : Language Achievements Paur, s.r.o., 2020. 283 s. KUCHARÍKOVÁ, A. a kol.: English for students of Mechanical Engineering. Bratislava: Slovenská technická univerzita, 2010. - 130 s. - ISBN 978-80-227-3250-5.
6.	**Additional notes**
	- ASSESSMENT According to Syllabus of Project Study
7.	**Optional information**
	-

Topics 2

1.	**The subject of the exercises**
	PREPARATION OF A TECHNICAL PROFESSIONAL TERMS DICTIONARY
2.	**Thematic scope of the exercises (abstract, maximum 500 words)**
	Students will work with English technical documentation and with scientific articles in the field of material engineering with regard to the project study topics. On the bases of studied materials, students will prepare a technical professional terms dictionary – each student at least 30 terms from the field of material engineering according to the topic of diploma thesis.
3.	**Learning outcomes**
	Students can use information from literature and other available sources, interpret and critically evaluate them.
4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**
	assimilation methods/providing - **reading**, activating methods: **peer learning, flipped classroom** a) work in class based on previously studied material indicated by the teacher b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other. Classes are held in the following order: - teachers clarification of unclear matters - student's work with the teacher's accompaniment, - student's work in couples
5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**
	PAUR, J. - DONIČ, T.: Flow of material in manufacturing enterprise: textbook of technical English for technicians, managers, PhD students, undergraduates and self-learners. Žilina : Language Achievements Paur, s.r.o., 2020. 283 s. KUCHARÍKOVÁ, A. a kol.: English for students of Mechanical Engineering. Bratislava: Slovenská technická univerzita, 2010. - 130 s. - ISBN 978-80-227-3250-5.
6.	**Additional notes**
	- ASSESSMENT According to Syllabus of Project Study.
7.	**Optional information**
	-

Topics 3

1. The subject of the exercises

THEORETICAL FOUNDATIONS OF THE PROJECT STUDY TOPIC

2. Thematic scope of the exercises (abstract, maximum 500 words)

Students will prepare, summarize and process theoretical foundations of the project study topic selected according to the diploma thesis topic. They will be able to present the prepared materials in the form of 10 – 15 min. oral speech with PowerPoint presentation.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to present *Theoretical foundations of the project study topic.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, conference discussion**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- presentation
- discussion

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

PAUR, J. - DONIČ, T.: Flow of material in manufacturing enterprise: textbook of technical English for technicians, managers, PhD students, undergraduates and self-learners. Žilina : Language Achievements Paur, s.r.o., 2020. 283 s.
KUCHARÍKOVÁ, A. a kol.: English for students of Mechanical Engineering. Bratislava: Slovenská technická univerzita, 2010. - 130 s. - ISBN 978-80-227-3250-5.

6. Additional notes

- ASSESSMENT
According to Syllabus of Project Study.

7. Optional information

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Topics 4

1. The subject of the exercises

EXPERIMENTAL PART OF THE PROJECT STUDY

2. Thematic scope of the exercises (abstract, maximum 500 words)

Students will describe experimental methods, summarize, evaluate and process results of experiments carried out in the frame of Diploma thesis. They will be able to present the prepared experimental results and conclusions in the form of 15 min oral speech with PowerPoint presentation and discuss them.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them. Students are able to present and discuss *Experimental Part of the project study*.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
activating methods: **peer learning, conference discussion**

a) work in class based on previously studied material indicated by the teacher
b) learning through the exchange of knowledge in a couple (group) - student activity with the accompaniment of an teacher conducting classes, students with a similar level of experience learn from each other.

Classes are held in the following order:
- teachers clarification of unclear matters
- student's work with the teacher's accompaniment,
- presentation
- discussion

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

PAUR, J. - DONIČ, T.: Flow of material in manufacturing enterprise: textbook of technical English for technicians, managers, PhD students, undergraduates and self-learners. Žilina : Language Achievements Paur, s.r.o., 2020. 283 s.
KUCHARÍKOVÁ, A. a kol.: English for students of Mechanical Engineering. Bratislava: Slovenská technická univerzita, 2010. - 130 s. - ISBN 978-80-227-3250-5.

6. Additional notes

- ASSESSMENT
According to Syllabus of Project Study.

7. Optional information

-

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

QUALITY CONTROL OF MATERIALS

Code: QCM

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1.	**The subject of the lecture**

Introduction. Quality - basic concepts, signs and methods of quality assessment. Development of quality management systems.

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

Quality is a vital aspect in various industries, encompassing multiple dimensions and indicators. Assessing quality requires methods such as inspection, testing, statistical process control, and quality control charts. To ensure consistent quality, organizations develop quality management systems, which involve implementing standards, documenting procedures, focusing on quality assurance and control, and fostering a culture of continuous improvement. By prioritizing and managing quality effectively, organizations can enhance customer satisfaction, increase operational efficiency, and maintain a competitive edge in the marketplace.

3.	**Learning outcomes**

Completing this topic the student has extensive and in-depth substantive knowledge about quality as it self and methods how to ensure and manage the quality in factories. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at quality management system.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 17, Nondestructive Evaluation and Quality Control. 1997.
- Mechanical Engineers' Handbook, Volume 3: Manufacturing and Management, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112847, Publisher: Wiley, 817 pages.

- Mechanical Engineers' Handbook, Volume 2: Design, Instrumentation, and Controls, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112830, Publisher: Wiley, 982 pages.

6. Additional notes

NO

Topics 2

1. The subject of the lecture

Legal regulations, conformity marks, quality certificates, quality manuals, ISO 9001 documents

2. Thematic scope of the lecture (abstract, maximum 500 words)

Legal regulations vary by country and industry, but they often include requirements related to product safety, environmental impact, labour standards, and consumer protection. These regulations ensure that products and services meet minimum standards of quality and safety. Compliance with legal regulations is essential for businesses to operate legally and avoid penalties or legal consequences.

Conformity marks, also known as certification marks or compliance marks, are symbols or labels affixed to products to indicate that they meet specific standards or regulatory requirements. These marks demonstrate that the product has undergone testing, inspection, or certification by a recognized authority or third-party organization. Examples of conformity marks include the CE mark in the European Union and the UL mark for electrical products in the United States.

A quality certificate is a document issued by an organization, often as part of a quality management system, to confirm that a product, service, or process meets defined quality standards. It serves as proof that the product or service has undergone inspection, testing, or assessment and has met the specified criteria. Quality certificates may be required by customers, regulatory bodies, or industry standards organizations to ensure adherence to quality requirements.

A quality manual is a document that outlines the quality management system (QMS) implemented within an organization. It provides an overview of the organization's quality policy, objectives, processes, and procedures. The quality manual serves as a reference guide for employees, stakeholders, and auditors, detailing how the organization meets quality requirements and ensures consistent product or service quality.

ISO 9001 Documents: ISO 9001 is an international standard for quality management systems. It sets out the criteria for establishing, implementing, maintaining, and continuously improving a QMS. The standard requires the documentation of various documents and records to demonstrate compliance with its requirements. The specific documents needed for ISO 9001 certification can vary based on the organization's size, complexity, and industry.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge. Overall, understanding these concepts and documents provides individuals and organizations with the knowledge and skills needed to navigate regulatory requirements, implement effective quality management systems, and deliver high-quality products or services in compliance with applicable standards and regulations. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 17, Nondestructive Evaluation and Quality Control. 1997.
- Mechanical Engineers' Handbook, Volume 3: Manufacturing and Management, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112847, Publisher: Wiley, 817 pages.
- Mechanical Engineers' Handbook, Volume 2: Design, Instrumentation, and Controls, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112830, Publisher: Wiley, 982 pages.

6. Additional notes

NO

Topics 3

1. The subject of the lecture

Visual control. Metallographic assessment – preparation of metallographic specimens. Developing and etching of the structure. Microscopes - selection of magnification

2. Thematic scope of the lecture (abstract, maximum 500 words)

Visual control is a quality control technique that relies on the use of visual inspection to identify defects, deviations, or abnormalities in products or processes. It involves visually examining components, assemblies, or finished products to ensure they meet specified requirements or standards. Visual control can be conducted through direct observation, comparison with visual standards or reference samples, or the use of aids such as magnifying lenses or cameras.

Metallographic assessment is a technique used to examine the microstructure of metals and alloys. It involves the preparation of metallographic specimens, followed by their examination using optical or electron microscopes. This assessment helps in understanding the material's properties, grain structure, phase distribution, and the presence of defects or anomalies.

The preparation of metallographic specimens involves several steps to obtain a flat, polished surface that is suitable for examination under a microscope. The typical preparation process includes sectioning, mounting, grinding, and polishing.

After polishing, metallographic specimens are often subjected to a chemical etching process to reveal the microstructure more clearly. Etching involves the application of a chemical solution to the polished surface, which selectively attacks different phases or constituents in the material. This differential attack results in contrasting colours or textures, making the microstructure visible under a microscope. Different etchants are used depending on the type of material and the specific microstructural features of interest.

Microscopes are essential tools for metallographic assessment, enabling detailed examination of the microstructure. The selection of magnification depends on the specific purpose and requirements of the examination. Higher magnifications provide more detailed views but may have smaller fields of view. Lower magnifications allow for broader observations but may provide less detail. The choice of magnification is typically determined by the size and nature of the microstructural features to be observed, the level of detail required, and the field of view needed to capture the entire area of interest.

It is important to note that the specific techniques and procedures for metallographic assessment, specimen preparation, and microscope selection may vary depending on the material being analysed and the specific objectives of the examination.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about discussed and presented themes. Understanding these concepts and techniques provides learners with the knowledge and skills needed to conduct visual inspections, analyse metallographic specimens, and make informed observations and interpretations. These outcomes contribute to their abilities in quality control, materials analysis, and research within relevant fields. The students can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental visual control problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 9, *Metallography and Microstructures 2004*. ISBN 0-87170-706-3, 2733 p.

6. Additional notes

NO

Topics 4

1. The subject of the lecture

Structure control - macroscopic and microscopic evaluation

2. Thematic scope of the lecture (abstract, maximum 500 words)

Structure control refers to the manipulation and optimization of the internal arrangement and organization of materials at both macroscopic and microscopic scales. It involves understanding and modifying the structural characteristics of materials to enhance their properties and performance for various applications.

The macroscopic evaluation focuses on the overall structure and properties of materials, typically visible to the naked eye or under macroscopic imaging techniques. It involves the assessment of macrostructural features such as shape, size, orientation, and distribution of different components within a material. Macroscopic techniques commonly used for evaluation include visual inspection, mechanical testing, and non-destructive testing methods such as ultrasound or X-ray. In metal alloys, macroscopic evaluation may involve examining the grain size, crystallographic texture, and the presence of defects such as cracks or voids. By controlling these macrostructural features, engineers can tailor the mechanical, thermal, and electrical properties of the material to meet specific design requirements.

Microscopic evaluation delves into the structural characteristics of materials at the microscopic or atomic scale. It involves the analysis of microstructural features, such as grain boundaries, phase composition, crystal structure, and defects (e.g., dislocations, vacancies, impurities). Microscopic evaluation techniques allow researchers to gain insights into the material's internal arrangement and understand how it influences its properties. Various microscopy techniques are used for microscopic evaluation, including optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), and X-ray diffraction (XRD). These methods provide high-resolution imaging and characterization of materials, enabling the observation of fine details at the atomic or nanoscale. Microscopic evaluation helps in identifying and quantifying microstructural features that affect material behaviour, such as mechanical strength, electrical conductivity, corrosion resistance, or thermal stability. By manipulating the microstructure through processes like heat treatment, alloying, or surface modification, it is possible to optimize the material's properties for specific applications.

3. Learning outcomes

Overall, the learning outcomes of studying structure control involve a deeper understanding of material behaviour, the ability to optimize properties, improved material design and development, enhanced quality control, and the potential for research and innovation in materials science and engineering.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 9, *Metallography and Microstructures 2004*. ISBN 0-87170-706-3, 2733 p.

6. Additional notes

NO

Topics 5

1. The subject of the lecture

Reliability and diagnostics. Malfunctions - distribution, causes of component damage. Failure analysis.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Reliability and diagnostics, malfunctions, causes of component damage, and failure analysis are crucial aspects of ensuring the performance and durability of materials and components. Reliability refers to the ability of a material, component, or system to perform its intended function without failure or degradation over a specified period. Reliability analysis involves evaluating the probability of failure and determining the factors that affect the reliability of materials or components. Malfunctions refer to failures or deviations from expected performance in materials, components, or systems. Malfunctions can occur in various ways, including sudden catastrophic failures or gradual degradation over time. The distribution of malfunctions can vary, ranging from isolated occurrences to widespread failures. Causes of malfunctions can include material defects, manufacturing errors, design flaws, inadequate maintenance, environmental factors, excessive loads or stresses, corrosion, wear, or improper usage. Component damage can occur due to a variety of factors, such as mechanical overloading, exposure to extreme temperatures, chemical reactions, or material fatigue. Failure analysis is the systematic process of investigating and determining the root causes of component failures. It involves examining the failed component, analysing the fracture surfaces, conducting material testing and characterization, and considering the operating conditions and environmental factors. Failure analysis helps identify the specific mechanisms and factors that led to the failure, providing insights for improving material selection, design, manufacturing processes, and maintenance practices. By understanding the causes of component damage and conducting failure analysis, engineers and researchers can develop strategies to prevent future failures, enhance reliability, and improve the performance of materials and components. This knowledge aids in the development of more robust designs, selection of appropriate materials, implementation of effective maintenance programs, and overall optimization of system reliability.

3. Learning outcomes

Studying reliability, diagnostics, malfunctions, causes of component damage and failure analysis can lead to several important learning outcomes, including understanding failure mechanisms, problem-solving and troubleshooting skills, reliability engineering, maintenance optimization, quality improvement, product design and optimization, and continuous improvement. Overall, studying reliability, diagnostics, malfunctions, causes of component damage, and failure analysis includes enhanced problem-solving skills, knowledge of failure mechanisms, proficiency in reliability engineering and maintenance optimization, and the ability to contribute to quality improvement and product design optimization. These outcomes are valuable in various industries where reliability and performance are critical factors.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6. Additional notes

NO

Co-funded by the European Union

Topics 6

1. The subject of the lecture

Structure of the weld joint - macro, micro, measurement of microhardness. Classification of weld joint defects.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The structure of a weld joint can be evaluated at both macroscopic and microscopic levels, and microhardness measurement is one of the techniques used to assess the hardness distribution within the weld. Additionally, weld joint defects can be classified into various categories. Macroscopic evaluation of a weld joint involves the examination of visible features such as the weld size, shape, and overall appearance. It includes assessing parameters like weld penetration, weld reinforcement, and the presence of any visible defects or discontinuities. Microscopic evaluation delves into the internal structure of the weld joint at a microscopic scale. It involves analysing the metallurgical features, including the weld zone, heat-affected zone (HAZ), and base metal. Microstructural characteristics, such as grain structure, phase distribution, and the presence of defects like inclusions or porosity, are examined. Microhardness measurement is a technique used to assess the hardness distribution within the weld joint at a microscopic level. It involves indenting the material surface with a small indenter and measuring the hardness based on the indentation size. Microhardness measurements provide information about the hardness variations across different zones of the weld joint, which can help assess the mechanical properties and potential susceptibility to cracking or deformation.

Weld joint defects refer to imperfections or irregularities that can occur during the welding process. They can be classified into several categories, including lack of fusion, porosity, inclusions, cracks, and undercut.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about the structure of weld joints, microhardness measurement, and classification of weld joint defects including improved weld quality assessment, process optimization, weld design and selection capabilities, enhanced quality control and inspection skills, proficiency in problem-solving and troubleshooting, and a deeper understanding of material behaviour in welded structures. Can also use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 6, *Welding, Brazing, and Soldering 1993*. ISBN 0-87170-377-7(V.1), 2873 p.
- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6. Additional notes

NO

Topics 7

1. The subject of the lecture

Quantitative assessment of structural components. Evaluation of bearing steels.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Quantitative assessment of structural components involves evaluating the mechanical and structural properties of materials and components using various testing and analysis techniques. Evaluation of bearing steels specifically focuses on assessing the suitability and performance of steels used in bearing applications. Evaluation of bearing steels involves selecting appropriate steel grades based on their mechanical properties, wear resistance, toughness, and fatigue strength. Factors like load capacity, operating conditions, and lubrication requirements play a vital role in determining the suitability of bearing steels for specific applications. Metallurgical analysis techniques, such as microscopy, grain size measurement, phase identification, and inclusion analysis, are employed to assess the microstructure and quality of bearing steels. This analysis helps determine the presence of any detrimental features that may affect the material's performance. Bearing steels are subjected to wear and fatigue conditions during operation. Wear testing methods, such as sliding wear or rolling contact fatigue tests, assess the material's resistance to wear and frictional forces. Fatigue testing evaluates the endurance and fatigue strength of bearing steels under cyclic loading, simulating real-world operating conditions.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about quantitative assessment of structural components and evaluation of bearing steels including enhanced materials selection skills, proficiency in mechanical and material testing techniques, understanding of metallurgical analysis, the ability to evaluate component performance, expertise in failure analysis, and the capability to contribute to design optimization processes. These outcomes are valuable in various industries where the performance and reliability of structural components are critical. Can also use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 1, *Properties and Selection: Irons, Steels, and High-Performance Alloys1993*. ISBN 0-87170-380-7, 1618 p.
- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6. Additional notes

NO

Topics 8

1. The subject of the lecture

Assessment of corrosion resistance. Basic types of corrosion damage

2. Thematic scope of the lecture (abstract, maximum 500 words)

Assessment of corrosion resistance involves evaluating the ability of materials to withstand corrosion, which is the deterioration of a material due to chemical or electrochemical reactions with the surrounding environment. Assessment of corrosion resistance includes corrosion testing, corrosion standards and specifications, and corrosion modelling and prediction. The basic types of corrosion damage are uniform corrosion, pitting corrosion, crevice corrosion, galvanic corrosion, and stress corrosion cracking.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about corrosion resistance assessment and the basic types of corrosion damage including corrosion awareness, proficiency in corrosion testing and evaluation. Furthermore, the student can make expertise in material selection and design for corrosion resistance, the ability to implement corrosion prevention measures, proficiency in failure analysis related to corrosion, and compliance with industry standards for corrosion control. These outcomes are valuable in various industries where corrosion is a significant concern, such as oil and gas, marine, automotive, and infrastructure sectors. Can also use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 13, *Corrosion 1992*. ISBN 0-87170-007-7 (v.1), 3455 p.

6. Additional notes

NO

Topics 9

1. The subject of the lecture

Non-destructive testing (NDT). Basic concepts, classification of defects. NDT – surface defects and methodology description. NDT – internal defects and methodology description.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Non-destructive testing (NDT) is a collection of techniques used to inspect materials, components, and structures without causing any damage. NDT methods are crucial for identifying defects and ensuring the integrity and reliability of various products. Basic Concepts of NDT are: i) Non-Destructive: NDT techniques do not cause any permanent alteration or damage to the tested material or structure; ii) Defect Detection: NDT aims to identify and characterize defects, such as cracks, voids, discontinuities, or inclusions, that may compromise the material's strength or performance; iii) Inspection: NDT involves the use of various methods and equipment to examine the internal and external features of a test object; iv) Quality Assurance: NDT is widely employed to ensure the quality, reliability, and safety of materials, components, and structures.

Defects can be classified into two categories: a) Surface defects: These defects are located on the external surface of the material or component. Some common surface defects include cracks, pitting, scratches, and corrosion. b) Internal defects: These defects are located within the material or component and cannot be seen with the naked eye. Examples of internal defects include voids, inclusions, delamination, and welding defects.

NDT Methodology for Surface Defects includes Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing, and Ultrasonic Testing.

NDT methodology for internal defects includes radiographic testing, ultrasonic testing, magnetic particle testing, and liquid penetrant testing.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about NDT techniques. Mastering the concepts and techniques of NDT can provide a solid foundation for a career in quality control, inspection, and materials engineering, ensuring the reliability and safety of various industrial applications. Can also use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

At this point, we also specify the form of conducting classes.

- The main topic will be continued for two more classes.

In the first week, general information about NDT will be provided and the problems of the surface defect and NDT surface methodology will be discussed.

In the second week, the internal defect and NDT internal defect methodology and methods will be explained.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 17, *Nondestructive Evaluation and Quality Control 1997*, ISBN 0-87170-007-7 (v. 1), 1608 p.

6. Additional notes

The topics will be covered in the next two lectures.

Topics 10

1. The subject of the lecture

Control of properties - fundamental testing (measurement) of design materials' mechanical properties.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Control of properties through the measurement of design materials' mechanical properties is important for ensuring the performance, durability, and safety of materials used in various engineering applications. Fundamental testing involves the measurement and evaluation of mechanical properties, which describe how a material responds to mechanical forces or loads. These properties provide valuable information about a material's strength, stiffness, ductility, toughness, hardness, and other characteristics that govern its behaviour under different conditions. Key mechanical properties include tensile strength, yield strength, modulus of elasticity, ductility, toughness, hardness, fatigue strength, and creep resistance.

Measuring mechanical properties is essential for several reasons. It helps to provide better material selection, ensure that materials meet specified standards and quality requirements; helps assess the performance, durability, and reliability of materials in real-world operating conditions; and aid in investigating and understanding the causes of material failure or performance issues. Fundamental testing guides the development and improvement of materials by assessing their mechanical behaviour and identifying areas for optimization.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about measurement and control of mechanical properties. The fundamental testing equips engineers and materials scientists with essential knowledge and skills to make informed decisions regarding material selection, process optimization, and quality control in various industries such as automotive, aerospace, construction, and manufacturing. Also can use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 1, *Properties and Selection: Irons, Steels, and High-Performance Alloys1993*. ISBN 0-87170-380-7, 1618 p.
- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6. Additional notes

NO

Topics 11

1.	**The subject of the lecture**

Damage to railway materials - rails, track tops

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

Damage to railway materials, specifically rails and track tops, can have significant implications for the safety, performance, and operational efficiency of railway systems. The most common damage to rails is wear, rolling contact fatigue (RCF), and head checks for surface cracks, squats, and corrosion. For the track tops are ballast degradation, track misalignment, track geometry irregularities, and insufficient fastening.

3.	**Learning outcomes**

Completing this topic the student has extensive and in-depth substantive knowledge about railway materials damage and its impact. The mentioned knowledge equips professionals with the necessary skills to assess, prevent, and manage damage in railway systems. This knowledge is crucial for railway engineers, maintenance personnel, and stakeholders involved in maintaining safe and efficient railway operations. Also can use information from literature, databases and other available sources. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 1, *Properties and Selection: Irons, Steels, and High-Performance Alloys 1993*. ISBN 0-87170-380-7, 1618 p.
- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6.	**Additional notes**

NO

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Safety and health protection at work. Conditions for evaluation and completion of the course. Materials quality assessment tools.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 1 and also cover case examples for using of Pareto diagram and Lorentz curve as well as Ishikava's approach to quality management system.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about quality as it self and methods how to ensure and manage the quality in factories. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at quality management system.

4. Necessary equipment, materials, etc.

- Case studies references supplied by the teacher.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Mechanical Engineers' Handbook, Volume 3: Manufacturing and Management, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112847, Publisher: Wiley, 817 pages.
- Mechanical Engineers' Handbook, Volume 2: Design, Instrumentation, and Controls, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112830, Publisher: Wiley, 982 pages.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the reports; **1 report**, for **3 points**. **The sum of points achieved is 3.**

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Application of Fe-Fe$_3$C diagram in quality control of materials.
Meaning and use of T-T-T, C-C-T diagrams and their application in the heat treatment of steels.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Laboratory exercise entitled "Application of Fe-Fe$_3$C diagram in quality control of materials. Meaning and use of T-T-T (Time-Temperature-Transformation), C-C-T (Continuous-Cooling-Transformation) diagrams and their application in the heat treatment of steels." summarizes the basic knowledge about the Fe-Fe$_3$C system, which the student acquired by studying the previous subjects and the specific application of the above diagram in the control of the quality of heat treatment. The second part of the laboratory exercise, regarding the meaning and use of T-T-T and C-C-T diagrams in the heat treatment of steels, continuously follows the mentioned topic. The problem of the influence of alloying elements on the position of the transformation curves of the diagrams and the change in temperatures Ac1, Ac3 and Acm will also be discussed.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of fundamental materials engineering science and real application of the iron-carbon metastable diagram as well as practical using of transformation diagrams. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc.

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes in the form of a project task. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- *Heat Treater's Guide: Practices and Procedures for Nonferrous Alloys*, Harry Chandler (Editor), ASM International, 1996, ISBN: 0-87170-565-6, 669 p.
- ASM Handbook, Volume 3, *Alloy Phase Diagrams 1992*. ISBN: 0-87170-377-7 (v.1) 0-87170-381-5 (v.3), 1741 p.
- ASM Handbook, Volume 4, *Heat Treating 1991*. ISBN: ISBN 0-87170-379-3, 2173 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the reports; **2 reports**, each for **3 points**. **The sum of points achieved is 6.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

Evaluation of the macrostructure and microstructure of metallic materials.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Laboratory exercise with the main title "Evaluation of the macrostructure of metallic materials." consists of five separate subtopics with the names 1. Evaluation of the macrostructure of metallic materials. 2. Quality control of the production of cylinder head castings. 3. Macroscopic evaluation of weld joint defects. 4. Macro and microscopic assessment of corrosion attack. 5. Metallographic assessment of bearing steels according to DIN. Each topic is focused on the use of quantitative metallography methods using macro and microstructure evaluation of selected Al technical alloys, cast irons, bearing steels, welded joints of low carbon steels and evaluation of corrosion resistance of structural steels.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of evaluation of macro and microstructures of various metallic materials. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 5 classes in the form of a project task. *The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.*

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 9, *Metallography and Microstructures 2004*. ISBN 0-87170-706-3, 2733 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.
- ASM Handbook, Volume 13, *Corrosion 1992*. ISBN 0-87170-007-7 (v.1), 3455 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the reports; **5 reports**, each for **3 points**. **The sum of points achieved is 15.**

- The topics will be implemented during 5 classes.

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Non-destructive testing of materials (NDT)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Laboratory exercise with the main title "Non-destructive testing of materials." consists of two subtopics. The topic of the first laboratory exercise is the characterization and application of non-destructive methods for detecting surface defects of materials, namely the penetration method and the magnetic method. As part of the exercise, the procedures of the mentioned tests will be demonstrated, and the students themselves will subsequently test the controls on real and reference samples. The topic of the second laboratory exercise will be the application of the ultrasonic non-destructive method to determine the type of material depending on the propagation speed of the longitudinal ultrasonic wave in the material and basic measurements and indication of internal defects on real samples and standards.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of non-destructive testing of materials. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content

of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 17, *Nondestructive Evaluation and Quality Control 1997*, ISBN 0-87170-007-7 (v. 1), 1608 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the reports; **2 reports**, each for **3 points**. **The sum of points achieved is 6.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Use of mechanical tests for material identification. Creation of transfer protocols.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topic of the laboratory exercise will be the evaluation of mechanical tests on various types of technical materials and, based on the obtained results, to determine which group of materials it is. Students will be familiar with the meaning and importance of mechanical tests and the correct interpretation of the results. Based on the knowledge gained during the entire semester, students will develop the so-called transfer protocol for the customer of the specified machine component.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of mechanical testing of materials and practical knowledge of how to read and interpret results. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformation problems. Can formulate and test hypotheses related to simple research and implementation problems. He understands the need for an interdisciplinary approach to solving problems and the need for a comprehensive, scientific analysis of problems in the field of materials engineering. He is aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator;
- Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes, i.e.

- The main topic will be implemented in the form of a project task and transfer protocol.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.
- ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the report and transfer protocol; **1 report**, for **3 points** and **1 transfer protocol**, for **2 points**. The sum of points achieved is **5.**

8. Optional information

NO

Topics 6

1. The subject of the laboratory classes

Excursion in production factories

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The professional excursion in the production company is focused on the subject area. The manufacturing companies are from various areas of engineering production (within the Slovak Republic or the Czech Republic) and have an interesting production program or progressive implementation of the quality management system in their production process. The mentioned excursion is mandatory for full-time students of the subject Quality Control of Materials.

3. Learning outcomes

Students will see real processes for the production of machine parts and components as well as various types of semi-finished products (various profiles, wires, sheets, steel ropes, production of tires, glass, etc.). They will also be familiar with the quality management system, compliance with ISO standards at individual production facilities, as well as concerning safety and health protection at work.

4. Necessary equipment, materials, etc

- NO.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

NO

7. Additional notes

- ASSESSMENT – The excursion is obligatory for students and they get points to classification from excursion; **1 excursion**, for **5 points**. The sum of points achieved is **5.**

8. Optional information

NO

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

ADVANCED CONSTRUCTION MATERIALS

Code: ACM

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to Advanced Construction Materials. Graphite cast iron; Austempered Ductile cast irons, Ni-resist cast irons.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to develop trends in materials for castings. We will focus on the basic classification and characteristics of cast iron with an emphasis on cast iron with lamellae graphite, cast iron with worm-shaped graphite and cast iron with nodular graphite (characteristics, chemical composition, basic mechanical properties and use). Attention will also be paid to progressive types of cast iron such as isothermally refined cast iron (ADI - austempered ductile iron) and ductile cast iron with a high nickel content (Ni-resist ductile iron).

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about advanced materials for castings – cast irons of various types of matrix and graphite shape. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at advanced materials for castings.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

NO

Topics 2

1. The subject of the lecture

Unalloyed and alloyed steels and their development trends. Steel for the production of sheet metal; high-strength steel.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture is focused on ordinary quality steels (low-carbon and low-alloy steels, steels for welded constructions, so-called automatic steels) and medium-carbon and medium-alloy steels (steels intended for heat and chemical-heat treatment). Special steels intended for the automotive industry - super-strong steels with special properties (e.g. IF steels and IF steels with BH effect) will also be discussed.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about advanced materials for special applications in the automotive industry – e.g. IF and IF BH steels, low carbon and low alloyed steels for welds etc. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at advanced materials for the automotive industry.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

NO

Topics 3

1. The subject of the lecture

High-strength steels (TRIP, TWIP, Maraging steels) and thermo-mechanical treatment of carbon and alloyed steels.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to progress the high-strength steel used in the automotive industry. These steels are characterized by a high value of the ultimate strength (UTS) and the yield strength (YS 0.2), which are around 1500 - 2500 MPa with satisfactory ductility. Their unique properties are achieved either by chemical alloying or by special procedures, the so-called thermo-mechanical processing. The goal of this treatment is to achieve a very fine-grained microstructure with a grain size of about 100 nm, which will cause even for ordinary carbon steels (steels with a carbon content of 0.3 - 0.6%, low-alloy or non-alloy) a distinct increase in mechanical properties and resistance to fatigue load. The group of high-strength steels includes steels intended for refining, TRIP, TWIP and MARAGING steels.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about advanced materials for special applications in the automotive industry – e.g. TRIP, TWIP, and MARAGING steels. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at advanced materials for the automotive industry.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

NO

Topics 4

1. The subject of the lecture

HSLA steel. Steels for work at low temperatures.

2. Thematic scope of the lecture (abstract, maximum 500 words)

HSLA (High-Strength Low-Alloy) steel is a type of steel that offers high strength and improved mechanical properties compared to traditional carbon steels. It contains small amounts of alloying elements such as copper, nickel, chromium, and phosphorus, which contribute to its enhanced strength and toughness. HSLA steel is commonly used in various applications that require a combination of strength, toughness, and good weldability. One specific area where HSLA steels find application is in environments with low temperatures. These steels are designed to maintain their mechanical properties and performance even at extremely cold temperatures. When it comes to working at low temperatures, certain properties of the steel become crucial. HSLA steels for low-temperature applications typically possess excellent toughness, ductility, and impact resistance, allowing them to withstand brittle fractures and maintain their integrity under cold conditions. These properties make them suitable for applications such as structural components in offshore platforms, pipelines, bridges, and Arctic exploration equipment. Additionally, the alloying elements in HSLA steel contribute to the formation of a fine-grained microstructure, which further enhances its low-temperature performance. This refined grain structure improves the steel's resistance to crack propagation and improves its fatigue strength. Different grades of HSLA steels are available to meet the specific demands of different industries and environments.

3. Learning outcomes

Students will gain knowledge about the composition, microstructure, and mechanical properties of HSLA steel, including its high strength, improved toughness, and enhanced low-temperature performance. Furthermore, the students will become familiar with the role of alloying elements such as copper, nickel, chromium, and phosphorus in enhancing the strength and toughness of HSLA steel, as well as their influence on low-temperature properties. Can understand the specific challenges associated with working in low-temperature environments and how HSLA steel addresses those challenges. They will gain knowledge of the applications where HSLA steel is used, such as in offshore platforms, Arctic equipment, and cold climate infrastructure. The students will develop an understanding of the factors involved in selecting HSLA steel for low-temperature applications, including material properties, cost-effectiveness, and environmental factors. They will also learn about the design considerations to ensure optimal performance and safety in low-temperature environments.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

NO

Co-funded by the European Union

Topics 5

1. The subject of the lecture

Development trends of corrosion-resistant (stainless) steels. High-temperature and refractory steels. Steels for nuclear reactors.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to corrosion-resistant high-alloy steels. This group includes steels with a high content of chromium (12-23 %) and nickel (6-12 %). The general name for these steels is stainless steel. Students will be familiar with the influence of the main alloying elements on the microstructure of the matrix the influence of the matrix on the heat treatment of these steels and the mechanical properties. A special example of stainless steels are steels with a so-called austenitic matrix, which are suitable for working at low temperatures (up to approx. -100 °C) as well as at temperatures up to approx. 600 °C. These properties predetermine the mentioned type of steel also as a high-temperature and heat-resistant material used for the production of parts of steam and aircraft turbines

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about a specific group of steels – stainless steels. They become familiar with the influence of alloying elements such Cr or Ni etc. on microstructure evolution a mechanical properties changing. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at advanced materials for high-temperature and heat-resistant applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7

- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

NO

Topics 6

1. The subject of the lecture

Light metal alloys for castings – Al-based alloys and Mg-based alloys.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to light metal alloys, specifically aluminium-based (Al-based) alloys and magnesium-based (Mg-based) alloys. These alloys are commonly used for castings due to their lightweight, excellent casting properties, and favourable mechanical characteristics. The three general groups of Al-based alloys such Al-Si (Widely used for castings due to their excellent casting properties, good strength, corrosion resistance, and thermal conductivity. Al-Si alloys are commonly used in automotive components, engine parts, and various structural applications.) Al-Cu (This group of alloys is also age hardenable and offers improved strength and hardness compared to Al-Si alloys. They possess good machinability and wear resistance, making them suitable for applications such as cylinder heads, pistons, and aerospace components.) and Al-Mg (Al-Mg alloys provide excellent strength-to-weight ratio, good corrosion resistance, and good weldability. These alloys find applications in industries like aerospace, automotive, and marine for components that require lightweight and high strength, such as aircraft structures, engine parts, and marine equipment.). Next, the three general groups of Mg-based alloys will be presented as well. Mg-Al alloys offer good mechanical properties, a high strength-to-weight ratio, and excellent castability. They are commonly used in automotive applications, particularly for parts that require lightweight construction, such as transmission cases, engine blocks, and wheels. Mg-RE (Rare Earth) alloys exhibit improved high-temperature properties, creep resistance, and good corrosion resistance. These alloys are utilized in applications requiring high-temperature stability, such as aerospace components, automotive engine parts, and electronic devices. Mg-Zn alloys provide enhanced mechanical properties, good creep resistance, and improved castability. These alloys find applications in automotive, aerospace, and defence industries for components like gearbox housings, brackets, and structural parts.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about light metal alloys – Al-based and Mg-based alloys. They become familiar with the influence of alloying elements on microstructure evolution a mechanical properties changing via applied heat-treatment. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at light metals production, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

At this point, we also specify the form of conducting classes, i.e.

- The main topic will be continued for two more classes.
In the first week, issues related to Al-based alloys will be discussed.
In the second week, issues related to Mg-based alloys will be discussed.
Students will learn about examples of different technologies of light alloy production and how to improve the mechanical properties via heat-treatment.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

6. Additional notes

- The topics will be covered in the next two lectures.

Topics 7

1. The subject of the lecture

Ti-based and Co-based alloys. Biocompatible materials.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims at titanium-based alloys and Cobalt-based alloys, which are both important categories of metallic, non-ferrous alloys with distinct characteristics and applications. Ti-based alloys are characterised by lightweight and high strength, excellent corrosion resistance, excellent biocompatibility, and heat-resistance. On the other hand, Co-based alloys are heavy alloys due to the high density of cobalt and offer good wear and corrosion resistance, high-temperature strength (Co-based alloys fall into the superalloy group as well, together with Ni-based superalloys), good biocompatibility, and excellent magnetic properties. The specific properties and applications of Ti-based alloys and Co-based alloys can vary based on their alloying elements, microstructure, and processing techniques. Different grades and compositions within each alloy category offer a range of mechanical properties, corrosion resistance, and biocompatibility to suit various industrial and medical needs.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about specific properties of Ti-based and Co-based alloys. They went through the chemical composition of these groups of alloys and their influence on final mechanical, corrosion, heat-resistance, high-temperature, and biocompatible properties. The students can develop a comprehensive understanding of the properties, applications, and considerations related to titanium-based alloys and cobalt-based alloys, enabling them to make informed decisions in material selection and apply this knowledge in various industries and fields, including aerospace, automotive, medical, and energy sectors. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at Ti-based and Co-based alloys production, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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6. Additional notes

NO

Topics 8

1. The subject of the lecture

High-strength alloys – Ni-based alloys and superalloys. Alloys with shape memory effect. Superplasticity.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to specific group of non-ferrous alloys, that have unique properties (e.g. electric, magnetic, heat-resistance, high-temperature etc.). Nickel-based alloys and superalloys are a category of high-performance alloys known for their exceptional strength, corrosion resistance, and high-temperature capabilities. These alloys are extensively used in industries such as aerospace, power generation, chemical processing, and gas turbines. Shape memory alloys (SMAs) are a unique class of metallic alloys that exhibit the shape memory effect and superelasticity. SMAs can "remember" and recover their original shape after being deformed when subjected to a specific temperature change. The shape memory effect in SMAs is associated with a reversible phase transformation called the martensitic transformation. This transformation occurs due to the reorientation of atoms within the material's crystal structure, resulting in a change in the material's shape. SMAs exist in two distinct phases: austenite and martensite. Austenite is the high-temperature phase with a specific crystal structure, while martensite is the low-temperature phase with a different crystal structure. The shape memory effect occurs as the material undergoes a reversible transformation between these two phases. In addition to the shape memory effect, SMAs also exhibit superelasticity or pseudoelasticity. Superelasticity allows the SMA to undergo large elastic deformations and recover its original shape upon unloading, even without undergoing a phase transformation. This property arises from stress-induced martensite and its reversion to austenite upon unloading. Shape memory alloys are commonly based on nickel-titanium (Ni-Ti) compositions, known as Nitinol. Other alloy systems, such as copper-based alloys (Cu-based SMAs) and iron-based alloys (Fe-based SMAs), also exhibit shape memory properties.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about the properties and applications of nickel-based alloys, superalloys, alloys with shape memory effect, and superplastic alloys. They went through the chemical composition of these groups of alloys and their influence on final mechanical, corrosion, heat-resistance, high-temperature, and superplastic properties. The students can develop a comprehensive understanding of the properties, applications, and considerations related to Ni-based alloys and SMAs alloys, enabling them to make informed decisions in material selection and apply this knowledge in various industries and fields, including aerospace, automotive, medical, and energy sectors. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at Ni-based alloys, superalloys and SMAs production, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
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6. Additional notes

NO

Topics 9

1. The subject of the lecture

Materials and alloys produced by additive manufacturing (AM-alloys). Additive manufacturing fundamentals and processes.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to fundamental processes of additive manufactured alloys. Additive Manufacturing (AM), is a manufacturing process that allows the production of complex geometries directly from digital design files. Various materials and alloys can be utilized in AM processes, offering a wide range of possibilities for manufacturing applications. The most common materials used for AM are polymers, metals (titanium alloys, stainless steel, aluminium alloys, cobalt-chromium alloys, and nickel-based superalloys), and ceramics. During this lecture, students receive some facts about AM manufacturing fundamentals and processes as well. Techniques such as Powder Bed Fusion (Selective Laser Melting (SLM) and Electron Beam Melting (EBM)), Directed Energy Deposition, and Material Extrusion will be discussed too.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about the additive manufacturing processes. Advanced processes of preparation and production of powder and the next powder processing steps provide the students with fundamental knowledge from this area of material science. The students can develop a comprehensive understanding of the properties, applications, and considerations related to AM alloys, enabling them to make informed decisions in material selection and apply this knowledge in various industries and fields, including aerospace, automotive, medical, and energy sectors. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at AM metals production, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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6. Additional notes

NO

Topics 10

1. The subject of the lecture

Advanced ceramics for engineering practise.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Advanced ceramics are typically non-metallic materials composed of inorganic compounds, including oxides, carbides, nitrides, and borides. They possess a crystalline structure and can be engineered to exhibit a range of desired properties. Advanced ceramics are known for their high hardness, strength, and stiffness. They have excellent wear resistance, low friction coefficients, and superior dimensional stability even at high temperatures. These properties make them suitable for applications where strength and durability are crucial, such as cutting tools, bearings, and armour. Advanced ceramics exhibit excellent thermal stability and resistance to high temperatures. They have low thermal conductivity, making them effective insulators, high electrical resistivity, low dielectric constant, and exceptional piezoelectric or ferroelectric behaviour. While advanced ceramics offer exceptional properties, they also have challenges such as brittleness, difficulty in shaping intricate geometries, and high manufacturing costs. However, ongoing research and development efforts aim to address these challenges and expand the applications of advanced ceramics.

3. Learning outcomes

Completing this topic the student has fundamental knowledge about advanced ceramics. The students can develop a comprehensive understanding of the properties, applications, and considerations related to advanced ceramics, enabling them to make informed decisions in material selection and apply this knowledge in various industries and fields, including aerospace, automotive, medical, and energy sectors. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at advanced ceramics production, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
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6. Additional notes

NO

Topics 11

1. The subject of the lecture

Advanced composites. Metal glasses and nanocrystalline materials.

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture aims to advanced composites, metal glasses (amorphous metals), and nanocrystalline materials. Advanced composites are typically made up of two or more constituent materials with distinct properties, such as fibbers (e.g., carbon, glass, aramid) embedded in a matrix material (e.g., polymer, metal, and ceramic). Composites exhibit improved strength, stiffness, and specific properties compared to the individual components. They can also offer tailored properties such as high electrical conductivity or low thermal expansion. Metal glasses, or amorphous metals, have a non-crystalline atomic structure. Unlike traditional metals, they lack a regular repeating crystal lattice arrangement, resulting in unique properties (high strength, hardness, elasticity, and excellent corrosion resistance). Nanocrystalline materials have a fine-grained structure with grain sizes in the nanometer range. This ultra-fine grain structure imparts unique properties to the materials (improved strength, hardness, and wear resistance compared to their coarse-grained counterparts, they may also display enhanced electrical and thermal properties). Advanced composites are widely used in industries such as aerospace, automotive, sports equipment, and construction. Metal glasses find applications in areas such as aerospace, electronics, sporting goods, and medical devices. They are used in areas where high strength, corrosion resistance, and precise moulding capabilities are required. Nanocrystalline materials have diverse applications in areas such as electronics, energy storage, catalysis, and structural materials.

3. Learning outcomes

Completing this topic the student has fundamental knowledge about the innovative classes of materials such composites, metal glasses, and nanomaterials. The students can develop a comprehensive understanding of the properties, applications, and considerations related to advanced composite, metal glasses, and nanomaterials, enabling them to make informed decisions in material selection and apply this knowledge in various industries and fields, including aerospace, automotive, medical, and energy sectors. Can also use information from literature, databases and other available sources. He will be able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate the problems at innovative classes of materials, processes, mechanical properties, and applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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6. Additional notes

NO

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to laboratory classes of Advanced Construction Materials. Safety and health protection at work. Basic development trends in the field of materials engineering.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Introductory exercise where students will be familiar with the program of laboratory exercises for the whole semester. The teacher familiarizes the students with the course of the exercises (at the beginning of each exercise there is a repetition of theoretical knowledge from the issues solved in a specific exercise, a check of the assigned homework and the preparation of the laboratory work according to the teacher's instructions). Students are also familiar with the method of evaluating laboratory exercises and the necessary conditions for successful completion of laboratory exercises (obligatory participation in exercises, submission of all laboratory work and successful completion of tests).

3. Learning outcomes

Students know what to do to pass successfully the laboratory exercises from the Advanced Construction Materials subject.

4. Necessary equipment, materials, etc.

NO

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

NO

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

The effect of chemical composition on the mechanical properties of ductile cast iron. Report No. 1.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 1. The topic of the exercise is to assess the effect of the chemical composition (with an emphasis on the Cu and Mn content) on the change in the microstructure of the ductile iron matrix (how the proportion of ferrite and pearlite changes in the matrix) and subsequently to evaluate the effect of the change in the Cu and Mn content on the mechanical properties (UTS, YS, Reduction area, and Ductility). In the end, students will write a short discussion about the influence of chemical composition on the microstructure and mechanical properties of ductile iron.

3. Learning outcomes

Based on Report No. 1 of laboratory work, students will understand the relationship between the chemical composition, microstructure and mechanical properties of ductile iron.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete report No. 1; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

The effect of heat treatment on the mechanical properties of Austempered Ductile cast irons. Report No. 2.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 1. During the exercise, students must complete sub-tasks such as:

1. Basic definition of ADI cast iron and to characterize the method of heat treatment by which it is possible to obtain ADI cast iron and calculate the degree of eutecticity Sc.
2. What are the basic structural components of ADI cast iron, based on the data in Appendix A, draw the dependence of the change in the proportion of austenite (A), bainite (B) and martensite (M) and mechanical properties depending on the time of isothermal holding.
3. Draw graphic dependencies of mechanical properties, ADI of cast iron (appendix B) depending on the temperature of isothermal decomposition of austenite and change in hardness, ADI of cast iron depending on the temperature of isothermal decomposition of austenite and the time of holding at this temperature.
4. Based on the facts found, write a discussion and formulate conclusions about how the temperature and duration of isothermal decomposition of austenite affect the mechanical properties of ADI cast irons (two different starting types of cast irons with different chemical compositions).

3. Learning outcomes

Based on Report No. 2 of laboratory work, students will understand the relationship between the chemical composition, heat-treatment, microstructure and mechanical properties of asutempered ductile iron (ADI).

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content

of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete report No. 2; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Wrought pure Cu grain size evaluation. Report No. 3.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to the use of quantitative metallography techniques in the microstructure evaluation of metallic materials with a special accent on grain size (with ASTM E112-12 standard). To complete this laboratory exercise and Report No. 3, students have to complete the following partial goals:

1. Evaluate the grain size according to STN EN ISO 2624 (or ASTM E112-12) on microphotographs of heat-treated copper (Fig. 1 and 2 - attachment).
2. On microphotographs of heat-treated copper (fig. 1 and 2 - attachment) evaluate the grain size using the Jeffereis and Saltyk methods according to STN EN ISO 2624 (or ASTM E112-12 - planimetric and line methods for grain size evaluation). Determine the resulting value of the grain size for individual states of heat treatment of copper as an average value from at least three applications of the test grid.
3. Process the evaluation results in a table, compare the grain sizes determined by different methods and formulate a conclusion (how does the grain size affect the mechanical properties?).

3. Learning outcomes

Based on Report No. 3 of laboratory work, students will gain knowledge and skills on how to use the standards and various techniques to evaluate grain size in metallic materials. Students also realise that if using various techniques for grain size evaluation they receive slightly different values of "G" and it is up to them to decide which one they consider as the right one, and of course, they have to explain their decision.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metals constants and all necessary working materials (microstructures, mechanical properties, ASTM E112-12 standard etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content

of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete report No. 1; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Tool steels – heat-treatment to microstructure relation. Report No. 4.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 3-5. To complete this laboratory exercise and Report No. 4, students have to complete the following partial goals:

1. What are the basic requirements for the properties of tool steels?
2. Characterize the basic structural components of tool steels, which of them are beneficial and which are undesirable.
3. State which operations heat treatment of tool steels consists of.
4. Based on the observation, draw and describe the structure of tool steels 19 436, 19 191, 19 420, 19 573. According to the material sheets, divide the tool steels in terms of chemical composition and indicate the appropriate heat treatment procedure for the given types of steels.
5. Based on the observation, evaluate and schematically draw the effect of different tempering temperatures on the microstructure of tool steel 19 830, and describe the individual structural components.
6. Evaluate the effect of quenching temperature on the hardness (HRC) of 19830 tool steel.
7. Write a conclusion and formulate a discussion of the effect of quenching temperature on the resulting microstructure and hardness of 19830 tool steel.

3. Learning outcomes

Based on Report No. 4 of laboratory work, students will understand the relationship between the heat-treatment temperature, microstructure and mechanical properties of tool steels. Also, they gain knowledge about microstructure features and how they affect the utility properties of tool steels.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.

- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
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- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

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7. Additional notes

- ASSESSMENT – Students complete report No. 1; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 6

1.	The subject of the laboratory classes

CVD, PVD and diffusion layers applications and evaluation. Report No. 5.

2.	Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to previous laboratory work and show how to increase the efficiency of tool steel via surface layering (CVD or PVD layers). To complete this laboratory exercise and Report No. 5, students have to complete the following partial goals:

1. Based on knowledge from the theory, write:

- what are the basic physical and chemical characteristics of PVD layers,
- advantages of applying PVD layers,
- advantages and disadvantages of applying CVD layers,
- What are the differences between PVD and CVD coating methods?

2. According to Appendix A, evaluate the adhesion of the layers - Mercedes test, and based on the thickness measurement (Appendix B), determine what type of layer it is. Process the results.

3. Plot and evaluate the dependence of the microhardness on the distance from the surface, Appendix C, of diffusion layers (nitride, nitro-oxidized and nitro-oxidized cooled) 14 209 (100CrMnSi6-4) bearing steel.

4. Draw and evaluate the dependence of the coefficient of friction "μ" as a function of time, diffusion layers (nitride, nitro-oxidized and nitro-oxidized cooled) steel 14 209 (100CrMnSi6-4).

5. Write a discussion and formulate conclusions about adhesion of PVD and CVD layers, microhardness and coefficient of friction "μ".

3.	Learning outcomes

Based on Report No. 5 of laboratory work, students will understand the importance of surface treatment especially in tool steels, where the wearing and friction are the main causes of degrade the cutting properties of tool steels. Moreover, the degraded cutting properties lead to decreasing the final product quality and lower the profit of the company.

4.	Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

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- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 5; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 7

1. The subject of the laboratory classes

Quantitative evaluation of the fracture profile. Report No. 6. and Half-Semester test No. 1.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

At the beginning of the laboratory exercise, the students will write the half-semester test No. 1 where they should correctly answer the questions from Topics 2-6. To complete this laboratory exercise and Report No. 6, students have to complete the following partial goals:

1. Quantitatively evaluate the fracture profiles:

a) static fractures (Annex A),

b) impact fractures (Annex B)

of Al-Si alloy AlSi10MgMn depending on the amount of modifier (strontium) using the vertical roughness coefficient Rv, the value of which you determine according to method no. 1 (see theoretical introduction) as an average value from three measurements. Process the results in a table.

2. Develop graphical dependences of (UTS) R_m, (Ductility) A5, (Impact energy at bending load) K0 and Rv I (for static fractures) and Rv II (for impact fractures) on the content of the modifier Sr.

3. Write a discussion and formulate a conclusion about the effect of modification and loading on:

- nature of breaking Al-Si alloy AlSi10MgMn (Annex C),
- change in the vertical roughness factor Rv,
- change of mechanical properties.

3. Learning outcomes

Based on Report No. 6 of laboratory work, students will understand how the modification affects the microstructure of Al-Si alloy, the relation between modifier amount and properties of Al-Si alloy, and how the loading speed may change the failure mechanism in engineering materials.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 6 and write the half-semester test No. 1; **1 report**, for **2 points**, **half-semester test** for **9 points**. **The sum of points achieved is 2 + 9 = 11 points.**

8. Optional information

NO

Topics 8

1. The subject of the laboratory classes

Metallography of stainless and corrosion-resistant steels. Report No. 7.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 5. To complete this laboratory exercise and Report No. 4, students have to complete the following partial goals:

1. Based on the chemical composition of stainless steels (see STN standard) and using the Schaeffler diagram, estimate the microstructure of the selected steels (17 153, 17 381, 17 248, 17 353.4, 17 041, 17 102 and 17 240).

2. Process metallographic analysis of selected stainless steels (17 153, 17 381, 17 248, 17 353.4, 17 041, 17 102 and 17 240); observe and schematically draw the microstructure of selected stainless steels, describe their mechanical and physical properties according to STN, describe the heat treatment (definite classification into a group or type of stainless steel) and give examples of possible use.

3. Compare the results obtained from points 1 and 2, write a discussion of the results and formulate a conclusion.

3. Learning outcomes

Based on Report No. 7 of laboratory work, students will understand the relationship between the chemical composition, microstructure and mechanical properties of stainless steels.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with

a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 7; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 9

1. The subject of the laboratory classes

Metallographic assessment of corrosion attack on metals. Report No. 8

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 5. To complete this laboratory exercise and Report No. 8, students have to complete the following partial goals:

1. Metallographically evaluate the corrosion attack of the selected set of samples according to standard STN 038137.
2. Compare the types and forms of corrosion attack detected on the metallographic samples with the diagrams (Appendix No. 1), which are part of the standard STN 038137, used for the metallographic evaluation of corrosion attack of metals.
3. Describe and schematically draw the detected types of corrosion attack.

3. Learning outcomes

Based on Report No. 8 of the laboratory work, students will become familiar with the different types of corrosion found on steels and will be able to distinguish individual types of corrosion and their manifestations.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 8; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 10

1. The subject of the laboratory classes

Structural analysis of Al-based cast AlSi10MgMn alloy – Part I. Report No. 9.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 6 – part Al-based alloys. To complete this laboratory exercise and Report No. 9, students have to complete the following partial goals:

1. In the Sr-modified AlSi10MgMn alloy (0; 0.05% Sr; 0.10% Sr and 0.15% Sr), evaluate according to STN 42 0491:

a) content of α-phase dendrites,

b) fineness of α-phase dendrites;

c) SDAS factor;

d) shape of eutectic Si (according to STN the so-called β-phase);

e) degree of structure modification;

f) distribution of eutectic Si in the unmodified alloy.

2. Based on the results, formulate a conclusion about the influence of Sr modification on the change in the microstructure of the AlSi10MgMn alloy. Define the optimal amount of Sr.

3. Learning outcomes

Based on Report No. 9 of laboratory work, students evaluate and quantify various microstructural parameters in the Sr-modified AlSi10MgMn alloy and draw conclusions about the impact of strontium on the alloy's microstructure. Obtained results help to identify the best strontium concentration for the intended application.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

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- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 9; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 11

1. The subject of the laboratory classes

Structural analysis of Al-based cast AlSi10MgMn alloy – Part I. Report No. 10.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 6 – part Al-based alloys. To complete this laboratory exercise and Report No. 10, students have to complete the following partial goals, which are closely related and connected to the previous laboratory exercise:

1. Metallographically evaluate and schematically draw the microstructure of the AlSi10MgMn alloy samples modified with Sr (0; 0.05% Sr; 0.1% Sr and 0.15% Sr) after black and white (0.5% HF) and colour etching (MA and Weck-Al).

2. Based on the comparison of the microstructures of the samples after black-and-white and colour etching, describe the importance of colour etching in the study of Al-Si alloys.

3. On photographs of the microstructures of the AlSi10MgMn alloy (unmodified and modified), identify the basic intermetallic phases and evaluate their shape and distribution.

3. Learning outcomes

Based on Report No. 10 of laboratory work, students will understand the following:

- Use appropriate etchants (black and white etchants with 0.5% HF, and colour etchants like MA and Weck-Al) to reveal the microstructure of the samples.
- Observe and describe the microstructural features of the AlSi10MgMn alloy samples, including phases, grain structures, and any modifications due to Sr additions.
- Create accurate and detailed schematic drawings of the microstructures, clearly representing the observed features.
- Analyse and compare the microstructures revealed by black-and-white etching and colour etching techniques.
- Describe the advantages and limitations of each etching method in studying Al-Si alloys.
- Understand the role of colour etching in identifying different phases and microstructural constituents, as colour contrasts can provide additional information about the distribution and nature of phases.

These metallography tasks will provide valuable hands-on experience in the preparation and evaluation of microstructures in Al-Si cast alloys, enhancing the understanding of microstructural characteristics and the effects of Sr modification on the alloy properties.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

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5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

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- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

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7. Additional notes

- ASSESSMENT – Students complete report No. 10; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 12

1. The subject of the laboratory classes

Quantitative evaluation of Ni-based superalloy structure parameters. Report No. 11.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to LECTURE Topic 8. To complete this laboratory exercise and Report No. 11, students have to complete the following partial goals:

1. On microphotographs of Ni-based superalloys:

- IN 738 - annealing 800 ˚C/15 hours, different cooling rates (initial state, air, oil and water);
- ŽS6U - cast state (fig. 1 - appendix A);
- VŽL14 - heat-treated - solution annealing at a temperature of 1020 ˚C with a holding time of 4 hours. (Fig. 2 - Appendix B);

rate:

a) SDAS (Secondary Dendrite Arm Spacing) factor on IN 738 alloy,

b) the content and number of carbides of the IN 738 alloy by the point and area method,

c) the content of the γ′-phase by the point method,

d) a number of γ′-phase particles using a test grid with surface probes.

2. From the values of V (the content of the γ′-phase) and N (average number of particles of the γ′-phase) for alloys ŽS6U and VŽL14, determine the following dimensional parameters:

a) the average area of one particle of the γ′-phase,

b) linear dimension of one particle of the γ′-phase.

3. Write a discussion and formulate a conclusion about the influence of the cooling rate of the IN 738 alloy on SDAS, the number and area fraction of carbides, and heat treatment on the character of the γ′-phase in Ni-based superalloys.

3. Learning outcomes

Based on Report No. 11 of laboratory work, these tasks provide an opportunity for students to gain in-depth knowledge of microstructural analysis techniques for Ni-based superalloys and understand the significance of various microstructural parameters on the alloy's properties and performance. More detailed:

- Analyse and discuss the relationship between the cooling rate of the IN 738 alloy and the resulting SDAS factor. Understand how the cooling rate affects microstructural features like dendritic spacing.
- Interpret and discuss the influence of the cooling rate and heat treatment on the content, number, and area fraction of carbides in the IN 738 alloy. Explore the impact of cooling rate and heat treatment on carbide distribution and morphology.
- Formulate a conclusion about the effects of cooling rate and heat treatment on the character of the γ′-phase in Ni-based superalloys (IN 738, ŽS6U, and VŽL14). Discuss how these factors influence the distribution, size, and properties of the γ′-phase, which is crucial for the alloy's performance.

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,
- Tables for materials, metals physical constants,
- Tables of metal constants and all necessary working materials (microstructures, mechanical properties, etc.) supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

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- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
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7. Additional notes

- ASSESSMENT – Students complete report No. 11; **1 report**, for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 13

1. The subject of the laboratory classes

Final-Semester test No. 2.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Final laboratory exercise in which students write the second test in order from the areas covered in Topics 7-12. At this exercise, students also have the opportunity to complete and submit reports that have not been submitted so far or correct the first test if they did not pass it successfully.

In the overall evaluation of the work during the semester, the student should optimally get 40 points (11 reports x 2 max. points = 22 points and two tests 2 x 9 max. points = 18 points). Students who have obtained min. during the semester can apply for the final exam. 21 points.

3. Learning outcomes

NO

4. Necessary equipment, materials, etc.

- Ruler, pen and pencil,
- Calculator,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or the entire curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The final-semester test is evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
- *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.
- ASM Handbook, Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials,* 1992, ISBN 0-87170-378-5, 3470 p.
- ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
- ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
- ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – Students complete the final-semester test No. 2 and f**inal-semester test No. 2**, for **9 points**. **The sum of points achieved is 9.**

- FINAL ASSESSMENT – Students should obtain a maximum of 40 points, those who obtain a minimum of 21 points during the semester can attend the final exam from the Advanced Construction Materials subject. More information is in the syllabus file.

8. Optional information

NO

The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

MATERIALS SCIENCE MASTERS
Co-funded by the European Union

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

PROFESSIONAL PRACTICE

Code: PP

Course content – theoretical exercises

Topics 1

1. The subject of the laboratory classes

INTRODUCTION TO THE SUBJECT

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

This lecture aims to provide introductory information to the Professional Practice course – course content, organizational guidelines, choice of topic, assessment method and completion condition. The session includes guidance on health and safety at work.

3. Learning outcomes

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.
Case study.
Discussion - encouraging students to participate in the discussion on the issues actively.
Independent creative activity.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Books, monographs, professional articles dealing with the problem.

6. Additional notes

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7. Optional information

Guides and templates for multimedia presentations will be available.

Topics 2

1.	**The subject of the laboratory classes**

INFORMATION SURVEY

2.	**Thematic scope of the laboratory classes (abstract, maximum 500 words)**

This lecture aims to provide information to the Professional Practice course – realization of bibliographic survey, methods of processing survey results, work outline and experimental plan.

3.	**Learning outcomes**

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.
Case study.
Discussion - encouraging students to participate in the discussion on the issues actively.
Independent creative activity.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Books, monographs, professional articles dealing with the problem.

6.	**Additional notes**

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7.	**Optional information**

Guides and templates for multimedia presentations will be available.

Topics 3

1. The subject of the laboratory classes

IMPLEMENTATION OF RESEARCH

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

This lecture aims to provide information to the Professional Practice course – consultation and control of the implementation of work outline and experimental plan.

3. Learning outcomes

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.
Case study.
Discussion - encouraging students to participate in the discussion on the issues actively.
Independent creative activity.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Books, monographs, professional articles dealing with the problem.

6. Additional notes

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7. Optional information

Guides and templates for multimedia presentations will be available.

Topics 4

1. The subject of the laboratory classes

PARTIAL REPORTING

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

This lecture aims to provide information to the Professional Practice course – student continuously presents the results of independent research work in the form of presentations and professional discussions.

3. Learning outcomes

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.

Case study.

Discussion - encouraging students to participate in the discussion on the issues actively.

Independent creative activity.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Books, monographs, professional articles dealing with the problem.

6. Additional notes

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7. Optional information

Guides and templates for multimedia presentations will be available.

Topics 5

1. The subject of the laboratory classes

PREPARATION OF THE FINAL REPORT

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

This lecture aims to provide information to the Professional Practice course – student will work on the theoretical part of the thesis on the basis of a literature search, evaluate the experiments, prepare a discussion on the chosen topic and a final thesis and presentation of the research results.

3. Learning outcomes

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.
Case study.
Discussion - encouraging students to participate in the discussion on the issues actively.
Independent creative activity.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Books, monographs, professional articles dealing with the problem.

6. Additional notes

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7. Optional information

Guides and templates for multimedia presentations will be available.

Topics 6

1. The subject of the laboratory classes

FINAL REPORT

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

This lecture aims to provide information to the Professional Practice course – based on the literature search and research results, the student will prepare a final presentation and present the results of his professional practice. The student is able to lead a professional discussion of his results.

3. Learning outcomes

Can use knowledge and information from literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

Multimedia presentation - the use of PowerPoint presentations for discussed issues and examples.

Case study.

Discussion - encouraging students to participate in the discussion on the issues actively.

Independent creative activity.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Books, monographs, professional articles dealing with the problem.

6. Additional notes

- ASSESSMENT

4 reports related to the subject are assessed as follows:

- First report – 10 points,
- Second report – 20 points,
- Third report – 20 points,
- Fourth report – 50 points.

The reports include an explanation of the theoretical basis of the experiment, the procedure, a summary of the results and a conclusion.

7. Optional information

Guides and templates for multimedia presentations will be available.

The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

Co-funded by the European Union

This project has been funded with support from the European Commission. This publication reflects the views only of the author and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

DEGRADATION PROCESSES AND LIMIT CONDITIONS OF MATERIALS

Code: DPLCM

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Degradation and Limit Conditions

2. Thematic scope of the lecture

Materials degradation and limit conditions are vital topics in materials science and engineering, as they play a significant role in designing safe and reliable structures. In this lecture, we will take an in-depth look at these topics and explore the various mechanisms that cause materials to degrade and the conditions that lead to their failure.

We will begin by discussing the different types of materials degradation, including corrosion, fatigue, and creep. Corrosion, for example, is a process that results in the gradual deterioration of a material due to chemical reactions with its environment. Fatigue, on the other hand, refers to the progressive weakening of a material due to repeated loading and unloading cycles. Creep is the slow deformation of a material under constant stress.

We will also examine the physical and chemical processes behind each degradation mechanism and the factors that influence their occurrence and rate. These factors can include environmental conditions, loading conditions, material properties, and more.

Moreover, we will delve into the concept of limit conditions in materials. These conditions refer to the point at which a material can no longer perform its intended function due to excessive deformation, stress, or damage. We will investigate the different types of limit conditions, including yield, fracture, and buckling, and the factors that contribute to their occurrence.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms of degradation and limit conditions in materials. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials that can withstand the most extreme environments, from high-temperature applications to high-stress loads.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges. They will be able to apply this knowledge to design and build structures that are safe, reliable, and resilient, making the world a better place for everyone.

3. Learning Outcomes

Students should gain a comprehensive understanding of the different types of degradation mechanisms that materials can undergo, as well as the factors influencing these processes.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, considering didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

- The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- ANDERSON, T.L. Fracture Mechanics, Fundamentals and Applications, 4th ed. New York: CRC Press, 2017. ISBN-13: 978-1-4987-2813-3.
- self-education online.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 2

1. The subject of the lecture

Elastic and plastic deformation

2. Thematic scope of the lecture

Elastic and plastic deformation are two fundamental concepts in materials science and engineering that profoundly affect material properties and behavior. This lecture will provide a comprehensive exploration of the primary principles, methodologies, and practical applications of elastic and plastic deformation.

The lecture will begin by examining the fundamental concepts of elastic deformation, which is characterized by the material's ability to return to its original shape and dimensions once the applied load is removed. We will discuss the stress and strain analysis of materials under mechanical loads, the significance of the elastic range, and the linear relationship between stress and strain within this range. We will also explore important parameters such as Young's Modulus and Poisson's Ratio and the significance of these parameters in materials science and engineering.

Next, the lecture will delve into the thematic scope of plastic deformation, which is characterized by the material's ability to sustain deformation beyond the elastic range and undergo permanent changes in shape and dimensions. We will explore the primary mechanisms that drive plastic deformation, including dislocation motion and slip, and their significance in analyzing and mitigating plastic deformation failures.

Furthermore, the lecture will discuss laboratory techniques for conducting mechanical tests, including tensile, compression, and bending tests, and their role in simulating real-world conditions. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Additionally, the lecture will cover the various methods for preventing or mitigating plastic deformation failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various techniques for measuring and monitoring materials' mechanical properties, including hardness, toughness, and ductility. We will examine the significance of these techniques in assessing materials' performance under different loading conditions and evaluating the effectiveness of plastic deformation prevention and mitigation strategies.

Overall, this lecture on elastic and plastic deformation will provide students with a comprehensive understanding of the primary principles, methodologies, and practical applications of these concepts. It will equip students with the knowledge and insights necessary to assess, prevent, and mitigate elastic and plastic deformation failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

By the end of the lecture, students will gain a clear understanding of the concept of deformation, recognizing it as the material's response to applied forces or loads. They will distinguish between elastic and plastic deformation, comprehending the key differences and implications of each.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- Hearn, E.J.: Mechanics of Materials 2: The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials, 3rd Edition. Butterworth-Heinemann, 1997.
- self-education online.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 3

1. The subject of the lecture

Brittle and ductile fracture

2. Thematic scope of the lecture

Brittle and ductile fracture are two critical fracture modes that can significantly impact the safety, reliability, and performance of engineering systems. This lecture will provide a comprehensive exploration of the primary mechanisms that drive brittle and ductile fracture.

The lecture will begin by examining the fundamental concepts of brittle fracture, including the mechanisms that drive brittle failure, the factors that influence the rate and direction of brittle fracture, and the significance of stress concentration and fracture toughness in analyzing and mitigating brittle failures.

Next, the lecture will explore the fundamental concepts of ductile fracture, including the mechanisms that drive ductile failure, the factors that influence the rate and direction of ductile fracture, and the significance of ductility and strain hardening in analyzing and mitigating ductile failures.

Furthermore, the lecture will discuss laboratory techniques for conducting fracture mechanics tests, including the use of loading frames, extensometers, and other specialized equipment. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Moreover, the lecture will cover the various methods for preventing or mitigating brittle and ductile fracture, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various techniques for measuring and monitoring fracture toughness and ductility, including Charpy and Izod impact tests, and the significance of these techniques in assessing materials' performance under different loading conditions.

Overall, this lecture on brittle and ductile fracture will provide students with a comprehensive understanding of the mechanisms that drive these fracture modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate brittle and ductile fracture, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students will be able to differentiate between brittle and ductile fracture modes, understanding their fundamental differences and implications. Students will comprehend how material properties, temperature, loading rates, and stress concentrations influence brittle and ductile behavior.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

This lecture format encourages active learning, public speaking, and critical thinking skills. Teachers are available for consultation to support students both in person and online.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- Hearn, E.J.: Mechanics of Materials 2: The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials, 3rd Edition. Butterworth-Heinemann, 1997.

- self-education online.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 4

1. The subject of the lecture

Linear and elastoplastic fracture mechanics

2. Thematic scope of the lecture

Linear and elastoplastic fracture mechanics are two critical fields of study that revolutionized our understanding of how materials respond to external loads and the factors that govern their failure. This lecture will provide a comprehensive exploration of the primary principles, methodologies, and practical applications of these concepts.

The lecture will begin by examining the fundamental concepts of linear fracture mechanics, including the stress and strain analysis of materials under mechanical loads, the significance of the elastic range, and the linear relationship between stress and strain within this range. We will discuss important parameters such as Young's Modulus and Poisson's Ratio and the significance of these parameters in materials science and engineering.

Next, the lecture will delve into the thematic scope of elastoplastic fracture mechanics, which extends the scope of linear fracture mechanics by incorporating the effects of material plasticity. We will explore the primary mechanisms that drive elastic-plastic fracture, including the J-integral and crack-tip opening displacement, and their significance in analyzing and mitigating fracture failures.

Furthermore, the lecture will discuss laboratory techniques for conducting fracture mechanics tests, including the use of loading frames, extensometers, and other specialized equipment. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fracture failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on linear and elastoplastic fracture mechanics will provide students with a comprehensive understanding of the primary principles, methodologies, and practical applications of these concepts. It will equip students with the knowledge and insights necessary to assess, prevent, and mitigate fracture failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should gain a deep understanding of the fundamental principles of fracture mechanics, including concepts like stress intensity factors, fracture toughness, and the behavior of materials under stress. With the knowledge gained, students should be able to make informed decisions about material selection and design to ensure structural integrity and safety in engineering and design projects.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, considering didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- Hearn, E.J.: Mechanics of Materials 2: The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials, 3rd Edition. Butterworth-Heinemann, 1997.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 5

1. The subject of the lecture

Creep failure, impact load failure

2. Thematic scope of the lecture

Creep failure and impact load failure are two significant material failure modes that can significantly impact the safety, reliability, and performance of engineering systems. This lecture will provide a comprehensive exploration of the primary mechanisms that drive creep failure and impact load failure.

The lecture will begin by examining the fundamental concepts of creep failure, including the mechanisms that drive creep deformation, the factors that influence the rate and direction of creep failure, and the significance of strain rate in determining material behavior and strength under impact loads.

Next, the lecture will explore laboratory techniques for conducting creep tests, including constant load and elevated temperature tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of impact load failure and its influence on the failure of materials under impact loads. We will examine the various types of impact load failure, including ductile and brittle failure, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating creep failure and impact load failure, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on creep failure and impact load failure will provide students with a comprehensive understanding of the mechanisms that drive these failure modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate creep failure and impact load failure, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should develop a thorough understanding of the primary mechanisms behind creep deformation, including diffusion-controlled and dislocation creep. Students should be able to explain how stress and temperature interact in determining creep behavior and understand the practical implications of these interactions in engineering applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, considering didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- Kassner, M.E.: Fundamentals of Creep in Metals and Alloys. Elsevier Ltd. All, 2015.
- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 6

1. The subject of the lecture

Fatigue fracture

2. Thematic scope of the lecture

Fatigue fracture is a critical field of study that profoundly affects structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive fatigue fracture, including crack initiation, propagation, and eventual failure.

The lecture will begin by examining the fundamental concepts of fatigue fracture, including the mechanisms that drive crack initiation and propagation, the factors that influence the rate and direction of fatigue crack growth, and the significance of stress intensity factors in analyzing and mitigating fatigue failures.

Next, the lecture will explore laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of crack propagation and its influence on the failure of materials under cyclic loading conditions. We will examine the various types of fracture propagation, including ductile and brittle fracture propagation, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fatigue fracture, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on fatigue fracture will provide students with a comprehensive understanding of the mechanisms that drive fatigue fracture, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating fatigue-related failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate fatigue fracture, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students will gain the ability to estimate a material's endurance limit and its performance in a fatigue environment. Students should have a deep understanding of the fundamental principles and mechanisms of fatigue fracture, including crack initiation, propagation, and final rupture under cyclic loading conditions.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 7

1. The subject of the lecture

Fatigue fracture propagation

2. Thematic scope of the lecture

Fatigue fracture propagation is a critical field of study that profoundly affects structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive fatigue fracture propagation, including crack initiation, propagation, and eventual failure.

The lecture will begin by examining the fundamental concepts of fatigue fracture propagation, including the mechanisms that drive crack initiation and propagation, the factors that influence the rate and direction of fatigue crack growth, and the significance of stress intensity factors in analyzing and mitigating fatigue failures.

Next, the lecture will explore laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of crack propagation and its influence on the failure of materials under cyclic loading conditions. We will examine the various types of fracture propagation, including ductile and brittle fracture propagation, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fatigue fracture propagation, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on fatigue fracture propagation will provide students with a comprehensive understanding of the mechanisms that drive fatigue fracture propagation, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating fatigue-related failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate fatigue fracture propagation, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students will delve into the fundamental stages of fatigue fracture propagation, including the initiation of microcracks and their subsequent growth under cyclic loading. Participants will gain insights into the factors affecting crack growth rates, such as material properties, stress levels, and the impact of stress cycles.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 8

1. The subject of the lecture

Creep and fatigue, thermal fatigue, thermo-mechanical fatigue

2. Thematic scope of the lecture

Creep and fatigue are two fundamental material failure modes that significantly affect structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive creep deformation under constant load and elevated temperatures and the mechanisms that drive fatigue failure, encompassing crack initiation, propagation, and final rupture.

In addition to creep and fatigue, this lecture will also cover thermal fatigue and thermo-mechanical fatigue. Thermal fatigue is a form of fatigue failure that occurs due to thermal cycling, which can cause mechanical stresses and strains in materials. Thermo-mechanical fatigue, on the other hand, is a combination of thermal and mechanical fatigue that occurs when materials are subjected to cyclic thermal and mechanical loads.

The lecture will also discuss the role of stress intensity factors in analyzing and mitigating fatigue failures, emphasizing their significance in understanding and predicting the behavior of materials under cyclic loading conditions. An overview of laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions will also be provided.

Moreover, the lecture will explore the mechanisms that drive creep deformation, including diffusion-controlled and dislocation creep, and the role of strain rate in influencing a material's behavior and strength under impact loads.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating creep and fatigue-related failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on creep and fatigue, thermal fatigue, and thermo-mechanical fatigue will provide students with a comprehensive understanding of the primary mechanisms that drive these failure modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate creep and fatigue-related failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should have a deep understanding of the mechanisms of creep, including diffusion-controlled and dislocation creep, and how materials deform under constant load and elevated temperatures. Students should gain practical skills in conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and be able to interpret the results.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 9

1. The subject of the lecture

Hydrogen-induced degradation

2. Thematic scope of the lecture

Hydrogen-induced degradation is a critical issue in various industries, including oil and gas, chemical, and aerospace. In this lecture, we will explore the thematic scope of this phenomenon, its causes, and the measures that can be taken to prevent or mitigate it.

Hydrogen-induced degradation occurs when hydrogen atoms penetrate the surface of metals, alloys, or polymers, causing them to become brittle and prone to cracking or failure. This can lead to catastrophic consequences, such as pipeline ruptures, equipment failures, or structural collapses.

The causes of hydrogen-induced degradation are numerous and complex. Hydrogen can be introduced into materials through various processes, such as corrosion, electrochemical reactions, or exposure to hydrogen gas. The presence of impurities, such as sulfur or oxygen, can accelerate the diffusion of hydrogen and exacerbate the degradation.

To prevent or mitigate hydrogen-induced degradation, several approaches can be adopted. The selection of materials with high resistance to hydrogen embrittlement is one option. This can include the use of coatings, surface treatments, or alloys with low hydrogen permeability. Another approach is to control the environmental conditions, such as temperature, pressure, or humidity, to minimize exposure to hydrogen.

In addition, monitoring and testing techniques can be used to detect the early signs of hydrogen-induced degradation and assess the risk of failure. These can include non-destructive testing methods, such as ultrasonic or X-ray inspection, or mechanical testing, such as tensile or fatigue testing.

Overall, the thematic scope of hydrogen-induced degradation is broad and encompasses various aspects of materials science, corrosion engineering, and safety management. By understanding the causes and effects of this phenomenon and adopting appropriate measures, we can ensure the reliability and integrity of critical infrastructure and equipment.

3. Learning Outcomes

By diving into the intricacies of hydrogen embrittlement, hydrogen-induced cracking, detection, prevention, and practical applications, participants will gain valuable insights into enhancing the safety, reliability, and performance of materials and structures across diverse industries.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 10

1. The subject of the lecture

Corrosion-induced degradation

2. Thematic scope of the lecture

Corrosion-induced degradation is a critical topic in materials science and engineering. It refers to the gradual deterioration of materials due to chemical reactions with their environment, which can result in significant structural damage and reduced service life. This lecture will explore the various types of corrosion and their effects on materials, as well as the mechanisms and processes behind corrosion-induced degradation.

We will begin by discussing the different types of corrosion, including uniform corrosion, galvanic corrosion, pitting corrosion, and crevice corrosion. Uniform corrosion occurs when the entire surface of a material corrodes at a relatively uniform rate. Galvanic corrosion, on the other hand, occurs when two dissimilar metals come into contact in the presence of an electrolyte, resulting in the more active metal corroding at an accelerated rate. Pitting corrosion is characterized by the localized formation of pits or holes in the metal surface, while crevice corrosion occurs in confined spaces where oxygen and other corrosive agents are limited.

We will also examine the mechanisms and processes behind corrosion-induced degradation, including the electrochemical reactions involved in corrosion and the factors that influence their occurrence. These factors can include environmental conditions, such as temperature, humidity, and pH, as well as the presence of other chemicals or contaminants.

Furthermore, we will discuss the various methods used to prevent or mitigate corrosion-induced degradation, including protective coatings, cathodic protection, and corrosion inhibitors. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of corrosion-induced degradation. They will be able to apply this knowledge to design materials and structures that are resistant to corrosion and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to corrosion-induced degradation.

3. Learning Outcomes

The lecture will provide students with a comprehensive understanding of the mechanisms and effects of corrosion-induced degradation and the methods used to prevent or mitigate these effects. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 11

1. The subject of the lecture

Degradation by adhesion, abrasion, erosion, cavitation

2. Thematic scope of the lecture

Degradation by adhesion, abrasion, erosion, and cavitation is a critical topic in materials science and engineering. These types of degradation can cause significant damage to materials in various applications, including machinery, transportation, and construction. In this lecture, we will explore the mechanisms and processes behind these types of degradation, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of degradation, starting with adhesion. Adhesion occurs when two surfaces come into contact and stick together, causing wear and damage to the surfaces. Abrasion is another type of degradation that occurs when two surfaces rub against each other, resulting in the removal of material from one or both surfaces. Erosion is the gradual loss of material due to the impact of solid particles or fluids, while cavitation is the formation and collapse of bubbles in a fluid, causing damage to nearby surfaces.

We will also examine the physical and chemical processes behind each type of degradation, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved.

Furthermore, we will discuss the various methods used to prevent or mitigate degradation by adhesion, abrasion, erosion, and cavitation, including the use of protective coatings, lubrication, and material selection. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by adhesion, abrasion, erosion, and cavitation. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to degradation by adhesion, abrasion, erosion, and cavitation.

3. Learning Outcomes

Students will have a comprehensive understanding of the mechanisms and effects of degradation by adhesion, abrasion, erosion, and cavitation. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 12

1. The subject of the lecture

Degradation by radiation and energy fields

2. Thematic scope of the lecture

Degradation by radiation and energy fields is a critical topic in materials science and engineering. Materials used in various applications, including nuclear and space exploration, are exposed to high levels of radiation and energy fields that can cause significant damage and degradation. In this lecture, we will explore the mechanisms and processes behind degradation by radiation and energy fields, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of radiation and energy fields, including ionizing radiation, electromagnetic radiation, and particle radiation. These types of radiation and energy fields can cause various types of degradation, such as atomic displacement, chemical changes, and structural damage.

We will also examine the physical and chemical processes behind degradation by radiation and energy fields, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved.

Furthermore, we will discuss the various methods used to prevent or mitigate degradation by radiation and energy fields, including the use of shielding materials, design modifications, and material selection. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by radiation and energy fields. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to degradation by radiation and energy fields.

3. Learning Outcomes

This lecture will provide students with a comprehensive understanding of the mechanisms and effects of degradation by radiation and energy fields, as well as the methods used to prevent or mitigate these effects. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting, particularly in industries such as nuclear and space exploration.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 13

1. The subject of the lecture

Degradation by tearing, liquid metal, and welds

2. Thematic scope of the lecture (abstract, maximum 500 words)

Degradation by tearing, liquid metal, and welds is a critical topic in materials science and engineering. Materials used in various applications, including manufacturing, transportation, and construction, can experience degradation and failure due to these types of degradation. In this lecture, we will explore the mechanisms and processes behind degradation by tearing, liquid metal, and welds, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of degradation, starting with tearing. Tearing is a type of degradation that occurs due to the propagation of cracks in materials, leading to fracture and failure. Liquid metal corrosion occurs when liquid metal comes into contact with a material's surface and causes corrosion, erosion, and cracking. Welding is another type of degradation that can cause material failure due to the formation of defects or cracks in the welded area.

We will also examine the physical and chemical processes behind each type of degradation, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved.

Furthermore, we will discuss the various methods used to prevent or mitigate degradation by tearing, liquid metal, and welds, including the use of protective coatings, material selection, and design modifications. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by tearing, liquid metal, and welds. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions.

3. Learning Outcomes

This lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to degradation by tearing, liquid metal, and welds.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture and Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

The form specification of the lecture:

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Course content – exercises

The semester is structured around 13 distinct topics, each corresponding to different areas of study. Students will have the opportunity to select topics that align with their interests and are relevant to their final thesis work. This approach allows students to delve deeper into subjects that directly contribute to their academic pursuits.

As part of this assignment, students are tasked with preparing and delivering a 20-minute lecture to their classmates. This presentation should provide a comprehensive explanation of the chosen topic, enabling a thorough understanding of the subject matter within the given time frame. This exercise not only fosters in-depth knowledge but also hones the student's presentation and communication skills, an essential aspect of academic and professional growth.

Topics 1

1. The subject of the exercise

Degradation and Limit Conditions

2. Thematic scope of the laboratory classes

The topic of the exercise is related to the lectures:

Materials degradation and limit conditions are vital topics in materials science and engineering, as they play a significant role in designing safe and reliable structures. In this lecture, we will take an in-depth look at these topics and explore the various mechanisms that cause materials to degrade and the conditions that lead to their failure.

We will begin by discussing the different types of material degradation, including corrosion, fatigue, and creep. Corrosion, for example, is a process that results in the gradual deterioration of a material due to chemical reactions to its environment. Fatigue, on the other hand, refers to the progressive weakening of a material due to repeated loading and unloading cycles. Creep is the slow deformation of a material under constant stress.

We will also examine the physical and chemical processes behind each degradation mechanism and the factors that influence their occurrence and rate. These factors can include environmental conditions, loading conditions, material properties, and more.

Moreover, we will delve into the concept of limit conditions in materials. These conditions refer to the point at which a material can no longer perform its intended function due to excessive deformation, stress, or damage. We will investigate the different types of limit conditions, including yield, fracture, and buckling, and the factors that contribute to their occurrence.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms of degradation and limit conditions in materials. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials that can withstand the most extreme environments, from high-temperature applications to high-stress loads.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges.

3. Learning Outcomes

Students should gain a comprehensive understanding of the different types of degradation mechanisms that materials can undergo, as well as the factors influencing these processes.

4. Necessary equipment, materials, etc.

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topics 2

1. The subject of the exercise

Elastic and plastic deformation

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Elastic and plastic deformation are two fundamental concepts in materials science and engineering that profoundly affect material properties and behavior. This lecture will provide a comprehensive exploration of the primary principles, methodologies, and practical applications of elastic and plastic deformation.

The lecture will begin by examining the fundamental concepts of elastic deformation, which is characterized by the material's ability to return to its original shape and dimensions once the applied load is removed. We will discuss the stress and strain analysis of materials under mechanical loads, the significance of the elastic range, and the linear relationship between stress and strain within this range. We will also explore important parameters such as Young's Modulus and Poisson's Ratio and the significance of these parameters in materials science and engineering.

Next, the lecture will delve into the thematic scope of plastic deformation, which is characterized by the material's ability to sustain deformation beyond the elastic range and undergo permanent changes in shape and dimensions. We will explore the primary mechanisms that drive plastic deformation, including dislocation motion and slip, and their significance in analyzing and mitigating plastic deformation failures.

Furthermore, the lecture will discuss laboratory techniques for conducting mechanical tests, including tensile, compression, and bending tests, and their role in simulating real-world conditions. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Additionally, the lecture will cover the various methods for preventing or mitigating plastic deformation failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various techniques for measuring and monitoring materials' mechanical properties, including hardness, toughness, and ductility. We will examine the significance of these techniques in assessing materials' performance under different loading conditions and evaluating the effectiveness of plastic deformation prevention and mitigation strategies.

Overall, this lecture on elastic and plastic deformation will provide students with a comprehensive understanding of the primary principles, methodologies, and practical applications of these concepts. It will equip students with the knowledge and insights necessary to assess, prevent, and mitigate elastic and plastic deformation failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

By the end of the lecture, students will gain a clear understanding of the concept of deformation, recognizing it as the material's response to applied forces or loads. They will distinguish between elastic and plastic deformation, comprehending the key differences and implications of each.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

The form specification of the lecture:

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topics 3

1. The subject of the exercise

Brittle and ductile fracture

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Brittle and ductile fracture are two critical fracture modes that can significantly impact the safety, reliability, and performance of engineering systems. This lecture will provide a comprehensive exploration of the primary mechanisms that drive brittle and ductile fracture.

The lecture will begin by examining the fundamental concepts of brittle fracture, including the mechanisms that drive brittle failure, the factors that influence the rate and direction of brittle fracture, and the significance of stress concentration and fracture toughness in analyzing and mitigating brittle failures.

Next, the lecture will explore the fundamental concepts of ductile fracture, including the mechanisms that drive ductile failure, the factors that influence the rate and direction of ductile fracture, and the significance of ductility and strain hardening in analyzing and mitigating ductile failures. Furthermore, the lecture will discuss laboratory techniques for conducting fracture mechanics tests, including the use of loading frames, extensometers, and other specialized equipment. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Moreover, the lecture will cover the various methods for preventing or mitigating brittle and ductile fracture, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various techniques for measuring and monitoring fracture toughness and ductility, including Charpy and Izod impact tests, and the significance of these techniques in assessing materials' performance under different loading conditions.

Overall, this lecture on brittle and ductile fracture will provide students with a comprehensive understanding of the mechanisms that drive these fracture modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate brittle and ductile fracture, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students will be able to differentiate between brittle and ductile fractures, understanding their fundamental differences and implications. Students will comprehend how material properties, temperature, loading rates, and stress concentrations influence brittle and ductile behavior.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- brittle and ductile fracture specimens for macroscopic observation and explanation

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topics 4

1. The subject of the exercise

Linear and elastoplastic fracture mechanics

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Linear and elastoplastic fracture mechanics are two critical fields of study that revolutionized our understanding of how materials respond to external loads and the factors that govern their failure. This lecture will provide a comprehensive exploration of the primary principles, methodologies, and practical applications of these concepts.

The lecture will begin by examining the fundamental concepts of linear fracture mechanics, including the stress and strain analysis of materials under mechanical loads, the significance of the elastic range, and the linear relationship between stress and strain within this range. We will discuss important parameters such as Young's Modulus and Poisson's Ratio and the significance of these parameters in materials science and engineering.

Next, the lecture will delve into the thematic scope of elastoplastic fracture mechanics, which extends the scope of linear fracture mechanics by incorporating the effects of material plasticity. We will explore the primary mechanisms that drive elastic-plastic fracture, including the J-integral and crack-tip opening displacement, and their significance in analyzing and mitigating fracture failures.

Furthermore, the lecture will discuss laboratory techniques for conducting fracture mechanics tests, including the use of loading frames, extensometers, and other specialized equipment. We will examine the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fracture failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on linear and elastoplastic fracture mechanics will provide students with a comprehensive understanding of the primary principles, methodologies, and practical applications of these concepts. It will equip students with the knowledge and insights necessary to assess, prevent, and mitigate fracture failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should gain a deep understanding of the fundamental principles of fracture mechanics, including concepts like stress intensity factors, fracture toughness, and the behavior of materials under stress. With the knowledge gained, students should be able to make informed decisions about material selection and design to ensure structural integrity and safety in engineering and design projects.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 5

1. The subject of the exercise

Creep failure, impact load failure

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Creep failure and impact load failure are two significant material failure modes that can significantly impact the safety, reliability, and performance of engineering systems. This lecture will provide a comprehensive exploration of the primary mechanisms that drive creep failure and impact load failure.

The lecture will begin by examining the fundamental concepts of creep failure, including the mechanisms that drive creep deformation, the factors that influence the rate and direction of creep failure, and the significance of strain rate in determining material behavior and strength under impact loads.

Next, the lecture will explore laboratory techniques for conducting creep tests, including constant load and elevated temperature tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of impact load failure and its influence on the failure of materials under impact loads. We will examine the various types of impact load failure, including ductile and brittle failure, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating creep failure and impact load failure, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on creep failure and impact load failure will provide students with a comprehensive understanding of the mechanisms that drive these failure modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate creep failure and impact load failure, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should develop a thorough understanding of the primary mechanisms behind creep deformation, including diffusion-controlled and dislocation creep. Students should be able to explain how stress and temperature interact in determining creep behavior and understand the practical implications of these interactions in engineering applications.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 6

1. The subject of the exercise

Fatigue fracture

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Fatigue fracture is a critical field of study that profoundly affects structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive fatigue fracture, including crack initiation, propagation, and eventual failure.

The lecture will begin by examining the fundamental concepts of fatigue fracture, including the mechanisms that drive crack initiation and propagation, the factors that influence the rate and direction of fatigue crack growth, and the significance of stress intensity factors in analyzing and mitigating fatigue failures. Next, the lecture will explore laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of crack propagation and its influence on the failure of materials under cyclic loading conditions. We will examine the various types of fracture propagation, including ductile and brittle fracture propagation, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fatigue fracture, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on fatigue fracture will provide students with a comprehensive understanding of the mechanisms that drive fatigue fracture, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating fatigue-related failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate fatigue fracture, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students will gain the ability to estimate a material's endurance limit and its performance in a fatigue environment. Students should have a deep understanding of the fundamental principles and mechanisms of fatigue fracture, including crack initiation, propagation, and final rupture under cyclic loading conditions.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- samples used for fatigue testing, fatigue surfaces samples

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:
- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 7

1. The subject of the exercise

Fatigue fracture propagation

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Fatigue fracture propagation is a critical field of study that profoundly affects structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive fatigue fracture propagation, including crack initiation, propagation, and eventual failure.

The lecture will begin by examining the fundamental concepts of fatigue fracture propagation, including the mechanisms that drive crack initiation and propagation, the factors that influence the rate and direction of fatigue crack growth, and the significance of stress intensity factors in analyzing and mitigating fatigue failures.

Next, the lecture will explore laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions. We will discuss the advantages and limitations of each testing method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Furthermore, the lecture will cover the significance of crack propagation and its influence on the failure of materials under cyclic loading conditions. We will examine the various types of fracture propagation, including ductile and brittle fracture propagation, and their implications for the design and durability of engineering structures.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating fatigue fracture propagation, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

3. Learning Outcomes

Students will delve into the fundamental stages of fatigue fracture propagation, including the initiation of microcracks and their subsequent growth under cyclic loading. Participants will gain insights into the factors affecting crack growth rates, such as material properties, stress levels, and the impact of stress cycles.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer

- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- samples used for fatigue testing, fatigue surfaces samples

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:
- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 8

1. The subject of the exercise

Creep and fatigue, thermal fatigue, thermo-mechanical fatigue

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Creep and fatigue are two fundamental material failure modes that significantly affect structural integrity and safety. This lecture will provide a comprehensive exploration of the primary mechanisms that drive creep deformation under constant load and elevated temperatures and the mechanisms that drive fatigue failure, encompassing crack initiation, propagation, and final rupture.

In addition to creep and fatigue, this lecture will also cover thermal fatigue and thermo-mechanical fatigue. Thermal fatigue is a form of fatigue failure that occurs due to thermal cycling, which can cause mechanical stresses and strains in materials. Thermo-mechanical fatigue, on the other hand, is a combination of thermal and mechanical fatigue that occurs when materials are subjected to cyclic thermal and mechanical loads.

The lecture will also discuss the role of stress intensity factors in analyzing and mitigating fatigue failures, emphasizing their significance in understanding and predicting the behavior of materials under cyclic loading conditions. An overview of laboratory techniques for conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and their role in simulating real-world conditions will also be provided.

Moreover, the lecture will explore the mechanisms that drive creep deformation, including diffusion-controlled and dislocation creep, and the role of strain rate in influencing a material's behavior and strength under impact loads.

Finally, the lecture will provide an overview of the various methods for preventing or mitigating creep and fatigue-related failures, including material selection, design optimization, and maintenance strategies. We will discuss the advantages and limitations of each method and highlight the importance of selecting the appropriate method based on the specific application and environmental conditions.

Overall, this lecture on creep and fatigue, thermal fatigue, and thermo-mechanical fatigue will provide students with a comprehensive understanding of the primary mechanisms that drive these failure modes, the laboratory techniques for testing and simulating these mechanisms, and the various methods for preventing or mitigating these failures. It will also equip students with the knowledge and insights necessary to assess, prevent, and mitigate creep and fatigue-related failures, ensuring the safety, reliability, and performance of materials and structures in diverse applications.

3. Learning Outcomes

Students should have a deep understanding of the mechanisms of creep, including diffusion-controlled and dislocation creep, and how materials deform under constant load and elevated temperatures. Students should gain practical skills in conducting fatigue tests, including constant amplitude, variable amplitude, and spectrum loading tests, and be able to interpret the results.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

The form specification of the lecture:

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 9

1. The subject of the exercise

Hydrogen-induced degradation

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Hydrogen-induced degradation is a critical issue in various industries, including oil and gas, chemical, and aerospace. In this lecture, we will explore the thematic scope of this phenomenon, its causes, and the measures that can be taken to prevent or mitigate it.

Hydrogen-induced degradation occurs when hydrogen atoms penetrate the surface of metals, alloys, or polymers, causing them to become brittle and prone to cracking or failure. This can lead to catastrophic consequences, such as pipeline ruptures, equipment failures, or structural collapses.

The causes of hydrogen-induced degradation are numerous and complex. Hydrogen can be introduced into materials through various processes, such as corrosion, electrochemical reactions, or exposure to hydrogen gas. The presence of impurities, such as sulfur or oxygen, can accelerate the diffusion of hydrogen and exacerbate the degradation.

To prevent or mitigate hydrogen-induced degradation, several approaches can be adopted. The selection of materials with high resistance to hydrogen embrittlement is one option. This can include the use of coatings, surface treatments, or alloys with low hydrogen permeability. Another approach is to control the environmental conditions, such as temperature, pressure, or humidity, to minimize the exposure to hydrogen.

In addition, monitoring and testing techniques can be used to detect the early signs of hydrogen-induced degradation and assess the risk of failure. These can include non-destructive testing methods, such as ultrasonic or X-ray inspection, or mechanical testing, such as tensile or fatigue testing.

Overall, the thematic scope of hydrogen-induced degradation is broad and encompasses various aspects of materials science, corrosion engineering, and safety management. By understanding the causes and effects of this phenomenon and adopting appropriate measures, we can ensure the reliability and integrity of critical infrastructure and equipment.

3. Learning Outcomes

By diving into the intricacies of hydrogen embrittlement, hydrogen-induced cracking, detection, prevention, and practical applications, participants will gain valuable insights into enhancing the safety, reliability, and performance of materials and structures across diverse industries.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- samples after hydrogen exposure – fracture surfaces

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 10

1. The subject of the exercise

Corrosion-induced degradation

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Corrosion-induced degradation is a critical topic in materials science and engineering. It refers to the gradual deterioration of materials due to chemical reactions with their environment, which can result in significant structural damage and reduced service life. This lecture will explore the various types of corrosion and their effects on materials, as well as the mechanisms and processes behind corrosion-induced degradation.

We will begin by discussing the different types of corrosion, including uniform corrosion, galvanic corrosion, pitting corrosion, and crevice corrosion. Uniform corrosion occurs when the entire surface of a material corrodes at a relatively uniform rate. Galvanic corrosion, on the other hand, occurs when two dissimilar metals come into contact in the presence of an electrolyte, resulting in the more active metal corroding at an accelerated rate. Pitting corrosion is characterized by the localized formation of pits or holes in the metal surface, while crevice corrosion occurs in confined spaces where oxygen and other corrosive agents are limited. We will also examine the mechanisms and processes behind corrosion-induced degradation, including the electrochemical reactions involved in corrosion and the factors that influence their occurrence. These factors can include environmental conditions, such as temperature, humidity, and pH, as well as the presence of other chemicals or contaminants.

Furthermore, we will discuss the various methods used to prevent or mitigate corrosion-induced degradation, including protective coatings, cathodic protection, and corrosion inhibitors. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of corrosion-induced degradation. They will be able to apply this knowledge to design materials and structures that are resistant to corrosion and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to corrosion-induced degradation.

3. Learning Outcomes

The lecture will provide students with a comprehensive understanding of the mechanisms and effects of corrosion-induced degradation and the methods used to prevent or mitigate these effects. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- samples with different type of corrosion degradation

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 11

1. The subject of the exercise

Degradation by adhesion, abrasion, erosion, cavitation

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Degradation by adhesion, abrasion, erosion, and cavitation is a critical topic in materials science and engineering. These types of degradation can cause significant damage to materials in various applications, including machinery, transportation, and construction. In this lecture, we will explore the mechanisms and processes behind these types of degradation, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of degradation, starting with adhesion. Adhesion occurs when two surfaces come into contact and stick together, causing wear and damage to the surfaces. Abrasion is another type of degradation that occurs when two surfaces rub against each other, resulting in the removal of material from one or both surfaces. Erosion is the gradual loss of material due to the impact of solid particles or fluids, while cavitation is the formation and collapse of bubbles in a fluid, causing damage to nearby surfaces.

We will also examine the physical and chemical processes behind each type of degradation, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved.

Furthermore, we will discuss the various methods used to prevent or mitigate degradation by adhesion, abrasion, erosion, and cavitation, including the use of protective coatings, lubrication, and material selection. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by adhesion, abrasion, erosion, and cavitation. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting. Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to degradation by adhesion, abrasion, erosion, and cavitation.

3. Learning Outcomes

Students will have a comprehensive understanding of the mechanisms and effects of degradation by adhesion, abrasion, erosion, and cavitation. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

The form specification of the lecture:

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 12

1. The subject of the exercise

Degradation by radiation and energy fields

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Degradation by radiation and energy fields is a critical topic in materials science and engineering. Materials used in various applications, including nuclear and space exploration, are exposed to high levels of radiation and energy fields that can cause significant damage and degradation. In this lecture, we will explore the mechanisms and processes behind degradation by radiation and energy fields, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of radiation and energy fields, including ionizing radiation, electromagnetic radiation, and particle radiation. These types of radiation and energy fields can cause various types of degradation, such as atomic displacement, chemical changes, and structural damage.

We will also examine the physical and chemical processes behind degradation by radiation and energy fields, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved.

Furthermore, we will discuss the various methods used to prevent or mitigate degradation by radiation and energy fields, including the use of shielding materials, design modifications, and material selection. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by radiation and energy fields. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting.

Overall, this lecture will equip students with the knowledge, tools, and skills necessary to tackle real-world materials science and engineering challenges related to degradation by radiation and energy fields.

3. Learning Outcomes

This lecture will provide students with a comprehensive understanding of the mechanisms and effects of degradation by radiation and energy fields, as well as the methods used to prevent or mitigate these effects. This knowledge will be invaluable in creating new, innovative materials and structures that are safe, reliable, and long-lasting, particularly in industries such as nuclear and space exploration.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint
- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

<u>The form specification of the lecture:</u>

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

Topic 13

1. The subject of the exercise

Degradation by tearing, liquid metal, and welds

2. Thematic scope of the exercise

The topic of the exercise is related to the lectures:

Degradation by tearing, liquid metal, and welds is a critical topic in materials science and engineering. Materials used in various applications, including manufacturing, transportation, and construction, can experience degradation and failure due to these types of degradation. In this lecture, we will explore the mechanisms and processes behind degradation by tearing, liquid metal, and welds, as well as the methods used to prevent or mitigate their effects.

We will begin by discussing the different types of degradation, starting with tearing. Tearing is a type of degradation that occurs due to the propagation of cracks in materials, leading to fracture and failure. Liquid metal corrosion occurs when liquid metal comes into contact with a material's surface and causes corrosion, erosion, and cracking. Welding is another type of degradation that can cause material failure due to the formation of defects or cracks in the welded area.

We will also examine the physical and chemical processes behind each type of degradation, including the factors that influence their occurrence and rate. These factors can include environmental conditions, such as temperature and humidity, as well as the properties of the materials involved. Furthermore, we will discuss the various methods used to prevent or mitigate degradation by tearing, liquid metal, and welds, including the use of protective coatings, material selection, and design modifications. We will explore the advantages and disadvantages of each method and the factors that influence their effectiveness.

By the end of this lecture, students will have a comprehensive understanding of the mechanisms and effects of degradation by tearing, liquid metal, and welds. They will be able to apply this knowledge to design materials and structures that are resistant to degradation and can withstand the intended loads and conditions.

3. Learning Outcomes

By the end of the lecture, students will gain a clear understanding of the concept of deformation, recognizing it as the material's response to applied forces or loads. They will distinguish between elastic and plastic deformation, comprehending the key differences and implications of each.

4. Necessary equipment, materials, etc

- computer with Microsoft PowerPoint

- Internet Connection
- pointer
- recommended readings (Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.)
- samples of different types of weld joints and their defects

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Presentation - Videos and Multimedia.

b. Visual Aids - diagrams, animations.

c. Discussion

d. Guest Lecturers (if possible)

e. Incorporations of Current Research

d. Self-directed learning: Students will be encouraged to engage in self-directed learning by conducting independent research and reading relevant literature on the topic. This will enable them to deepen their understanding of the topic and develop critical thinking skills.

The form specification of the lecture:

The lecture format allows students to take on an active role in their learning, develop their public speaking and critical thinking skills, and contribute to class discussions. The availability of teachers for consultation ensures that students receive the necessary support and guidance, both in person and through online platforms, to succeed in their presentations and further their understanding of materials science concepts.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:
- Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.
- self-education online
- consultation with teachers during consultation times

7. Additional Notes

The topics will be covered in the next two-hour exercise.

8. Optional Information

Any additional information

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

METHODS OF STRUCTURE ANALYSIS

Code: MSA

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1.	**The subject of the lecture**

Sampling methodology – procedure for the preparation of metallographic samples (2 hours)

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

The lecture on Procedure for the preparation of metallographic samples covers the step-by-step process of preparing specimens for microscopic analysis of metal structures. It details the techniques involved in sectioning, mounting, grinding, polishing, and etching metal samples to reveal their microstructural features. The goal is to equip participants with a thorough understanding of the methods essential for accurate metallographic examination and analysis.

3.	**Learning outcomes**

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:
Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6.	**Additional notes**

-

Topics 2

1. The subject of the lecture

Theoretical preparation of metallographic samples (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Theoretical preparation of metallographic samples covers the step-by-step process of preparing specimens for microscopic analysis of metal structures. It details the techniques involved in sectioning, mounting, grinding, polishing, and etching metal samples to reveal their microstructural features. The goal is to equip participants with a thorough understanding of the methods essential for accurate metallographic examination and analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 3

1. The subject of the lecture

Practical preparation of metallographic samples (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Practical preparation of metallographic samples covers the step-by-step process of preparing specimens for microscopic analysis of metal structures. It details the techniques involved in sectioning, mounting, grinding, polishing, and etching metal samples to reveal their microstructural features. The goal is to equip participants with a thorough understanding of the methods essential for accurate metallographic examination and analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 4

1. The subject of the lecture

Methods of sample etching (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Methods of sample etching focuses on elucidating various techniques used to selectively treat material surfaces for microscopic examination. It covers chemical etching methods employed in metallography, revealing microstructural details that aid in material characterization. The objective is to familiarize participants with the principles and applications of sample etching to enhance their understanding of materials and facilitate accurate analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 5

1. The subject of the lecture

Colour contrast in metallography (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Colour contrast in metallography explores the use of coloration techniques to enhance the visibility and differentiation of microstructural features in metallic samples under a microscope. It delves into various staining and tinting methods that highlight specific phases or structures, aiding in the detailed analysis of materials. The goal is to provide insights into how color contrast techniques contribute to a more comprehensive understanding of the microstructure and properties of metals.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 6

1. The subject of the lecture

Light metallographic microscopes (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Light metallographic microscopes addresses the design, features, and applications of optical microscopes specifically tailored for the examination of metallographic samples. It covers topics such as the magnification capabilities, illumination methods, and specialized accessories that contribute to the detailed observation of metallic structures. The goal is to provide a comprehensive understanding of how light metallographic microscopes play a crucial role in the analysis and characterization of materials in metallurgy and related fields.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 7

1. The subject of the lecture

Methodology of structure evaluation (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Methodology of structure evaluation focuses on the systematic approach and techniques employed in assessing the characteristics and properties of materials, particularly in the context of their internal structures. It covers methods such as microscopy, spectroscopy, and other analytical tools to evaluate the composition, morphology, and physical attributes of materials. The goal is to equip participants with a structured methodology for comprehensive structure evaluation, aiding in accurate material characterization and analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 8

1. The subject of the lecture

Metallographic analysis (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Metallographic analysis delves into the systematic examination of the microstructure of metals and alloys using various microscopy and analytical techniques. It covers the preparation of metallographic samples, the interpretation of microstructural features, and the implications for the mechanical and thermal properties of materials. The goal is to provide a comprehensive understanding of how metallographic analysis contributes to material characterization, quality control, and research in metallurgy.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 9

1. The subject of the lecture

Evaluation of structure according to standards (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Evaluation of structure according to standards explores the procedures and criteria outlined in industry or international standards for assessing and characterizing material structures. It covers the application of standardized methods for evaluating features such as grain size, inclusion content, and other microstructural aspects critical for quality control and compliance. The goal is to familiarize participants with the established protocols and benchmarks for structure evaluation, ensuring consistency and reliability in materials analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 10

1. The subject of the lecture

Quantitative metallography (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Quantitative metallography addresses the methods and techniques employed to numerically analyze and measure the microstructural features of metals and alloys. It covers aspects such as grain size, phase fractions, and other quantitative parameters essential for understanding the material's behavior and performance. The goal is to provide participants with the tools and knowledge needed to quantitatively assess and characterize the microstructure of metallic materials for various engineering applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 11

1. The subject of the lecture

Quantitative evaluation of structural parameters (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Quantitative evaluation of structural parameters by coherent test grids explores the application of coherent test grids as a systematic method for quantifying various structural parameters in materials. It covers the use of grid-based techniques to measure features such as grain size, porosity, and phase distribution in a precise and standardized manner. The goal is to provide insights into how coherent test grids contribute to accurate and reproducible quantitative evaluations of material structures for research, quality control, and industrial applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 12

1. The subject of the lecture

Methodology of metallographic report processing (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Methodology of metallographic report processing addresses the systematic approach and techniques involved in compiling and presenting findings from metallographic analyses. It covers the organization of data, inclusion of essential microstructural details, and the interpretation of results to generate comprehensive and meaningful reports. The goal is to equip participants with the skills to effectively communicate metallographic findings, facilitating informed decision-making in research, quality control, and industrial applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Topics 13

1. The subject of the lecture

Preparation of the final metallographic report (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on Preparation of the final metallographic report focuses on the systematic and thorough compilation of detailed findings from metallographic analyses into a comprehensive and organized document. It covers the structuring of the report, inclusion of key microstructural information, and the presentation of results in a clear and understandable format. The goal is to guide participants in producing well-documented and insightful reports that effectively communicate the outcomes of metallographic investigations for research, quality control, and materials characterization.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

6. Additional notes

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Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercises of *Methods of structure analysis* (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the introduction to the laboratory exercises for the subject *Methods of structure analysis*, the evaluation method, exam requirements, etc. The exercise familiarizes participants with the fundamental techniques and procedures used in the analysis of material structures. It provides hands-on experience in preparing samples, employing microscopy, and utilizing various analytical tools essential for understanding the microstructural characteristics of materials. The goal is to establish a practical foundation for participants to apply these methods effectively in subsequent laboratory exercises and real-world applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- computer, data projector,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 2

1. The subject of the laboratory classes

Cutting of metallographic samples (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Cutting of metallographic samples focuses on imparting practical skills related to the initial step of preparing specimens for microscopic analysis. Participants learn techniques for precisely sectioning metal samples, emphasizing the importance of accuracy in obtaining representative cross-sections. The goal is to provide hands-on experience in sample preparation, laying the groundwork for subsequent stages in metallographic analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- cutter,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 3

1. The subject of the laboratory classes

Practical preparation of metallographic samples (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Practical preparation of metallographic samples guides participants through the step-by-step process of sample preparation for microscopic examination. It covers hands-on techniques such as sectioning, mounting, grinding, polishing, and etching, emphasizing the importance of each stage in revealing the microstructure of metal samples. The goal is to equip participants with practical skills essential for accurate and detailed metallographic analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- pressing machine,
- grinder, polisher,
- microscope,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 4

1. The subject of the laboratory classes

Sample etching (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Sample etching immerses participants in the practical application of chemical etching methods to reveal and enhance the microstructural features of metal samples. Participants gain hands-on experience in selecting and applying appropriate etchants, observing how different materials respond to the process. The goal is to familiarize participants with the nuances of sample etching, a crucial step in metallography for accurate material characterization.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- etchants,
- microscope,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 5

1. The subject of the laboratory classes

Working with a microscope (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Working with a microscope provides participants with practical training on the operation and utilization of microscopes for the examination of material structures. It covers essential skills such as adjusting magnification, focusing, and navigating through different microscopy techniques to observe and analyze microstructural details. The goal is to ensure participants are proficient in using microscopes as a fundamental tool in the study of material science and metallography.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 6

1. The subject of the laboratory classes

Analysis of material structure (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Analysis of material structure guides participants through the systematic examination and interpretation of microstructural features in materials using various analytical techniques. It encompasses the application of microscopy, spectroscopy, and other methods to analyze grain boundaries, phases, and defects in order to gain insights into material properties. The goal is to provide hands-on experience in material structure analysis, fostering a practical understanding of how to apply different tools for comprehensive materials characterization.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 7

1. The subject of the laboratory classes

Photo documentation of the analysed structure (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Photo documentation of the analyzed structure instructs participants on the techniques and procedures for capturing detailed images of material structures during analysis. It covers aspects such as lighting, magnification, and framing to ensure accurate and representative documentation of microstructural features. The goal is to enable participants to create comprehensive visual records that aid in the communication and presentation of findings in the field of material science and metallography.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- computer, camera,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 8

1. The subject of the laboratory classes

Working with standards (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Working with standards involves instructing participants on the proper application and adherence to industry or international standards in the context of material analysis. It covers the identification of relevant standards, understanding their specifications, and implementing the prescribed methodologies for accurate and standardized material characterization. The goal is to familiarize participants with the role of standards in ensuring consistency, reliability, and comparability in materials testing and analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- standards, etalons,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 9

1. The subject of the laboratory classes

Evaluation of structure according to standards (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Evaluation of structure according to standards guides participants in applying industry or international standards to assess and characterize material structures systematically. It involves interpreting and implementing the criteria outlined in standards for parameters like grain size, phase distribution, and other microstructural features. The goal is to ensure participants can proficiently evaluate material structures in accordance with established standards, promoting consistency and accuracy in materials analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- standards, etalons,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 10

1. The subject of the laboratory classes

Quantitative metallography (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Quantitative metallography focuses on imparting practical skills related to the numerical analysis and measurement of microstructural features in metals and alloys. Participants learn quantitative techniques such as grain size determination, phase fraction analysis, and other measurements critical for understanding material behavior. The goal is to equip participants with hands-on experience in applying quantitative methods to assess and characterize material structures in various engineering applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- coherent test grids, image analyzer,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 11

1. The subject of the laboratory classes

Quantitative evaluation of structural parameters (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on Quantitative evaluation of structural parameters by coherent test grids and image analysis involves hands-on training in using coherent test grids and image analysis techniques to quantitatively assess various structural parameters in materials. Participants learn to apply systematic grid-based methods for measurements, including grain size, porosity, and other microstructural features. The goal is to provide practical experience in utilizing coherent test grids and image analysis tools for accurate and reproducible quantitative evaluations of material structures in research and industrial settings.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- coherent test grids, image analyzer,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Co-funded by the European Union

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 12

1. The subject of the laboratory classes

Design of a specific application of the analysed material (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on the Design of a specific application of the analyzed material involves participants in the practical application of their material analysis findings to design a tailored solution for a specific engineering or industrial purpose. It encourages the integration of material properties and structural characteristics into the development of functional applications. The goal is to bridge theoretical understanding with real-world applications, fostering a holistic approach to materials science and engineering.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples,
- microscope,
- computer,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 13

1. The subject of the laboratory classes

Defense of the metallographic report (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on the Defense of the metallographic report focuses on guiding participants in presenting and justifying their metallographic analysis findings in a structured and articulate manner. Participants are expected to defend their interpretations, methodologies, and conclusions, demonstrating a thorough understanding of the material studied and the applied analytical techniques. The goal is to enhance communication skills and the ability to convey scientific findings effectively, fostering a deeper comprehension of metallographic analysis and its implications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- computer,
- data projector,

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf

7. Additional notes

Assessment according to the syllabus *Methods of structure analysis*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

FRACTOGRAPHY

Code: FRAC

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Basis and importance of fractography and microfractography; theory of fractures under overload (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Basis and importance of fractography and microfractography; theory of fractures under overload" delves into the principles and significance of studying fractures in materials, emphasizing the role of fractography and microfractography in failure analysis. It covers the theoretical aspects of fractures occurring under overload conditions, exploring the mechanisms and factors influencing the rupture of materials. The goal is to provide a foundational understanding of fracture analysis, enabling participants to interpret and analyze material failures for improved design and reliability in engineering applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 2

1. The subject of the lecture

Classification of fractures according to macroscopic appearance; fractures according to structural features; fractures according to the way of stress (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Classification of fractures according to macroscopic appearance; fractures according to structural features; fractures according to the way of stress" discusses the systematic categorization of fractures based on their visible characteristics, underlying structural features, and the specific stresses that led to their formation. It covers macroscopic classifications, such as transcrystalline and intercrystalline fractures, structural classifications related to features like cleavage and dimples, and stress-related classifications like tensile, compressive, or shear fractures. The goal is to provide participants with a comprehensive framework for identifying and understanding the diverse nature of fractures in materials based on various observable and intrinsic factors.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 3

1. The subject of the lecture

Transit behaviour of materials; methods of study of fracture surfaces; macrofractographic methods (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Transit behavior of materials; methods of study of fracture surfaces; macrofractographic methods" explores how materials respond to various loading conditions during fracture events. It covers methods for studying fracture surfaces, emphasizing macrofractographic techniques that involve examining fractures at a larger scale to identify patterns, features, and characteristics. The goal is to provide insights into the transit behavior of materials under different stress scenarios and equip participants with macrofractographic tools for comprehensive fracture analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Co-funded by the European Union

Topics 4

1. The subject of the lecture

Classification of fractures according to the morphology of fracture surfaces (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Classification of fractures according to the morphology of fracture surfaces" delves into the systematic categorization of fractures based on the visual characteristics of their surfaces. It covers various morphological features such as cleavage, river patterns, and hackles, providing a framework for understanding and identifying different fracture types. The goal is to enhance participants' ability to analyze and interpret fractures by recognizing specific surface morphologies, contributing to a deeper understanding of material failure mechanisms.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 5

1. The subject of the lecture

Formation and propagation of cracks; micromechanisms of failure (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Formation and propagation of cracks; micromechanisms of failure" explores the mechanisms behind the initiation and growth of cracks in materials, focusing on the microscopic processes involved in failure. It covers the factors influencing crack formation, propagation, and the micromechanical aspects leading to material failure. The goal is to provide a comprehensive understanding of the intricacies of crack development and failure at the microscale, aiding in the analysis and prevention of material fractures.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 6

1. The subject of the lecture

Use of optical and electron microscopy in fractography (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on the "Use of optical and electron microscopy in fractography" explores the application of advanced microscopic techniques to analyze and characterize fracture surfaces in materials. It covers the advantages and limitations of both optical and electron microscopy, highlighting their respective roles in providing detailed insights into fracture mechanisms at different length scales. The goal is to equip participants with a comprehensive understanding of how these microscopy tools contribute to enhanced fractographic analysis for improved material failure investigations.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 7

1. The subject of the lecture

Microfractographic analysis; classification and morphological features (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Microfractographic analysis; classification and morphological features" focuses on the microscopic examination and categorization of fracture surfaces in materials. It covers the classification of fractures based on intricate morphological features observed at the microscale, providing participants with tools to identify specific characteristics indicative of different failure mechanisms. The goal is to enhance participants' proficiency in microfractographic analysis, allowing for a detailed understanding of material fractures and contributing to improved failure diagnosis and prevention strategies.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Topics 8

1. The subject of the lecture

Microfractography of fractures in heterogeneous systems; ways of description and interpretation of morphology of fracture surface (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Microfractography of fractures in heterogeneous systems; ways of description and interpretation of morphology of fracture surface" explores the microscopic analysis of fractures in materials with complex, heterogeneous structures. It covers various ways to describe and interpret the morphology of fracture surfaces in such systems, considering the interactions between different phases and constituents. The goal is to provide participants with insights and methodologies for effectively characterizing and understanding fractures in materials with diverse compositions and microstructures.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

6. Additional notes

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Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercises of *Fractography* (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the exercise is to acquaint students with the introduction to the laboratory exercises for the subject Fractography, the evaluation method, exam requirements etc. The exercise on "Introduction to the laboratory exercises of fractography" aims to familiarize participants with the fundamental principles and techniques involved in the microscopic analysis of fracture surfaces. It provides an overview of the equipment, methodologies, and safety protocols essential for conducting fractographic investigations in a laboratory setting.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- computer, data projector

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Co-funded by the European Union

Topics 2

1. The subject of the laboratory classes

Practical preparation of metallographic samples (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on the "Practical preparation of metallographic samples" focuses on hands-on training in the systematic and essential steps of preparing specimens for microscopic analysis. Participants learn the techniques of sectioning, mounting, grinding, polishing, and etching to reveal the microstructure of metal samples. The goal is to provide practical skills that are crucial for accurate and detailed metallographic analysis in research and industrial applications.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, cutter, pressing machine, grinder, polisher, etchants, microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 3

1. The subject of the laboratory classes

Working with an optical and electron microscope (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Working with an optical and electron microscope" provides participants with practical training on the operation and utilization of both optical and electron microscopes for detailed material analysis. Participants learn to navigate and manipulate these advanced microscopy tools, gaining hands-on experience in capturing high-resolution images of material structures. The goal is to ensure proficiency in using different types of microscopes, enabling participants to explore and analyze materials at various scales.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, optical and electron microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 4

1. The subject of the laboratory classes

Structural analysis of material (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Structural analysis of material" involves participants in hands-on activities related to the systematic examination and characterization of material structures using various analytical techniques. It covers the practical application of microscopy, spectroscopy, and other methods to study the composition, morphology, and microstructural features of materials. The goal is to provide participants with practical skills in structural analysis, fostering a deeper understanding of material properties and behavior.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, optical microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 5

1. The subject of the laboratory classes

Photo documentation of the analysed structure (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Photo documentation of the analyzed structure" guides participants in capturing detailed images of material structures during analysis. It covers techniques for effective photo documentation, emphasizing proper lighting, magnification, and framing to ensure accurate representation of microstructural features. The goal is to equip participants with the skills to create comprehensive visual records that support the communication and presentation of findings in the field of material science and analysis.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, optical microscope, computer, camera

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 6

1. The subject of the laboratory classes

Microfractographic analysis of material (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Microfractographic analysis of material" involves participants in hands-on activities related to the microscopic examination and categorization of fracture surfaces. It covers the identification and interpretation of various morphological features observed at the microscale to understand the mechanisms of material failure. The goal is to enhance participants' proficiency in microfractographic analysis, enabling them to effectively diagnose and interpret fractures in materials.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, electron microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 7

1. The subject of the laboratory classes

Description and interpretation of micromechanisms of failure (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Description and interpretation of micromechanisms of failure" focuses on providing participants with practical skills in analyzing and understanding the microscopic mechanisms leading to material failure. It involves hands-on activities related to the observation and interpretation of micromechanical features, such as crack initiation and propagation, under various loading conditions. The goal is to enhance participants' ability to describe and interpret the intricate processes at the microscale that contribute to material failure.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- samples, electron microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 8

1. The subject of the laboratory classes

Defense of the fractographic report (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The exercise on "Defense of the fractographic report" involves participants presenting and justifying their findings and conclusions derived from fractographic analysis. It focuses on honing participants' ability to articulate their interpretations, methodologies, and insights related to material fractures, fostering a deeper understanding of failure analysis. The goal is to enhance communication skills and facilitate a thorough defense of the fractographic report through effective and informed discussion.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- computer, data projector

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002. / González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

7. Additional notes

Assessment according to the syllabus *Fractography*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

DYNAMIC STRENGTH AND FATIGUE LIFE

Code: DSFL

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction. Systemization of limit states of materials.

2. Thematic scope of the lecture (abstract, maximum 500 words)

In the introductory part of the lecture we will approach the topic "Systemization of limit states of materials". We emphasize the importance of a systematic approach in the study of materials and their properties. The basic principles of materials engineering will be further developed with a reminder of the key properties of materials and their importance in the context of limit state analysis.

In the main section, we will explore the limit states of materials themselves in more detail. This section will focus on elastic and plastic deformation, shape and volume permanent deformation, as well as the stiffness and brittleness properties of materials. We will then look at the mechanical properties of materials and their relationship to the design and manufacture of materials with respect to limit states, including the effect of temperature.

In the section on analytical methods for studying limit states, we will discuss mathematical models of material deformation and the importance of experimental methods in limit state analysis.

The overall goal of the lecture is to provide students with a comprehensive view of the topic and to encourage them to develop a systematic and deeper understanding of the limit states of materials.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Kulak, G.L. et. al.(2011). Limit States Design in Structural Steel. COPYRIGHT, ISBN 978-0-88811-157-9.

Weichert, D., Ponter, A.,(2009). Limit States of Materials and Structrures, Springer Science+Business Media B.V., ISBN: 978-1-4020-9633-4.

6. Additional notes

NO

Topics 2

1. The subject of the lecture

Energeric criteria of fracture formation. Dimensioning and basic fatigue properties of parts in fracture initiation and propagation.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture will explore the topic "Energy criteria for fracture initiation, sizing and basic fatigue properties of parts in fracture initiation and propagation". We will begin with an introductory look at the energy criteria associated with fracture initiation of materials and emphasize their importance in the strength assessment process of materials.

Next, we will look at the sizing of materials and its importance in fracture prevention. We will explain the sizing process and analyze its effect on the strength and fracture resistance of materials.

In the section on fatigue properties of materials, we will look at the definition and importance of these properties. The process of fatigue-related failure initiation and propagation in materials will be investigated, especially in an energetic context.

We will conclude the talk by evaluating the importance of energy criteria and fatigue properties in engineering applications and suggest perspectives for further research in the area of fracture initiation in materials. The overall goal is to provide students with an in-depth and comprehensive view of the energetic aspects of materials fracture and related fatigue properties.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Sih, G., C. (1991). Mechanics of Fracture Initiation and Propagation: Surface and volume energy applied as failure criterion. Springer Science+Business Media B.V., ISBN 978-94-010-5660-1.

Krupp, U. (2007). Fatigue Crack Propagation in Metals and Alloys: Microstructural Aspects and Modelling Concepts. Wiley-VCH Verlag GmbH & Co. KGaA, ISBN:9783527315376.

Anderson, T., L. (2017). Fracture Mechanics: Fundamentals and Applications, Fourth Edition, Taylor & Francis Group LLC. ISBN 978-1-4987-2813-3.

6. Additional notes

NO

Topics 3

1. The subject of the lecture

Impact damage

2. Thematic scope of the lecture (abstract, maximum 500 words)

At the beginning of the lecture, we will define and explain the meaning of impact failure in the broader context of materials engineering. We will also identify the main factors that influence impact failure.

Next, we will analyze the different mechanisms that are responsible for the failure of materials due to impact loads. We will try to understand the microstructure and macrostructure of materials after their failure.

We will discuss the significant role of material strength, plasticity and toughness in evaluating the ability of a material to resist impact failure. We also examine how different materials respond to impact loading.

At the end of the talk, we will summarize the importance of impact failure in current engineering applications and suggest directions for future research in impact failure and potential innovations in materials engineering.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

ASM Handbook, Volume 11, *Failure Analysis and Prevention 2002*. ISBN 0-87170-704-7, 2909 p.

6. Additional notes

NO

Topics 4

1. The subject of the lecture

Transition of material from a tough to a brittle state

2. Thematic scope of the lecture (abstract, maximum 500 words)

At the beginning of the lecture, we will review the topic "Material Transition from a Tough to a Brittle State". We will go through what this transition means in the context of materials and why it is important to their behavior.

In this section, we will define toughness and brittleness as key properties of materials. We will explain how they manifest at the micro-level and how they affect the overall resistance of a material to deformation processes.

We analyze the various factors that can affect the transition of a material from a tough to a brittle state. These factors can include temperature, loading rate, and other circumstances that can affect the material's mechanical properties.

In this part of the lecture, we will look at the theoretical models used to describe a material's transition from a ductile to a brittle state. We will discuss the mathematical relationships and concepts that help explain this transition.

We will conclude the lecture by reviewing the importance of understanding the transition of a material from a ductile to a brittle state in the broader context of materials engineering. We will highlight the implications of this transition on the design of materials and their use in various industries.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Menard Kevin P., Menard Noah. (2020). Dynamic Mechanical Analysis. Taylor & Francis Group, LLC. ISBN 978-148-225-515.

Kobayashi, T. (2004). Strength and Toughness of Materials., Springer-Verlag Tokyo. ISBN 4-431-20038-X.

6. Additional notes

NO

Topics 5

1. The subject of the lecture

Characteristics of variable loads.

2. Thematic scope of the lecture (abstract, maximum 500 words)

We will begin the lecture by defining and discussing the importance of variable loading in materials engineering. We will explain why studying material responses to time-varying loads is important.

We will subject ourselves to the characteristics of variable loading, including factors such as frequency, amplitude, and format of loading cycles. Their role in influencing the mechanical properties of materials will be discussed.

Different variable loading types such as fatigue, cyclic, and impulse loading will be identified. Each type will be analyzed in its context and impact on materials.

We will conclude the talk by evaluating the importance of characterizing variable loading and suggest directions for future research in this area. We will highlight trends that may influence future developments in materials engineering related to variable loading.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Kappos, A. (2002). Dynamic Loading and Design of Structures. Spon Press. Taylor & Francis Group. ISBN 0-419-22930-2.

6. Additional notes

NO

Topics 6

1. The subject of the lecture

Material fatigue under simple and complex stresses.

2. Thematic scope of the lecture (abstract, maximum 500 words)

We begin by defining material fatigue and highlighting its importance in engineering applications. We will explain the concept of simple and complex stresses and their effects on materials.

We will take a detailed look at the fatigue mechanisms of materials under simple stress. We discuss cyclic load variations and their effect on the deformation properties of the material.

We will review complex forms of stress, including cyclic loading. We will identify the significant factors that affect the fatigue life of materials under complex conditions.

We discuss experimental methods for evaluating material fatigue and the models used to predict material fatigue life under simple and complex loading.

We analyze the effect of a material's microstructure on its resistance to fatigue failure. We discuss the role of dislocations, defects and microcracks in the fatigue process.

We will review preventive measures and engineering solutions to increase the resistance of materials to fatigue failures. We will focus on optimizing design and materials to minimize fatigue damage.

In the conclusion of the talk, we will review the importance of understanding material fatigue under simple and complex stresses. We will suggest directions for future research, highlighting issues that may be key to future developments in materials engineering related to material fatigue.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

<u>At this point, we also specify the form of conducting classes, i.e.</u>

- The main topic will be continued for two more classes.

In the first week, issues related to simple stresses.

In the second week, issues related to complex stresses.

Students will learn about examples of practical applications and case studies where material fatigue is a critical factor. We will consider industries such as aerospace, automotive, and others where material fatigue is becoming a significant engineering issue.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Suresh Subra, (1998). Fatigue of Materials. Press Syndicate of University of Cambridge. ISBN 0-521-57046-8.

Schijve, J. (2008). Fatigue Crack Growth. Analysis and Predictions. Springer Dordrecht. ISBN 978-1-4020-6807-2.

6. Additional notes

NO

Topics 7

1. The subject of the lecture

Changes in the structure and properties of materials caused by cyclic loading.

2. Thematic scope of the lecture (abstract, maximum 500 words)

Introduction to the issue of changes in the structure and properties of materials due to cyclic loading. We will explain why these changes are critical and how they affect the behaviour of materials.

We examine in detail the microstructural changes of materials after repeated loading cycles. We analyze dislocations, defects and other microstructural aspects that result from this process.

We discuss the effect of structural changes on the mechanical properties of materials, including strength, plasticity, and toughness. We will focus on how cyclic loading affects the resistance of materials to deformation processes.

We will discuss the relationship between structure changes and materials‘ durability. We identify critical points where accelerated wear and failure occur due to cyclic loading.

We show examples of engineering applications where changes in structure are critical. We will focus on procedures and strategies for designing materials to minimize the adverse effects of cyclic loading.

In the talk’s conclusion, we will evaluate the importance of understanding the changes in structure and properties of materials due to cyclic loading. We will suggest future research directions and highlight potential materials engineering innovations related to this phenomenon.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Halford, G. R. (2006). Fatigue and Durability of Structural Materials. ASM International. ISBN 0-87170-825-6.

M. Klesnil, P. Lukác. (2017). Fatigue of Metallic Materials. John Wiley & Sons Ltd. ISBN 978-111-918-0807.

6. Additional notes

NO

Topics 8

1. The subject of the lecture

Fatigue life and criteria for its assessment.

2. Thematic scope of the lecture (abstract, maximum 500 words)

At the beginning of the lecture, we will define fatigue life and explain its importance in the field of materials engineering. We will emphasize that fatigue life characterizes the resistance of a material to cyclic loading and is of key importance for the safety and reliability of structures and components.

We will discuss the basic fatigue mechanisms such as cyclic loading, crack formation, crack propagation, and ultimate material failure. We will focus on the micro- and macro-level processes that affect fatigue life.

We will identify various factors that affect the fatigue life of materials, including structure geometry, temperature, loading frequency, and material properties. We discuss how these factors affect the rate of crack initiation and the overall fatigue life of the material.

We will undergo a variety of experimental methods for evaluating fatigue life, including fatigue tests, fatigue life tests, and crack propagation analyses. We will emphasize their importance in determining material behavior under cyclic conditions.

In the conclusion of the talk, we will review the current state of research in the field of fatigue life and propose directions for future studies and developments. We will emphasize the importance of continuous development in this area for optimizing the performance of materials under highly stressed conditions.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

<u>At this point, we also specify the form of conducting classes, i.e.</u>

- The main topic will be continued for two more classes.

In the first week, issues related to the basic fatigue mechanisms such as cyclic loading, crack formation, crack propagation, and ultimate material failure.

In the second week, issues related to experimental methods for evaluating fatigue life, including fatigue tests, fatigue life tests, and crack propagation analyses.

Students will learn about examples of practical applications of fatigue life concepts in various industries.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Dieter Radaj, Michael Vormwald. (2013). Advanced Methods of Fatigue Assessment. Springer Heidelberg New York Dordrecht London. ISBN 978-3-642-30740-9.

Subra Suresh. (1998). Fatigue of Materials. Cambridge University Press. ISBN 0-521-57046-8.

6. Additional notes

NO

Topics 9

1. The subject of the lecture

Influence of factors on the fatigue resistance of materials

2. Thematic scope of the lecture (abstract, maximum 500 words)

At the beginning of the lecture, we will introduce the topic and explain the importance of understanding the factors that affect the fatigue resistance of materials. We will look at how different influences can determine the service life of a material under cyclic loading.

We will discuss material factors that include chemical composition, microstructure, and thermal properties. We discuss how these factors affect fatigue resistance and their importance in the design of materials for specific applications.

We will focus on design factors such as structure geometry, surface finish, and material forming. We will explain how these aspects can affect the stress concentration and therefore the fatigue resistance of the material.

Discuss the effect of environmental factors such as temperature, humidity and chemical environment on the fatigue resistance of materials. We identify how these factors can cause corrosion, oxidation, and other degradation processes.

We examine load factors, including frequency, amplitude, and type of load. We will explain how different loading conditions can affect the fatigue resistance of a material and contribute to its degradation.

We will examine the influence of microstructure and macrostructure on fatigue resistance. We analyze how dislocations, grain size, and other micro- and macro-level aspects of a material can affect its behavior under cyclic conditions.

We demonstrate various experimental methods that are used to evaluate the effects of factors on fatigue resistance. We will include fatigue tests, environmental simulations, and other methods that help understand the complex interactions between factors.

We will provide examples of real-world applications where it is important to consider the effects of factors on fatigue resistance. We will show how engineers take these factors into account when designing reliable and durable structures and components.

We will conclude the talk by assessing the overall importance of understanding the effects of factors on the fatigue resistance of materials. We will suggest directions for further research and highlight perspectives in the field of optimization of materials and structures with respect to cyclic loading.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Gary R. Halford. (2006). Fatigue and Durability of Structural Materials. ASM International. ISBN 0-87107-825-6.

Forrest P. G. (1962). Fatigue of Metals. Pergamon Press. ISBN 62-19278.

6. Additional notes

NO

Topics 10

1. The subject of the lecture

Calculations of reliability and fatigue life.

2. Thematic scope of the lecture (abstract, maximum 500 words)

At the beginning of the lecture we will focus on why reliability is a key aspect in the design of structures and materials. We discuss how reliability analyses allow for the assessment of failure probabilities under different conditions.

We review theoretical reliability models that are used to evaluate the performance of materials and structures.

We will discuss fatigue life calculations and methods for predicting the fatigue life of materials under cyclic loading.

We will review the various factors that affect the reliability and fatigue life of materials. We will include material properties, design parameters, environmental and loading factors, and analyze how these factors affect the results of reliability calculations.

We discuss the tools and software applications that are available for reliability and fatigue life calculations. We will focus on modern technologies and programs that facilitate engineers to analyze and design materials with reliability in mind.

We will conclude the talk with a review of current trends in reliability and fatigue life calculations. We will suggest possible directions for future research and highlight areas where improvements and innovations can be made.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

J.J. Xiong, R.A. Shenoi. (2011). Fatigue and Fracture Reliability Engineering. Springer Science+Busoness Media. ISBN 978-0-85729-217-9.

6. Additional notes

NO

Topics 11

1. The subject of the lecture

Recommendations for the design of cyclically and dynamically stressed components.

2. Thematic scope of the lecture (abstract, maximum 500 words)

We begin the lecture with an introductory overview of the challenges and importance of designing components subjected to cyclic and dynamic stresses. We will explain how such components can be subjected to a variety of loading conditions during their service life.

We will review methods of analyzing cyclic loads in component design. We will explain how to identify critical points where fatigue failures can occur and how to model load cycles for accurate assessment properly.

We discuss recommendations for material selection in the design of components under dynamic loading. We include material properties that are key to cyclic loading and highlight how these properties affect component life.

We will cover the geographic design and construction of components with respect to cyclic loading. We analyze how different geometric forms and design features affect stress concentrations and thus the component's resistance to fatigue failure.

We discuss strategies for improving the reliability of components subjected to cyclic and dynamic loads. We will cover factors such as proper material selection, geometry optimization, and design changes that can lead to longer component life.

We will conclude the lecture by reviewing current trends and innovations in designing cyclically and dynamically stressed components. We will discuss new technologies, materials and approaches influencing the direction in this design area.

3. Learning outcomes

Students can use knowledge and information from lectures, literature, and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to Systemization of limit states of materials.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Xibing Li, et. al. (2008). Innovative testing technique of rock subjected to coupled static and dynamic loads. International Journal of Rock Mechanics and Mining Sciences. ISSN 1365-1609.

6. Additional notes

NO

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercise - instruction on laboratory order and workplace safety. Introduction to the concept of limit states of structures.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Introductory exercise where students will be familiar with the program of laboratory exercises for the whole semester. The teacher familiarizes the students with the course of the exercises (at the beginning of each exercise there is a repetition of theoretical knowledge from the issues solved in a specific exercise, a check of the assigned homework and the preparation of the laboratory work according to the teacher's instructions). Students are also familiar with the method of evaluating laboratory exercises and the necessary conditions for successful completion of laboratory exercises (obligatory participation in exercises, submission of all laboratory work and successful completion of tests). In the exercises, students should be introduced to the concept of limit states of structures, which includes definitions of key terms, analysis of different loads, calculation methods, and standards .

3. Learning outcomes

Students know what to do to pass successfully complete the laboratory exercises in this subject. After completing the exercise on limit states of structures, students should have a basic understanding of the concept, the ability to apply the analysis to simple examples, knowledge of the prescriptive requirements, and the ability to solve real-world problems.

4. Necessary equipment, materials, etc

Case studies references supplied by the teacher.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics))

Students are expected to read below texts related to the lecture:

Kulak, G.L. et. al.(2011). Limit States Design in Structural Steel. COPYRIGHT, ISBN 978-0-88811-157-9.

Weichert, D., Ponter, A.,(2009). Limit States of Materials and Structrures, Springer Science+Business Media B.V., ISBN: 978-1-4020-9633-4.

- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Low cycle fatigue - fatigue life curve under load in controlled amplitude strain mode.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The low-cycle fatigue exercises, with emphasis on the fatigue life curve under load in the controlled strain amplitude regime, would involve students in theoretical inputs, laboratory examples, and numerical simulations. The topic would include identification of key variables, analysis of experimental data, and discussion of practical examples from industry. The goal would be to provide students with a comprehensive understanding of low-cycle fatigue and the ability to apply this knowledge to solve real-world problems in materials engineering.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related of this topic. Students are able to work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- ASM Handbook, Volume 8, *Mechanical Testing and Evaluation 2000*. ISBN 0-87170-389-0, 2235 p.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

High cycle fatigue - fatigue life curves and Smith diagram under load in controlled stress amplitude mode.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Exercises in high-cycle fatigue with emphasis on fatigue life curves and Smith diagrams under controlled stress amplitude loading would include a theoretical introduction, identification of important variables, and laboratory experiments. Students would become familiar with the Smith diagram and numerical simulations, analyze the effect of stress amplitude on fatigue characteristics, and discuss the results. They would also look at applications in industry and evaluate the knowledge gained, thus gaining a practical understanding of high-cycle fatigue concepts.

3. Learning outcomes

Exercises on high-cycle fatigue, focusing on fatigue life curves and Smith diagrams, should provide students with a deep theoretical understanding and practical experience in the field of high-cycle fatigue of materials. It is expected that students will be able to analyse the effect of stress amplitude on fatigue properties, work effectively with tools such as the Smith diagram, and apply the knowledge gained in practice in the design and analysis of materials. As a result, students should be able to critically evaluate experimental results, discuss their applications in real-world situations, and lay the groundwork for possible future research in the field.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Mechanical Engineers' Handbook, Volume 2: Design, Instrumentation, and Controls, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112830, Publisher: Wiley, 982 pages.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Ultra-high cycle fatigue - fatigue life curve and Smith diagram under load in controlled voltage amplitude mode.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

An exercise on ultra-high cycle fatigue, with emphasis on fatigue life curves and the Smith diagram, would begin with an introduction to this specific area of materials engineering. Students would identify the key variables affecting ultra-high cycle fatigue and then engage in laboratory experiments and numerical simulations using the Smith Diagram. Results would be discussed, with emphasis on the effect of controlled stress amplitude on the fatigue properties of materials. The exercise would also include an analysis of industrial applications, with emphasis on aerospace, power generation and automotive. Students would participate in group discussion and critical evaluation of the knowledge gained, opening the way to identify areas for further research in ultra-high cycle fatigue. The assessment would include a discussion of the importance and perspectives in this specific area of materials engineering.

3. Learning outcomes

An exercise on ultra-high cycle fatigue should result in a deep understanding of students of this specific area of materials engineering. Students should gain hands-on experience with laboratory experiments and numerical simulations specific to ultra-high cycle fatigue. Discussions of results and applications in industry should foster critical thinking and the ability to apply the knowledge gained in real-world scenarios. This exercise should also stimulate interest in possible directions for further research in the area of ultrahigh-cycle fatigue and controlled stress amplitude.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:

Menard Kevin P., Menard Noah. (2020). Dynamic Mechanical Analysis. Taylor & Francis Group, LLC. ISBN 978-148-225-515.

Kobayashi, T. (2004). Strength and Toughness of Materials., Springer-Verlag Tokyo. ISBN 4-431-20038-X.

Students should prepare a theoretical introduction to the laboratories.

7.	**Additional notes**

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8.	**Optional information**

NO

Topics 5

1. The subject of the laboratory classes

Fracture mechanics - determination of fracture toughness.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Students would focus on material characterization, learning about standardized tests such as Charpy or Izod and their practical implementation. Numerical methods to predict fracture toughness would be another important aspect, along with a discussion of the influence of various factors on the mechanical properties of the material.

Exercises would include applications in industry and examination of real examples. Students would perform tests to determine fracture toughness under the supervision of the instructor. Group discussion would cover the experience of the laboratory exercises, numerical simulations and their practical applications in industries.

3. Learning outcomes

An exercise focusing on the determination of fracture toughness of materials will result in students gaining a comprehensive understanding of the mechanical properties of materials and methods for determining their resistance to fracture. Practical implementation of standardized tests and numerical simulations will provide students with real-world experience and skills in the evaluation of fracture toughness.

The exercise will also have the benefit of highlighting the importance of fracture toughness in the design of structures in industrial sectors, which in turn has a consequent impact on the safety and reliability of structures. This exercise will provide students with the skills and knowledge required to be successful in the field of materials engineering and mechanics.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:

Kappos, A. (2002). Dynamic Loading and Design of Structures. Spon Press. Taylor & Francis Group. ISBN 0-419-22930-2.

Students should prepare a theoretical introduction to the laboratories.

7.	**Additional notes**

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8.	**Optional information**

NO

Topics 6

1. The subject of the laboratory classes

Fatigue crack propagation - fatigue crack propagation speed curve + determination of fatigue crack propagation speed based on fractographic analysis.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Students perform experiments on model materials to measure the fatigue crack propagation rate and then participate in numerical simulations to compare with experimental results.

The next part of the exercise involves fractographic analysis, where students learn to determine the fatigue crack propagation velocity using fractographic analysis. Discussion then takes place on the results obtained, their interpretation and practical applications in industry. Students have the opportunity to actively participate in the determination of fatigue crack propagation speed on real specimens. The aim is to provide students not only with theoretical knowledge, but also with practical experience and skills that are crucial in evaluating and predicting the fatigue behaviour of materials.

3. Learning outcomes

The exercise provides students with a comprehensive understanding of fatigue crack dynamics and methods for determining crack propagation rates. Experimental and numerical tests, together with fractographic analysis, allow the practical application of theoretical knowledge in real situations.

Students acquire skills in the measurement and interpretation of fatigue crack propagation velocity, which has important applications in the field of materials engineering. The determination of fatigue crack propagation speed based on fractographic analysis provides additional insights into material behaviour under load and has the potential to improve the prediction and evaluation of fatigue properties. Overall, the exercise allows students to apply the knowledge gained in real experiments and hone their data analysis and interpretation skills, enhancing their readiness for future engineering challenges in the field of fatigue of materials.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Kappos, A. (2002). Dynamic Loading and Design of Structures. Spon Press. Taylor & Francis Group. ISBN 0-419-22930-2.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

8. Optional information

NO

Topics 7

1. The subject of the laboratory classes

Excursion in production factories

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The professional excursion in the production company is focused on the subject area. The manufacturing companies are from various areas of engineering production (within the Slovak Republic or the Czech Republic) and have an interesting production program . The mentioned excursion is mandatory for full-time students of the subject Dynamic strength and fatigue life.

3. Learning outcomes

A field trip to a manufacturing plant associated with the course "Dynamic Strength and Fatigue Life" could have significant educational benefits for students. Participants would be able to see the application of their theoretical knowledge in a real industrial setting, gaining an insight into the manufacturing processes and environments in which dynamic strength and fatigue properties of materials are studied and applied.

This internship would allow students to encounter modern technologies and methods in industry, discuss with specialists in the field, and gain valuable insights for their professional careers. In addition, they would be able to gain practical skills and experience directly in a real production environment, which is invaluable for their professional development.

The field trip could serve as inspiration for future research and projects, encouraging students to find innovative solutions in the field of force dynamics and fatigue of materials. Overall, this experience could strengthen the link between theory and practice and contribute to the development of students as future professionals in the field of materials engineering.

4. Necessary equipment, materials, etc

NO

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

NO

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

NO

7. Additional notes

- ASSESSMENT – The excursion is obligatory for students and they get points to classification from excursion.

8. Optional information

NO

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

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SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

MATERIALS TECHNOLOGIES

Code: MT

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction. Material technologies - basic concepts, features, division.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The first lecture will focus on the basic concepts and importance of materials technology in contemporary engineering and manufacturing. Different types of materials including metals, polymers, ceramics and composites will be discussed, and new and advanced materials such as nanomaterials and smart materials will be highlighted. In addition, we will explore different methods of manufacturing materials, ranging from classical to advanced technologies. The lecture will also cover the selection of materials for specific applications in industries such as construction, electronics, and automotive.We will also look into the future of materials technology, include trends in materials research and development, and discuss potential innovations and challenges.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Groover, M., P. (2020). Fundamentals of modern manufacturing: materials, processes, and systems. John Wiley & Sons, Inc., ISBN 978-0470-467002

Prasad, N., E. (2017). Aerospace Materials and Material Technologies. Springer Science+Buisiness Media Singapore. ISBN 978-981-10-2133-6

6. Additional notes

No

Topics 2

1.	**The subject of the lecture**

Slow solidification - controlled crystallization, rapid solidification - non-crystalline materials, dispersion hardened materials.

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

The second lecture is devoted to the basic concepts of solidification, underlining the importance of this process in an industrial and research context. The theoretical foundations of slow and fast solidification are distinguished, with emphasis on their impact on materials.Slow solidification will be analysed in terms of the mechanisms and factors that influence it, focusing on its practical applications in industry and research. Rapid solidification will then be discussed, highlighting the principles, thermodynamics and kinetics associated with this method. Dispersion-strengthened materials, composites in which one phase is uniformly dispersed in another to improve mechanical properties. It will include an introduction to their definition and advantages, manufacturing methods, types (polymer matrices with dispersed fillers, metal matrices with dispersed particles), mechanical properties, industrial applications, advanced technologies and challenges associated with their development.

3.	**Learning outcomes**

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems with crystallization and dispersion materials.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

a. Lecture conducted with a traditional board or an interactive board.
b. Lecture conducted with the use of multimedia.
c. During the lecture, presentations of experiments illustrating the discussed topics are made.
d. During the lecture, there is a discussion with the students.

<u>At this points, we also specify the form of conducting classes, i.e.</u>

The main theme will continue in two sessions.
In the first week, issues related to slow and fast solidification will be discussed.
In the second week, issues related to dispersion hardened materials will be discussed.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Glicksman, M.,E. 2011. Princples of Solidification, An Introduction to Modern Casting and Crystal Growth Concepts .Springer Science+Buisiness Media, LLC. ISBN 978-4419-7343-6

6.	**Additional notes**

No

Topics 3

1.	The subject of the lecture

Production of composites, eutectic composites, polymer matrix composites.

2.	Thematic scope of the lecture (abstract, maximum 500 words)

The following lecture focuses on the fabrication of composites with emphasis on eutectic composites and polymer matrix composites. The introduction will provide an overview of the manufacturing principles and the various methods available. We then discuss eutectic composites, detailing the manufacturing process and unique properties. Next, we discuss polymer matrix composites and the impact of the manufacturing methods on the final material properties.The lecture continues with a discussion of the applications and benefits of these composites in various industries, and considers modern technologies in composites manufacturing, such as 3D printing and automation. The final section addresses current challenges in composites manufacturing and an overview of future perspectives and trends. An interactive discussion with questions from the students concludes the lecture, allowing for further exploration of the topics presented.

3.	Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems in the production of composites.

4.	Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5.	Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Cawla, K.,K. 1987. Composite Materials, Science and Engineering. Springer Science+Buisiness Media, LLC. ISBN. 978-1-4757-394-5

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

6.	Additional notes

No

Topics 4

1. The subject of the lecture

Ceramic matrix composites, particle composites, fibre and whisker composites.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The fourth lecture focuses on different types of composites including those with ceramic matrix, particle, fiber and whisker composites. The introductory section will give an overview of the importance of composite materials and their applications in a wide range of industries. We trace the characteristics of ceramic matrix composites and their applications in areas such as aerospace and energy. We then discuss particulate composites, focusing on their definition and practical applications. Fiber composites, their structure and applications in the automotive and construction industries, are the next focus of the talk. In addition, we will present information on whisker composites and their advanced applications. The lecture will conclude with examples of successful implementation, challenges in composites development and a discussion with questions from the students.

3. Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to ceramic matrix fibre and whisker composites.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

Cawla, K.,K. 1987. Composite Materials, Science and Engineering. Springer Science+Buisiness Media, LLC. ISBN. 978-1-4757-394-5

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

6. Additional notes

No

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

Topics 5

1. The subject of the lecture

Intermetallic compounds. Intermediate phases.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture will focus on intermetallic compounds and intermediate phases in materials. After an introduction to intermetallic compounds and their importance to industry, it will focus on the characterization of intermediate phases and their role in the microstructure of materials. A wide range of research and industrial applications of these compounds will be discussed, giving examples of their successful implementation in specific industries. The properties and formation mechanisms of intermetallic compounds and their importance in the microstructure and macrostructure of materials will be discussed in detail. We will also look at modern intermetallic materials research technologies and their potential impact on current knowledge and applications.The lecture will conclude with discussion and questions from the students, allowing an interactive space for a deeper understanding of the topics presented and their relevance to the field of intermetallic compounds and interfacial phases.

3. Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the given issue.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Sauthoff, G. 1995. Intermatallics. VCH Verlagsgesellschft, Weinheim. ISBN 3-527-29320-5

Steurer, W. et.al. 2016. Intermetallics, Structures, Properties and Statistics. CPI Group (UK). ISBN 978-0-19-871455-2

6. Additional notes

No

Topics 6

1. The subject of the lecture

Superconductor production technologies.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture will focus on superconductor fabrication technologies, an important area with a significant impact on current scientific and industrial research. After an introduction regarding superconductivity and its importance, different types of superconductors will be discussed, including high-temperature variants. The lecture will explain the fabrication processes of high temperature superconductors, analyzing the techniques and the influence of fabrication parameters on their properties. In addition, applications of superconductivity in industry and research will be presented, with examples of successful implementations. Nanotechnology and its impact on the fabrication and properties of superconductors will be the next focus of the talk, considering future perspectives in this field. Overcoming current challenges in superconductor manufacturing and innovation will be discussed, concluding the lecture with questions from the students, opening the floor for a deeper understanding of the topics presented in the lecture.

3. Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the technology of production of superconductors.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Braginski, A. et. al. 2022. Hanbook of Superconductivity. Taylor & Francis Group. ISBN 9781439817360

6. Additional notes

No

Topics 7

1. The subject of the lecture

Modification of surface properties - preparation of thin films, chemical vapour deposition (CVD), physical vapour deposition (PVD) techniques.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The following lecture focuses on the modification of surface properties of materials with emphasis on thin film preparation and chemical (CVD) and physical (PVD) deposition techniques. The introductory section defines the importance of surface property modification in industry and research, followed by a look at the characteristics of thin films and methods of their preparation. The lecture then describes CVD and PVD techniques, their applications and a comparison of advantages and disadvantages. Actual applications in various industries and examples of materials created by these methods will be highlighted. The final section will cover current innovations and trends in this field, closing with a discussion and questions from the students.

3. Learning outcomes

Študent vie využívať poznatky a informácie z prednášok, literatúry a iných dostupných zdrojov, interpretovať ich a kriticky hodnotiť, vyvodzovať závery, formulovať a riešiť problémy súvisiace s povrchovými modifikáciami vlastností.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Mattox, D., M. 2010. Handbook of Physical Vapor Deposition (PVD) Processing. Elsevier Inc. ISBN 978-0-8155-2037-5

Morosanu, C., E. Thin Films by Chemical Vapour Deposition. Elsevier. ISBN 9733102288

6. Additional notes

No

Topics 8

1. The subject of the lecture

Glow injections, modern electroplating.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The ninth lecture will thoroughly discuss two important techniques for modifying the surface properties of materials. It begins with an introduction to glow-in-the-dark spray techniques, highlighting their diverse applications in a variety of industries. The different types of these processes will be discussed and examples of materials achieved through these techniques will be presented. It will then discuss modern electroplating coatings, presenting their current developments and advantages in industrial applications. Galvanic coating processes and their effect on the surface properties of materials will be discussed in detail, giving specific examples of successful applications in various industries. The lecture will conclude with a discussion of current innovations in the field of glow-in-the-dark coatings and electroplating, with a look at future perspectives. An interactive session afterwards provides space for questions and discussion with the students.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems in the field of glow-in-the-dark coatings and gavlanic coatings.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

<u>At this points, we also specify the form of conducting classes, i.e.</u>

The main theme will continue in two sessions.
In the first week, issues related to glow-in-the-dark spraying will be discussed.
In the second week, issues related to modern electroplating will be discussed.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Hanson, D., et. al. 2019. Electroplating. The Crowood Press Ltd. ISBN 9781785005145

6. Additional notes

No

Topics 9

1. The subject of the lecture

Unconventional technologies of processing and machining of materials. Laser and plasma technologies.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The ninth lecture explains non-traditional technologies for processing and machining materials, with an emphasis on laser and plasma methods. The introductory section defines the importance of these non-traditional technologies and their advantages over conventional techniques. It focuses in more detail on laser technologies, discussing their characteristics and various applications, with an emphasis on their accuracy and efficiency in materials processing. Plasma technologies are introduced with an aspect on their specific characteristics and applications in materials processing and industry. The lecture further compares these technologies with other non-traditional approaches and gives examples of their successful applications. An analysis of the impact on material structures and a discussion of the material properties achieved through these technologies will provide deeper insight into their applications. Real-world examples in industrial sectors illustrate the current use of non-traditional technologies. The lecture concludes with a look into the future, highlighting innovations and trends in the field, and opens the floor for questions and discussion, allowing for an interactive deepening of the topics presented in the lectures.

3. Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems in the field of laser and plasma technologies.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Youssef, H. et. al. 2021. Non.traditional and advanced Machining Technologies. Taylor & Francis Group. LLC. ISBN 978-0-367-43134-1

Bhattacharyya, B. et. al. 2020. Modern Machining Technology. Elsier. ISBN 978-0-12-812894-7

Gupta, K., et. al. 2020. Optimization of Manuacturing Processes. Springer. ISBN 978-3-030-19637-0

6. Additional notes

No

Topics 10

1. The subject of the lecture

Electron beam technologies, ultrasonic technologies, electrospark and ion technologies.

2. Thematic scope of the lecture (abstract, maximum 500 words)

The last lecture, focusing on Electron Beam Technology, Ultrasonic Technology, Electrospark and Ion Technology, will present four innovative approaches in the field of materials processing. Electron beam technologies will be analyzed in detail with emphasis on their impact on materials processing and modification. Subsequently, the lecture will discuss ultrasonic technologies, introducing their various applications and benefits for materials processing and treatment. The lecture will further focus on electrospark technologies and ion technologies with examples of their applications in industry. The pairing of these technologies forms a key point, concentrating on achieving optimal results. Real-world examples of their use in industrial sectors and their contributions to current materials research provide a concrete context. The lecture concludes with a look into the future and expected developments in these technologies, opening the floor for interactive discussion and questions from students.

3. Learning outcomes

The student can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems in the field of electron, ultrasonic electrospark and ion technologies.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

At this points, we also specify the form of conducting classes, i.e.

The main theme will continue in two sessions.

In the first week, issues related to electron beam technologies and ultrasound technologies will be discussed.

In the second week, issues related to electrospark and ion beam technologies will be discussed.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Youssef, H. et. al. 2021. Non.traditional and advanced Machining Technologies. Taylor & Francis Group. LLC. ISBN 978-0-367-43134-1

Bhattacharyya, B. et. al. 2020. Modern Machining Technology. Elsier. ISBN 978-0-12-812894-7

Gupta, K., et. al. 2020. Optimization of Manuacturing Processes. Springer. ISBN 978-3-030-19637-0

6. Additional notes

No

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercise - instruction on laboratory order and safety at work.ch plants.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During the introduction to the laboratory exercise, emphasis is placed on safety and proper procedures. Students are instructed in general safety rules and instrument protection. Instruction includes a check of the work environment prior to the experiment. Students are taught to record results correctly. Maintaining order in the laboratory and understanding first aid rules are important components. The goal is to ensure that students have a clear understanding of safety standards and work responsibly in the laboratory.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

References to any studies provided to teachers.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Groover, M., P. (2020). Fundamentals of modern manufacturing: materials, processes, and systems. John Wiley & Sons, Inc., ISBN 978-0470-467002

Prasad, N., E. (2017). Aerospace Materials and Material Technologies. Springer Science+Buisiness Media Singapore. ISBN 978-981-10-2133-6

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

No

Topics 2

1. The subject of the laboratory classes

Controlled and uncontrolled solidification.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Practical training in controlled and uncontrolled solidification includes demonstrations, experiments and laboratory exercises. It starts with visual aids and models to explain the differences in these processes. Students experiment with materials and temperatures, observe the processes, and compare results. Laboratory exercises allow simulation control of solidification with different parameters. This is followed by an evaluation of the results and a discussion of applications of the processes in industry. An interactive platform allows questions and presentations. The aim is to provide a comprehensive view of these processes and their practical applications in materials manufacturing.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

Periodic table of elements; Physical-mathematical tables; Tables for materials, physical constants of metals; Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Glicksman, M.,E. 2011. Princples of Solidification, An Introduction to Modern Casting and Crystal Growth Concepts .Springer Science+Buisiness Media, LLC. ISBN 978-4419-7343-6

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

No

Topics 3

1. The subject of the laboratory classes

Preparation of polymer matrix composites.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Practical training in the preparation of polymer matrix composites includes experiments and laboratory exercises with a focus on active student participation. Students learn about polymer properties, preparation of composites with different fillers and variations in mixing processes. Laboratory exercises introduce them to special techniques for preparing composites and working with polymer blending, forming and curing technologies. Students analyze the properties of composites, discuss process variation and applications in industry. This approach provides students with a comprehensive understanding of the preparation of polymer matrix composites and their real-world applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

safety goggles, gloves and laboratory clothing, or software tools for simulating processes or analysing results.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Cawla, K.,K. 1987. Composite Materials, Science and Engineering. Springer Science+Buisiness Media, LLC. ISBN. 978-1-4757-394-5

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

No

Topics 4

1. The subject of the laboratory classes

Evaluation of microstructural parameters and fillers of metal and ceramic matrix composites.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Hands-on training in microstructure and filler evaluation of metal and ceramic matrix composites includes sample preparation, microscope work for detailed observation of microstructure and fillers, image analysis, and microstructure quantification programs. Students also perform laboratory tests to measure the mechanical properties of composites and compare the effect of microstructure on material properties. Discussion and evaluation of findings provide students with applicable knowledge of microstructural parameters in composites and their matrices.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Pupils can work in a group, divide tasks and work collaboratively, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

Samples, microscope, hardness tester

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

Cawla, K.,K. 1987. Composite Materials, Science and Engineering. Springer Science+Buisiness Media, LLC. ISBN. 978-1-4757-394-5

Mortensen, A. 2006. Concise Encyclopedia of Composite Materials. Elsevier Science. ISBN 978-0080451268

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

Nie

Topics 5

1. The subject of the laboratory classes

Evaluation of the quality and performance of PVD coatings, glow-in-the-dark coatings and electroplating.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Hands-on training in the evaluation of the quality and properties of PVD coatings, glow-in-the-dark coatings and electroplating includes sample preparation, the use of analytical tools such as microscopy and spectroscopy, mechanical tests and electrochemical measurements. Students compare results, discuss the advantages and disadvantages of different types of coatings and their practical applications in industry. Test results are summarized in reports, giving students a comprehensive understanding of the evaluation and application of different coatings on materials.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

Samples, microscope, spectrometer, electron restoration microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Mattox, D., M. 2010. Handbook of Physical Vapor Deposition (PVD) Processing. Elsevier Inc. ISBN 978-0-8155-2037-5

Morosanu, C., E. Thin Films by Chemical Vapour Deposition. Elsevier. ISBN 9733102288

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

No

Topics 6

1. The subject of the laboratory classes

Evaluation of microstructural changes in surface layers of structural materials after application in non-traditional materials processing and machining technologies (laser, plasma, electron-beam, ultrasonic, electrospark and ion technologies).

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Practical training in the evaluation of microstructural changes in the surface layers of structural materials after the application of non-traditional processing technologies includes the preparation of materials, the application of technologies such as laser, plasma, electron-beam and other technologies for surface modification, followed by microscopic analysis of the changes, laboratory tests of mechanical properties and physical measurements. The results of these experiments and measurements are then discussed and summarized with emphasis on their potential application in structural applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

Specimens, microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

-During the lab sessions, students work in groups, share tasks and collaborate to develop a work plan, analyze results and draw conclusions.

- During the laboratory lessons, students use the method of practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with evaluation of the effects.

- During the laboratory sessions, students work with a textbook structured to cover part or all of the module's learning with a specific form of content study; including working with a subject textbook, atlas, catalogue, workbook or using a website in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Youssef, H. et. al. 2021. Non.traditional and advanced Machining Technologies. Taylor & Francis Group. LLC. ISBN 978-0-367-43134-1

Bhattacharyya, B. et. al. 2020. Modern Machining Technology. Elsier. ISBN 978-0-12-812894-7

Gupta, K., et. al. 2020. Optimization of Manuacturing Processes. Springer. ISBN 978-3-030-19637-0

7. Additional notes

The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

No

Topics 7

1. The subject of the laboratory classes

Excursion in production factories.

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The professional excursion in the production company is focused on the subject area. The manufacturing companies are from various areas of engineering production (within the Slovak Republic or the Czech Republic) and have an interesting production program or progressive implementation of the quality management system in their production process. The mentioned excursion is mandatory for full-time students of the subject Materials Technologies.

3. Learning outcomes

A visit to a manufacturing plant provides students in the Materials Technology course with a realistic view of the processes, which enhances the understanding of specific processes and techniques in an industrial environment. It is also an opportunity to gain hands-on experience with new technologies and materials, which combines theoretical learning with practice. Such an experience can also help to build a network of contacts and strengthen industry relationships, which has the potential to influence their future careers in materials and technology.

4. Necessary equipment, materials, etc

No

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

No

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

No

7. Additional notes

8. Optional information

No

The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

MATERIALS SCIENCE MASTERS
Co-funded by the European Union

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

FATIGUE OF MATERIALS

Code: FM

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to fatigue of materials

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture aims to equip students with a foundational understanding of fatigue in materials, enabling them to recognize, analyze, and potentially prevent or manage fatigue-related issues in engineering applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

- BOKŮVKA, O., NICOLETTO, G., GUAGLIANO, M., KUNZ, L., PALČEK, P., NOVÝ, F., CHALUPOVÁ, M. Fatigue of Materials at Low and High Frequency Loading. University of Žilina, 2014. ISBN 978-80-554-0857-6

- PALČEK, P., CHALUPOVÁ, M., NICOLETTO, G., BOKŮVKA, O. Prediction of Machine Element Durability. University of Žilina, 2003. ISBN 80-8070-103-2

6. Additional notes

NO

Topics 2

1. The subject of the lecture

Cyclic deformation in ductile single crystals and in polycrystalline ductile solids

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture aims to provide a deeper understanding of the behavior of materials under cyclic loading conditions, specifically focusing on the differences and similarities between single crystals and polycrystalline materials. The goal is to equip students with insights into the mechanisms governing cyclic deformation, enabling better material design and engineering practices in different applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 3

1. The subject of the lecture

Fatigue crack initiation in ductile solids

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture's aim is to provide a comprehensive understanding of the processes and factors governing fatigue crack initiation in ductile solids. It seeks to equip students with the knowledge necessary to recognize, analyze, and potentially prevent fatigue crack initiation in engineering materials, thus contributing to enhanced material reliability and durability in various applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 4

1. The subject of the lecture

Cyclic deformation and crack initiation in brittle solids and in noncrystalline solids

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a comprehensive understanding of how cyclic loading affects brittle and noncrystalline materials, particularly focusing on deformation mechanisms and crack initiation. The lecture aims to equip students with insights into the distinct behaviors of these materials under cyclic loading conditions, enabling better understanding, prediction, and potentially improved engineering practices in various applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 5

1. The subject of the lecture

Stress–life approach

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to equip students with a comprehensive understanding of the stress–life approach in fatigue analysis. The lecture aims to enable individuals to apply stress-based methodologies effectively in predicting fatigue life and assessing the durability of materials and components in engineering applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 6

1. The subject of the lecture

Strain–life approach

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide students with a comprehensive understanding of the strain–life approach in fatigue analysis. The lecture aims to enable individuals to effectively apply strain-based methodologies in predicting fatigue life and assessing the durability of materials and components in engineering applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

- BOKŮVKA, O., NICOLETTO, G., GUAGLIANO, M., KUNZ, L., PALČEK, P., NOVÝ, F., CHALUPOVÁ, M. Fatigue of Materials at Low and High Frequency Loading. University of Žilina, 2014. ISBN 978-80-554-0857-6

- PALČEK, P., CHALUPOVÁ, M., NICOLETTO, G., BOKŮVKA, O. Prediction of Machine Element Durability. University of Žilina, 2003. ISBN 80-8070-103-2

6. Additional notes

NO

Topics 7

1. The subject of the lecture

Fracture mechanics and its implications for fatigue

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a deep understanding of how fracture mechanics principles are applied to analyze fatigue-induced crack initiation and propagation in engineering materials. The lecture aims to equip students with the knowledge required to predict and manage fatigue-related failures through a fracture mechanics perspective.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.
- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0
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6. Additional notes

NO

Topics 8

1. The subject of the lecture

Fatigue crack growth in ductile solids and in brittle solids

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture aims to provide a comprehensive understanding of the mechanisms and behaviors of fatigue crack growth in both ductile and brittle materials. The goal is to equip students with insights into these distinct behaviors, enabling better prediction, analysis, and management of fatigue-related issues in engineering applications involving different material types.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

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- PALČEK, P., CHALUPOVÁ, M., NICOLETTO, G., BOKŮVKA, O. Prediction of Machine Element Durability. University of Žilina, 2003. ISBN 80-8070-103-2

6. Additional notes

NO

Topics 9

1. The subject of the lecture

Fatigue crack growth in noncrystalline solids

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a comprehensive understanding of fatigue crack growth in noncrystalline or amorphous materials. The lecture aims to equip students with insights into the unique behaviors and mechanisms governing crack propagation in these materials, enabling better understanding, prediction, and potentially improved engineering practices in various applications involving noncrystalline solids.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 10

1. The subject of the lecture

Contact fatigue: sliding, rolling and fretting

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a comprehensive understanding of the various forms of contact-induced fatigue—sliding, rolling, and fretting—and their implications in engineering materials. The lecture aims to equip students with insights into the mechanisms, influential factors, and strategies to mitigate contact fatigue, thus contributing to improved material durability and reliability in various applications involving contact interactions.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 11

1. The subject of the lecture

Retardation and transients in fatigue crack growth

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a comprehensive understanding of the transient behavior and retardation phenomena observed during fatigue crack growth. The lecture aims to equip students with insights into the mechanisms, factors influencing, and predictive methodologies related to transient behavior and retardation in fatigue crack growth, thereby contributing to improved fatigue life prediction and material durability in engineering applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.
- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0
- BOKŮVKA, O., NICOLETTO, G., GUAGLIANO, M., KUNZ, L., PALČEK, P., NOVÝ, F., CHALUPOVÁ, M. Fatigue of Materials at Low and High Frequency Loading. University of Žilina, 2014. ISBN 978-80-554-0857-6
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6. Additional notes

NO

Topics 12

1. The subject of the lecture

Small fatigue cracks

2. Thematic scope of the lecture (abstract, maximum 500 words)

The aim of this lecture is to provide a comprehensive understanding of small fatigue cracks and their implications in materials subjected to cyclic loading. The lecture aims to equip students with insights into the behaviors, detection, analysis, and potential management of small fatigue cracks, contributing to improved material reliability and failure prevention in engineering applications.

3. Learning outcomes

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6. Additional notes

NO

Topics 13

1.	**The subject of the lecture**

Environmental interactions: corrosion-fatigue and creep-fatigue

2.	**Thematic scope of the lecture (abstract, maximum 500 words)**

The aim of this lecture is to provide a comprehensive understanding of the combined effects of environmental factors with cyclic loading on material fatigue behavior, specifically focusing on corrosion-fatigue and creep-fatigue interactions. The lecture aims to equip students with insights into the mechanisms, detection, analysis, and potential management strategies to address environmental interactions in fatigue-related failures, enhancing material reliability and durability in various engineering applications.

3.	**Learning outcomes**

The student is able to use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve related problems.

4.	**Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)**

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

5.	**Recommended reading, pre-lesson preparation (required knowledge of students on the topics)**

Students are expected to read below texts related to the lecture:

- KLESNIL, M., LUKÁŠ, P. Fatigue of Metallic Materials. 2nd rev.ed. Amsterdam: Elsevier, 1992. ISBN 0-444-98723-1.

- BROOKS, CH. R., CHOUDHURY, A. Failure Analysis of Engineering Materials. 1st ed. McGraw Hill, 2001. ISBN 0-07-135758-0

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6.	**Additional notes**

NO

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to limit states. Basic classification

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with a foundational understanding of limit states in structural engineering, their classifications, and their role in ensuring the safety, reliability, and serviceability of structures. Through theoretical explanations, practical examples, and discussions, students gain insights into the principles and applications of limit states in engineering design and analysis.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the laboratory:

- MAITII, S. K. Fracture mechanics: fundamentals and applications. Delhi, India: Cambridge University Press, 2015. ISBN 978-1-107-09676-9
- LEE, Y. L. Fatigue testing and analysis: theory and practice. Boston: Elsevier Butterworth-Heinemann, 2005. ISBN 978-0-7506-7719-6.
- BORESI, A. P., SCHMIDT, R. J. Advanced mechanics of materials. 6th ed. New York: John Wiley, 2003. ISBN 0471438812.
- BOKŮVKA, O., NICOLETTO, G., GUAGLIANO, M., KUNZ, L., PALČEK, P., NOVÝ, F., CHALUPOVÁ, M. Fatigue of Materials at Low and High Frequency Loading. University of Žilina, 2014. ISBN 978-80-554-0857-6
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Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.
- The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Limit states in elastic and plastic region

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to material behaviors in both the elastic and plastic regions. By engaging in hands-on experiments, students gain a deeper understanding of the concepts of elastic and plastic limits, yield criteria, and the transition from elastic to plastic deformation in engineering materials.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the laboratory:

- MAITII, S. K. Fracture mechanics: fundamentals and applications. Delhi, India: Cambridge University Press, 2015. ISBN 978-1-107-09676-9

- LEE, Y. L. Fatigue testing and analysis: theory and practice. Boston: Elsevier Butterworth-Heinemann, 2005. ISBN 978-0-7506-7719-6.

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Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.

- The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

Body fracture initiators. Structural notches

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to notch effects and their influence on fracture initiation in structural materials. Through hands-on experiments and analyses, students gain a deeper understanding of how geometric irregularities and stress concentrations, introduced by notches, impact the structural integrity and failure behavior of engineering components.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the laboratory:

- MAITII, S. K. Fracture mechanics: fundamentals and applications. Delhi, India: Cambridge University Press, 2015. ISBN 978-1-107-09676-9

- LEE, Y. L. Fatigue testing and analysis: theory and practice. Boston: Elsevier Butterworth-Heinemann, 2005. ISBN 978-0-7506-7719-6.

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7. Additional notes

ASSESSMENT

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8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Linear fracture mechanics

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to the principles of linear fracture mechanics. Through hands-on experiments and analyses, students gain a deeper understanding of stress analysis near crack tips, fracture toughness measurements, and crack growth behavior, contributing to their comprehension of fracture mechanics principles and their applications in engineering design and failure analysis.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

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7. Additional notes

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8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Nonlinear fracture mechanics

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to the principles of nonlinear fracture mechanics. Through hands-on experiments and analyses, students gain a deeper understanding of plasticity effects near crack tips, the ductile-to-brittle transition, and the influence of large deformations on fracture behavior. This practical knowledge contributes to a more comprehensive understanding of fracture mechanics principles and their applications in materials testing and failure analysis.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

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7. Additional notes

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8. Optional information

NO

Topics 6

1. The subject of the laboratory classes

Material fatigue - introduction, basic knowledge. Experimental approaches

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with foundational knowledge of material fatigue and practical experience in fatigue testing techniques. Through hands-on experiments and analyses, students gain a deeper understanding of fatigue behavior, experimental methodologies, and the factors influencing fatigue life in engineering materials.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

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ASSESSMENT

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8. Optional information

NO

Topics 7

1. The subject of the laboratory classes

Material fatigue - High cycle uniaxial fatigue

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to high-cycle uniaxial fatigue testing and to deepen their understanding of fatigue behavior in materials subjected to cyclic loading. Through hands-on experiments and analyses, students gain insights into the factors influencing high-cycle fatigue life, crack initiation, and propagation, contributing to their understanding of material durability and failure mechanisms in engineering applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

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8. Optional information

NO

Topics 8

1. The subject of the laboratory classes

Material fatigue - High cycle multiaxial fatigue

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to high-cycle multiaxial fatigue testing and to deepen their understanding of fatigue behavior in materials experiencing complex stress states. Through hands-on experiments and analyses, students gain insights into the factors influencing multiaxial fatigue life, crack initiation, and propagation, contributing to their understanding of material durability and failure mechanisms in real-world engineering applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

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8. Optional information

NO

Topics 9

1. The subject of the laboratory classes

Material fatigue - High cycle fatigue - experimental approaches

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to various experimental approaches in high-cycle fatigue testing. Through hands-on experiments, data analysis, and discussions, students gain insights into the factors influencing high-cycle fatigue behavior, crack initiation, and propagation in engineering materials. This practical knowledge contributes to their understanding of material durability and failure mechanisms in real-world applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

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7. Additional notes

ASSESSMENT

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8. Optional information

NO

Topics 10

1. The subject of the laboratory classes

Material fatigue - Low cycle uniaxial fatigue

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to low-cycle uniaxial fatigue testing and deepen their understanding of the characteristics and behavior of materials subjected to cyclic loading within the low-cycle fatigue regime. Through hands-on experiments, data analysis, and discussions, students gain insights into the factors influencing low-cycle fatigue behavior, crack initiation, and material response under cyclic loading conditions typical of the LCF regime.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

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7. Additional notes

ASSESSMENT

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8. Optional information

NO

Topics 11

1. The subject of the laboratory classes

Material fatigue - Low cycle multiaxial fatigue

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to low-cycle multiaxial fatigue testing and to deepen their understanding of materials undergoing cyclic loading in complex stress states within the low-cycle fatigue regime. Through hands-on experiments, data analysis, and discussions, students gain insights into the factors influencing low-cycle multiaxial fatigue behavior, crack initiation, and material response under various multiaxial loading conditions.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

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7. Additional notes

ASSESSMENT

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8. Optional information

NO

Topics 12

1. The subject of the laboratory classes

Material fatigue - Low cycle fatigue - experimental approaches

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to provide students with practical exposure to various experimental approaches in low-cycle fatigue testing and to deepen their understanding of materials undergoing cyclic loading within the low-cycle fatigue regime. Through hands-on experiments, data analysis, and discussions, students gain insights into the factors influencing low-cycle fatigue behavior, crack initiation, and material response under controlled testing conditions simulating real-world applications.

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

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During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

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7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.
- The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

NO

Topics 13

1. The subject of the laboratory classes

Numerical procedures for material fatigue

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of these laboratory classes is to equip students with the skills to use numerical methods for fatigue analysis, enabling them to predict and understand fatigue behavior in materials under different loading conditions. Through hands-on exercises, simulations, and discussions, students gain practical experience in applying numerical procedures to assess fatigue life, understand failure mechanisms, and improve material/component design for enhanced fatigue resistance

3. Learning outcomes

Students are able to use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve a problem. Students are able to work in a group, share tasks and collaborate, analyse results and draw conclusions.

4. Necessary equipment, materials, etc

- Ruler, pen and pencil,
- Calculator

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the laboratory:

- MAITII, S. K. Fracture mechanics: fundamentals and applications. Delhi, India: Cambridge University Press, 2015. ISBN 978-1-107-09676-9

- LEE, Y. L. Fatigue testing and analysis: theory and practice. Boston: Elsevier Butterworth-Heinemann, 2005. ISBN 978-0-7506-7719-6.

- BORESI, A. P., SCHMIDT, R. J. Advanced mechanics of materials. 6th ed. New York: John Wiley, 2003. ISBN 0471438812.

- BOKŮVKA, O., NICOLETTO, G., GUAGLIANO, M., KUNZ, L., PALČEK, P., NOVÝ, F., CHALUPOVÁ, M. Fatigue of Materials at Low and High Frequency Loading. University of Žilina, 2014. ISBN 978-80-554-0857-6

- PALČEK, P., CHALUPOVÁ, M., NICOLETTO, G., BOKŮVKA, O. Prediction of Machine Element Durability. University of Žilina, 2003. ISBN 80-8070-103-2

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

ASSESSMENT

- Activity in the exercises and preparation of the theoretical part are evaluated.
- The report related to this laboratory exercise is evaluated. The report shall include an explanation of the theoretical background of the experiment, the procedure, a summary of the results and a conclusion.

8. Optional information

NO

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

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SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

FUELS AND LUBRICANTS IN AUTOMOTIVE INDUSTRY

Code: FLAI

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

INTRODUCTION TO FUELS AND LUBRICANTS AND CRUDE OIL CHARACTERIZATION

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 1 contain two basic issues - characteristics and classification of fuels and lubricants in automotive industry and characteristics, origin, composition and processing of crude oil as the most important source of traditional fuels and lubricants:

- Fuels and lubricants – main definitions, characteristic and classification;
- definition of crude oil, significance, global sources and distribution;
- characteristics of crude oil – density, color, odor, viscosity, chemical properties;
- origin of crude oil – formation processes, geological conditions for formation, reservoir rocks;
- composition – hydrocarbons types, non-hydrocarbon compounds, undesirable substances;
- processing of crude oil – exploration, transportation, refining processes (fractional distillation at atmospheric pressure and under vacuum, processing of fractions from vacuum distillation);
- environmental impact of crude oil extraction and processing.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related *to basic definitions and classification of fuels and lubricants and characteristics, origin, composition and processing of crude oil.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073

FANCHI, J.R. – CHRISTIANSEN, R.L. 2016. Introduction to Petroleum Engineering. Wiley, USA, ISBN 978-1119193449.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 2

1. The subject of the lecture

AUTOMOTIVE GASOLINE AND DIESEL FUELS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 2 are designed to provide a comprehensive understanding of automotive gasoline and diesel fuels, covering their characteristics, composition, properties, engine systems and future trends. The inclusion of case studies ensures that students gain insights into real-world applications and challenges in the automotive fuel sector:

- Importance of gasoline and diesel in the transportation sector;
- automotive gasolines – chemical composition (hydrocarbons and additives) and basic characteristics, mixture formation and combustion disorders in petrol engines;
- evaporation properties of gasolines, distillation test, description of the distillation curve;
- anti-detonation properties of gasolines - octane rating, anti-knock additives, other quality indicators of automotive gasolines (vapor pressure, color and odor, combustion characteristics, flame propagation, auto-ignition);
- diesel fuel – chemical composition (hydrocarbons, sulfur content) and basic characteristics, mixture formation in diesel engines;
- ignition delay, cetane rating, physical properties of diesel (distillation range, viscosity, density, flash point, properties at low temperatures), other indicators of diesel quality;
- fuel efficiency and performance – impact of fuel properties on engine efficiency, relationship between octane and performance;
- fuel standards and regulations, emission standards;
- case studies – notable advancements and global trends in gasoline and diesel technology.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Automotive gasoline and diesel fuels.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

activating methods **– case study**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073

6. Additional notes

The topics will be covered in 2 and half two-hour lectures.

Topics 3

1. The subject of the lecture

ALTERNATIVE AUTOMOTIVE FUELS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 3 delve into a variety of alternative fuels that aim to reduce dependence on traditional fossil fuels, minimize environmental impact, and address the challenges of climate change. They provide a structured exploration of alternative automotive fuels, covering various options from biofuels to hydrogen, natural gas, and electric vehicles. It aims to equip students with an understanding of the diverse landscape of alternative fuels, their benefits, challenges, and potential impact on the future of transportation:

- Overview of alternative automotive fuels – definition and importance, motivation for exploring alternatives, environmental and economic implications, classification of biofuels;
- gaseous fuels (Compressed natural gas CNG, Liquefied natural gas LNG, Liquefied petroleum gas LPG) - basic characteristics, properties, comparison, advantages/ disadvantages, vehicle compatibility;
- alcohols, ethers, biodiesel (production, feedstock sources, compatibility with diesel engines), emulsion diesel - basic characteristics, production, comparison, advantages/disadvantages, availability in EU countries;
- hydrogen as an alternative fuel - hydrogen combustion engine, fuel cell principle, advantages and disadvantages, availability in EU countries;
- challenges and considerations in alternative fuels – infrastructure development, cost implications, role in sustainable transportation, implication for the future of automotive industry.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Alternative automotive fuels.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073

Optional:

DENTON, T. 2018. Alternative Fuel Vehicles. Routledge, UK, ISBN 978-1138503700.

6. Additional notes

The topics will be covered in 2 two-hour lectures.

Topics 4

1. The subject of the lecture

FRICTION AND LUBRICANTS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 4 aim to the explaining and understanding fundamental principles of friction, its effects on materials, its influence on machine efficiency and the crucial role of lubricants in mitigating friction, enhancing system reliability, and extending the lifespan of mechanical components. The lectures of Topics 4 name also basic functions of lubricants and bring overview of their important properties. Lubricants are classified according to their physical state:

- Friction, types of friction in general and during lubrication, wear – definitions, explanations;
- fundamental roles of lubricants in machinery;
- basic functions of lubricants, overview of properties of lubricants - characteristics, methods of measurement (density, dynamic and kinematic viscosity, viscosity index, compressibility, flash point, fire point, ignition temperature, properties at low temperatures, oxidation and thermal stability, surface properties, protective and physiological properties;
- classification of lubricants according to the physical state;
- gas lubricants - basic characteristics and properties;
- liquid lubricants - their classification according to their origin and the chemical composition, additives improving their properties.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Friction and lubricants.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073.

6. Additional notes

The topics will be covered in 2 and half two-hour lectures.

Topics 5

1. The subject of the lecture

OVERVIEW OF LUBRICANTS - ENGINE OILS, TRANSMISSION OILS, LUBRICATING GREASE, SOLID LUBRICANTS, HYDRAULIC FLUIDS

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lectures of Topics 5 provide a comprehensive overview of various lubricants, their compositions, characteristics, properties, applications, and the factors influencing their selection. From traditional engine oils to advanced solid lubricants, the lecture explore the intricate details of lubrication and its crucial role in ensuring the reliability and efficiency of mechanical systems:

- Engine oils – functions in internal combustion engines, composition and properties, additives for performance enhancement, viscosity and performance classifications and standards (SAE, API, ACEA), testing;
- transmission oils – role in hydraulic systems, composition and properties. Manual transmission and gear oils, automatic transmission fluids (ATF), extreme pressure (EP) additives, viscosity and performance classifications and standards (SAE, API GL), testing ;
- lubricating greases – composition and structure, thickener types, properties, application and advantages/disadvantages, testing;
- solid lubricants – introduction and characteristics, properties, graphite, molybdenium disulphide, applications and benefits. Sliding varnishes and their applications;
- lubricant selection criteria – operating conditions and environment, compatibility with materials, maintenance considerations;
- hydraulic fluids - characteristics, properties. Shock absorber oils and brake fluids – composition, properties, applications, testing.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Lubricants – engine oils, transmission oils, lubricating grease, solid lubricants, hydraulic fluids.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073.

6. Additional notes

The topics will be covered in 2 and half two-hour lectures.

Topics 6

1. The subject of the lecture

ECOLOGICAL ASPECTS OF AUTOMOTIVE FUELS AND LUBRICANTS

2. Thematic scope of the lecture (abstract, maximum 500 words)

- The lectures of Topics 6 aim to provide an explanation and understanding of the ecological aspects associated with automotive fuels and lubricants, exploring both the challenges and opportunities in fostering sustainable practices within the automotive industry. Through a multidisciplinary lens, students will gain insights into the intricate relationship between automotive technology and environmental stewardship:
- Life Cycle Assessment (LCA) of fuels and lubricants - definition and importance of LCA, stages of LCA (extraction, production, utilization, and disposal), quantifying environmental Impacts (greenhouse gas emissions, resource depletion, eco-toxicity);
- harmful components of exhaust gases – origin, characteristics, toxicity;
- influence of design, engine settings and operating conditions on the composition of exhaust gases;
- methods of reducing the content of harmful emissions (secondary air systems, catalysts, exhaust gas recirculation, particulate filters, selective catalytic reduction).
- lubricants and environmental Impact - disposal of used lubricants, biodegradability and ecotoxicity of lubricating oils, emerging trends in environmentally friendly lubricants;
- regulatory frameworks and environmental standards - global emission standards for vehicles, eco-labeling and certification for fuels and lubricants, role of international organizations in shaping ecological policies.

3. Learning outcomes

Can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to *Ecological aspects of automotive fuels and lubricants.*

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **informative lecture, monographic lecture, description, explanation/clarification**

problem methods – **discussion/debate**

Lectures are conducted with a traditional board and with the use of multimedia. Lectures begin with a short discussion of the raised topic and they are finished by a short discussion focused on repeating the main points of the lecture.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073.

6. Additional notes

The topics will be covered in 1 and half two-hour lectures.

Course content – laboratory classes

Topics 1 Lab 1

1. The subject of the laboratory classes

DETERMINATION OF FLASHPOINTS OF GASOLINE AND DIESEL FUELS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The laboratory classes of Topics 1 contain two issues. The first one is focused on instruction on laboratory order and safety at work, the second one aims to determination of the flashpoints of gasoline and diesel fuels by Cleveland open-cup method. This experiment will verify the theoretical knowledge of the property of automotive fuels, which is a quickly verifiable and unambiguous criterion of their quality. The students will perform the stated experiment on three specimens of the same type automotive gasoline and on the three specimens of the same type of diesel. The resulting flashpoint values will be obtained as arithmetic average of values of three measured parallel specimens (gasoline diesel).

Students will work in a group, sharing tasks and working together to prepare specimens, to carry out measurements, analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to physical properties of automotive fuels namely to the *Determination of flashpoints of gasoline and diesel fuels.* Students are able to work in a group sharing tasks and working together analyze the results and draw conclusions.

4. Necessary equipment

Cleveland open cup flashpoint tester (ASTM D 92 standard test method) with thermometer (0 °C to 200 °C).

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- introduction to the laboratory classes – instruction on laboratory order and safety at work,
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Device and exercise manual will be available.

Topics 2 Lab 2

1. The subject of the laboratory classes

LABORATORY PREPARATION OF BIODIESEL

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of chemical properties of lipids, fatty acids and their esterification by alcohols will be verified. This laboratory exercise is designed to provide hands-on experience in the preparation of biodiesel, offering participants a firsthand understanding of the chemical processes involved in transforming raw materials into a viable and eco-friendly fuel source. The students will carry out transesterification of the rapeseed oil specimen (4 ml) by heating with sodium methanolate solution (8 ml, previously prepared by reaction of methanol with sodium hydroxide solution). During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Laboratory preparation of biodiesel* by transesterification. Students are able to work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Laboratory preparation of biodiesel* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Beaker 400 ml,

large test tubes (diameter approx. 2.5 cm),

magnetic stirrer with heating, return cooler to the test tube: perforated stopper with 40 cm tube,

stand and clamps,

thermometer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073.

DENTON, T. 2018. Alternative Fuel Vehicles. Routledge, UK, ISBN 978-1138503700.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 3 Lab 3

1. The subject of the laboratory classes

DETERMINATION OF DYNAMIC VISCOSITY OF NEW AND USED ENGINE OILS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of functional properties of engine oils, which include dynamic viscosity as a measure of internal friction in flowing liquids will be verified. The students will carry out measurements of dynamic viscosity η (Pa.s) of new and used engine oils (the same type of oil) using the Physica MCR 301 Oscillatory/Rotational Rheometer with cone–plate measuring system (controlled share rate (CSR) method). The dynamic viscosity measurements of both oils will be performed at the temperatures of 20, 40 and 100 °C. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to properties of liquids and *Determination of dynamic viscosity of new and used engine oils*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of dynamic viscosity of new and used engine oils* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Oscillatory/Rotational Rheometer with cone – plate measuring system (diameter 25 mm), the bottom plate is stationary, the cone rotates, the lubricant fills the gap; control shear rate method (measurement of dynamic viscosity in dependence of shear rate in the range 5 – 1000 s^{-1}).

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Device and exercise manuals will be available.

Topics 4 Lab 4

1. The subject of the laboratory classes

DETERMINATION OF KINEMATIC VISCOSITY OF NEW AND USED ENGINE OILS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of functional properties of engine oils, which include kinematic viscosity as a measure of resistance to the liquids flow will be verified. The students will carry out measurements of kinematic viscosity *v* ($mm^2.s^{-1}$) of new and used engine oils (the same type of oil) using Ubbelohde capillary viscometer. The kinematic viscosity measurements of both oils will be performed at the temperatures of 20, 40 and 100 °C. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to properties of liquids and *Determination of kinematic viscosity of new and used engine oils*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on properties of liquids and *Determination of kinematic viscosity of new and used engine oils* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Ubbelohde capillary viscometer (U6 type, calibration constant =1),
thermometer,
thermostatic water bath,
stand and clamps.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,
a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 5 Lab 5

1. The subject of the laboratory classes

DETERMINATION OF THE DENSITY OF NEW AND USED ENGINE OILS

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of functional properties of engine oils, which include density as an important parameter for the characterization of the oil from the point of view of chemical composition and for various calculations, will be verified. The students will carry out measurements of density ρ (g.cm^{-3}) of new and used engine oils (the same type of oil) using hydrometer for density range 0.7500 – 0.9500 g.cm^{-3}. The density measurements of both oils will be performed at the temperatures of 20, 40 and 100 °C. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Determination of density of new and used engine oils*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Determination of density of new and used engine oils* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Hydrometer for density range 0.7500 – 0.9500 g.cm^{-3}

thermometer,

thermostatic water bath,

graduated cylinder 250 ml,

stand and clamps.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:
- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Co-funded by the European Union

Topics 6 Lab 6

1. The subject of the laboratory classes

ASSESSMENT OF PROTECTIVE PROPERTIES OF USED ENGINE OIL

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

During laboratory classes, students' theoretical knowledge of chemical properties of engine oils pH of the aqueous extract and the indicative water content, that are related to protection ability of the used oils, will be verified. The students will carry out pH measurements of the aqueous extract used engine oils and determine the indicative water content in the used oil (the same type of oil than in Lab 3 – Lab 5). The pH test is an important criterion for assessing the degree of degradation of used oils in terms of their corrosiveness (pH value should be approximately neutral). Before the test, distilled water is added to the used oil sample. After thorough shaking, the mixture is poured into a separating funnel with tap. After separating the water layer (lower layer with higher density) and draining it from the separating funnel, the pH is determined using an acid-base indicator.

An indicative determination of the water content in the used oil is carried out using the sputtering test, which is based on the observation of visual signs (intensity of foaming, sputtering, smoke) observed in the used oil. During laboratory classes, students will work in a group, sharing tasks and working together to analyze the results and draw conclusions. The completed experiment will be the basis for the report on the exercises.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to *Assessment of protective properties of used engine oil*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description to the laboratories on *Assessment of protective properties of used engine oil* including critical analysis, synthesis and conclusions.

4. Necessary equipment

Separating funnel (200 ml) with tap,

graduated cylinder 100 ml,

stand and clamps,

methyl orange acid-base indicator

aluminium foil,

alcohol flame.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

a set of practical methods - **laboratory exercise/experiment; observation**

a) Laboratory classes are carried out with the use of special research equipment

b) During laboratory classes, students perform the experiment and perform it on their own.

c) During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

Classes are held in the following order:

- discussion (checking students' knowledge) of the theoretical foundations and the procedure for performing the experiment - getting acquainted with the research equipment in the laboratory,
- students in groups, students carry out a selected experiment,
- during the experiment, students make observations, record comments and the results of the experiment,
- completion of the experiment and formulation of preliminary conclusions.

Students prepare the final report independently at home.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

7. Additional notes

- ASSESSMENT

Report related to this laboratory exercise is evaluated (max. 5 points). The report contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

8. Optional information

Exercise manuals will be available.

Topics 7 Lab 7

1. The subject of the laboratory classes

DATA ANALYSIS AND REPORTING

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The final topics of laboratory classes is focused on demonstration of students' comprehensive understanding of the properties of engine oils. The students will develop skills in data analysis and effective reporting through preparation the report summarizing procedures, results, and conclusions, focused on comparison of properties of new and used engine oils on the basis of results obtained in topics 3 – 6. During data processing, students will work in a group, sharing tasks and working together to analyze all available data related to the results of the performed engine oils tests and draw conclusions. The completed data analysis will be the basis for the summarizing report comparing the new and used engine oils properties and behavior on the basis of results obtained in Topics 3 – 6.

3. Learning outcomes

Students can use information from literature and other available sources, interpret and critically evaluate them, draw conclusions and formulate and solve problems related to comparison of properties of new and used engine oils od the bases of *Data analysis and reporting*. Students are able to work in a group, sharing tasks and working together to analyze the results and draw conclusions. They can prepare a theoretical introduction and final results description related to comparison of properties of new and used engine oils od the bases of *Data analysis and reporting*.

4. Necessary equipment

-

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

assimilation methods/providing - **reading**,

activating methods: **discussion/debate**

type of discussion: brainstorming

activating methods: **seminar/proseminar**

verbal presentation of a problem

During data analysis students work in a group, sharing tasks and working together to analyze the results and draw conclusions.

Classes are held in the following order:

- discussion

- data analyzing and processing
- summarizing procedures, results, and conclusions, focused on comparison of properties of new and used engine oils on the basis of results obtained in topics 3 – 6.
- students prepare the final summarizing report.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

TOTTEN, E.G. - VESTBROOK, S.R. - RAJESH, J.S. 2003. Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing. ASTM International, USA, ISBN 0-8031-2096-6.

7. Additional notes

- ASSESSMENT

Report related to the data analysis is evaluated (max. 10 points). The report contains comparison of properties of new and used engine oils on the basis of results obtained in experiments performed during laboratory classes topics 3 – 6 and final conclusions.

8. Optional information

-

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

PROPERTIES AND USE OF MATERIALS

Code: PUM

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to the subject *Properties and use of materials*;

Properties of metal materials – distribution of properties; physical, physico-chemical, mechanical and technological properties (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Properties of metal materials" deals with fundamental aspects of metals, encompassing their physical, physico-chemical, mechanical and technological characteristics. The individual properties of metals and their importance in the application of these materials in practice are described in detail.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.1 Properties of metal materials

6. Additional notes

-

Topics 2

1. The subject of the lecture

Mechanical tests – division of mechanical tests, basic principles in mechanical tests, preparation of test bars (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Mechanical tests" deals with the division of mechanical tests according to different aspects, the basic principles of mechanical testing and the preparation of test bars. The lecture also describes the process of preparing standardized test bars, crucial for ensuring accurate and reproducible results in assessing the mechanical properties of materials.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.1 Division and principles of mechanical tests

6. Additional notes

-

Topics 3

1. The subject of the lecture

Tensile test – principle of the tensile test; test bars; pull diagram; evaluation of the test; test machines (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Tensile test" focuses on the experimental procedure and the method of evaluation of the mechanical properties of the material in tensile testing. It covers the procedure for performing a tensile test to determine tensile strength, yield strength, elongation and reduction of area. The lecture further discusses the stress-strain curve, which provides insight into the deformation behavior and mechanical properties of the material at different levels of applied stress. Types of test bars and experimental machines for performing this test are also discussed.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.2 Tensile test

6. Additional notes

-

Topics 4

1. The subject of the lecture

Impact bending test – principle of the impact bending test; test bars; evaluation of the test; test machines (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Impact bending test" focuses on the experimental procedure and the method of evaluation of the mechanical properties of the material in the impact bending test. It covers the procedure for performing a impact bending test to determine the absorbed energy and transit temperature. The lecture further discusses the transit curve, which provides insight into the fracture behavior and mechanical properties of the material at different operating temperatures. Types of test bars and experimental machines for performing this test are also discussed.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.3 Impact bending test

6. Additional notes

-

Topics 5

1. The subject of the lecture

Hardness tests – definition of hardness; distribution of test methods; static hardness tests/ Brinell, Vickers, Knoop and Rockwell - test principle, indentation bodies, determination of hardness, marking of hardness, test conditions, use and comparison of hardness measurement methods; dynamic hardness tests/ Poldi hammer, Leeb - test principle, determination of hardness, marking of hardness; test machines (4 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Hardness tests" deals with static and dynamic methods of evaluation of material hardness. It focuses on the experimental procedure and ways of evaluation of hardness by different methods (Brinell, Vickers, Knoop, Rockwell, Poldi hammer, Leeb). It covers the test principle, procedure for performing hardness tests, types of indentation bodies, determination of hardness, marking of hardness, test conditions, use and comparison of methods of hardness measurement. It also discusses the types of experimental machines (hardness testers) for carrying out hardness tests.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be discussed in two lectures.
In the first week, students will learn about static methods of hardness measurement (Brinell, Vickers, Knoop and Rockwell).
In the second week, students will learn about dynamic methods of hardness measurement (Poldi hammer, Leeb).

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.
- chapter 1.2.4 Hardness tests

6. Additional notes

The topics will be covered in two lectures.

Topics 6

1. The subject of the lecture

Fatigue tests – definition of material fatigue; evaluation of the resistance of the material to fatigue; principle of the fatigue test; test bars; evaluation of the test; test machines (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Fatigue tests" focuses on the experimental procedure and the method of evaluation of the mechanical properties of the material in fatigue tests. It covers the procedure for performing fatigue tests to determine the fatigue limit and the timed fatigue limit. The lecture further discusses the Wohler fatigue curve and Smith fatigue diagram, which provide insight into the fatigue behavior and mechanical properties of the material at different levels of applied stress and different loading modes. Types of test bars and experimental machines for performing this test are also discussed.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.5 Fatigue tests

6. Additional notes

-

Topics 7

1. The subject of the lecture

Creep tests – effect of elevated temperatures on mechanical properties; definition of material creep; creep curve; evaluation of the resistance of the material against creep; test bars; evaluation of the test (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Creep test" focuses on the experimental procedure and the method of evaluating the mechanical properties of the material in creep tests. It covers the procedure for performing creep tests to determine the creep limit and creep strength. The lecture further discusses the creep curve, which provide insight into the creep behavior and mechanical properties of the material at different temperatures and different levels of applied stress. Types of test bars and experimental machines for performing this test are also discussed.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.6 Creep tests

6. Additional notes

-

Topics 8

1. The subject of the lecture

Material standards – division of steels and cast irons, marking of steels and cast irons; classification of non-ferrous metals, marking of non-ferrous metals and alloys (Al, Mg, Cu, Ni+Co, Zn) (6 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Material standards" deals with standards for various metal materials, which contain basic information about these materials, for example their chemical composition, physical, mechanical and technological properties, ways of heat treatment etc. The lecture further deals with the detailed classification of steels, cast irons and alloys of non-ferrous metals (aluminium, magnesium, copper, nickel, cobalt, zinc) and their designation according to the standards.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

The main topic will be discussed in three lectures.

In the first week, students will learn about division of steels and marking of steels.

In the second week, students will learn about division of cast irons and marking of cast irons.

In the third week, students will learn about classification of non-ferrous metals and marking of non-ferrous metals and their alloys.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.1 Material standards,
- chapter 2.1.1 Steels, 2.1.2 Cast irons, 2.1.3 Non-ferrous metals and their alloys

6. Additional notes

The topics will be covered in three lectures.

Topics 9

1. The subject of the lecture

Material databases – use of material databases (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Material databases" deals with the use of databases for various metal materials (steels, cast irons and alloys of non-ferrous metals) that contain basic information about these materials, e.g. their chemical composition, physical, mechanical and technological properties, ways of heat treatment, equivalent material designations etc.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.2 Material databases

6. Additional notes

-

Co-funded by the European Union

Topics 10

1. The subject of the lecture

Principles of material choice – division of metal materials; considerations for the choice of material; methodology of material design (2 hours)

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture "Principles of material choice" covers the division of metal materials, their properties and applications. It deals with considerations for the choice of material, examining factors such as mechanical properties, durability, reliability and cost. The methodology of material design is also discussed, providing insight into the systematic approach used in the selection and design process.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. During the lecture, there is a discussion with the students.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.3 Principles of material choice

6. Additional notes

-

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to the laboratory exercises of the subject *Properties and use of materials*

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the exercise is to acquaint students with the introduction to the laboratory exercises for the subject *Properties and use of materials*, the evaluation method, exam requirements, etc.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- no equipment or materials

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter Introduction

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 2

1. The subject of the laboratory classes

Properties of metal materials (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with fundamental aspects of metals, encompassing their physical, physico-chemical, mechanical and technological properties.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- material standards
- tables of physical, physico-chemical, mechanical and technological properties of materials

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.1 Properties of metal materials

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 3

1. The subject of the laboratory classes

Tensile test (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in tensile test.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.2 Tensile test

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 4

1. The subject of the laboratory classes

Impact bending test (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in impact bending test.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.3 Impact bending test

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 5

1. The subject of the laboratory classes

Hardness tests – static methods (Brinell, Vickers, Rockwell) (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in static hardness tests (Brinell, Vickers, Rockwell).

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.4 Hardness tests

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 6

1. The subject of the laboratory classes

Hardness tests – dynamic methods (Poldi hammer, Leeb) (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in dynamic hardness tests (Poldi hammer, Leeb).

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.4 Hardness tests

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 7

1. The subject of the laboratory classes

Fatigue tests (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in fatigue tests.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.5 Fatigue tests

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 8

1. The subject of the laboratory classes

Creep tests (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the experimental procedure and the method of evaluation of the mechanical properties of the material in creep tests.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- test bars
- experimental machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 1.2.6 Creep tests

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 9

1. The subject of the laboratory classes

Material standards – marking of steels and cast irons (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the designation of steels and cast irons according to standards.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- standards for designation of steels and cast irons

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.1 Material standards, chapter 2.1.1 Steels, 2.1.2 Cast irons

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 10

1. The subject of the laboratory classes

Material standards – marking of non-ferrous metals and alloys (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the designation of non-ferrous metals and alloys according to standards.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- standards for designation of non-ferrous metals and alloys

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.1.3 Non-ferrous metals and their alloys

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 11

1. The subject of the laboratory classes

Material database – Lexicon of metals (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the use of material databases, such as the Lexicon of metals.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- material databases, for example Lexicon of metals
- material standards

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.2 Material databases

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

Topics 12

1. The subject of the laboratory classes

Principles of material choice (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the laboratory exercise is to acquaint students with the principles of material choice.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- material standards

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour lesson in the form of an experimental task, in which the students in cooperation with the teacher will design the assumptions and plan of the experiment.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter 2.3 Principles of material choice

Students should prepare a theoretical introduction to the laboratory exercise.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

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Topics 13

1. The subject of the laboratory classes

Semester thesis presentations (2 hours)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The aim of the exercise is to present topics from the field of properties and use of materials which the students have developed during the semester.

3. Learning outcomes

After completing this topic, the student has detailed knowledge of this area, he/she can use knowledge and information from lectures, literature and other available sources, interpret and critically evaluate them, draw conclusions, formulate and solve problems related to the mentioned topic.

4. Necessary equipment, materials, etc

- no equipment or materials

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Laboratory classes are carried out with the use of specialist research equipment.

b. During laboratory classes, students independently plan the course of the experiment and perform it on their own.

c. During the laboratory classes, presentations of experiments illustrating the discussed topics are made.

d. During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.

The topic of the exercise will be implemented during 2-hour theoretical lesson.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

Vaško, A. – Skočovský, P.: Properties and use of metal materials. EDIS, Žilina 2014.

- chapter according to the selected topic

Students should prepare a semester thesis presentations.

7. Additional notes

Assessment according to the syllabus *Properties and use of materials*.

8. Optional information

Exercise instructions are described in detail in the recommended literature.

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

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SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

MATERIALS ENGINEERNIG

Code: ME

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – <u>lecture</u>

Topics 1

1. The subject of the lecture

Basic Principles of Materials Structure and Properties

2. Thematic scope of the lecture (abstract, maximum 500 words)

Explore fundamental concepts in materials science, focusing on crystalline structures, crystal disorders, and diffusion mechanisms. Investigate the labeling of crystal planes and directions, essential for understanding material properties. Gain insights into the crystallization process of pure metals and the significance of equilibrium diagrams in materials engineering.

3. Learning outcomes

Through this lecture, students will develop the ability to comprehend the crystalline structure of metals and alloys, including identifying crystal disorders and diffusion mechanisms. They will also learn to label crystal planes and directions and understand the crystallization process for pure metals. Equipped with the knowledge of equilibrium diagrams, students will analyze phase transformations in materials and predict material properties and behavior, enhancing their skills in materials engineering.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. The lecture, films related to the discussed issues are presented.

e. During the lecture, there is a discussion with the students.

- The main topic will be continued for two more classes.

In the first week, issues related to fundamentals of crystalline structure, crystal disorders, and diffusion mechanisms in metals and alloys, laying the groundwork for understanding material properties.

In the second week, Students will learn about crystallization process of pure metals and the interpretation of equilibrium diagrams to analyze phase transformations, further enhancing skills in materials engineering.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.
- Lynch, Ch.T.: Handbook of Materials Science, Taylor & Francis Ltd, 2021, 448 p.

6. Additional notes

- The topics will be covered in the next two lectures.

Topics 2

1. The subject of the lecture

Phase Transformations and Heat Treatment

2. Thematic scope of the lecture (abstract, maximum 500 words)

Delve into the complexities of phase transformations within solid-state materials, focusing on the iron-carbon system and the role of alloy structures. Explore various heat treatment procedures and chemical-heat treatment methods to manipulate material properties effectively.

3. Learning outcomes

In this lecture, students will develop a comprehensive understanding of phase transformations in solid-state materials, particularly within the iron-carbon system and alloy structures. They will learn to interpret equilibrium diagrams to predict phase changes and their effects on material properties. Additionally, students will explore various heat treatment procedures and chemical-heat treatment methods to modify material characteristics for specific engineering applications. By the end of the session, students will be able to evaluate the impact of phase transformations and heat treatment on the mechanical properties and performance of materials, and effectively select appropriate heat treatment processes to optimize material properties based on engineering requirements.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. The lecture, films related to the discussed issues are presented.

e. During the lecture, there is a discussion with the students.

- The main topic will be continued for three more classes.

In the first week, will be main focus on investigation of phase transformations in solid-state materials, focusing on the iron-carbon system and alloy structures, and their impact on material properties.

In the second week, Students will explore various heat treatment methods such as annealing, quenching, and tempering, and their influence on material microstructure and mechanical properties.

In the third week, we will discuss advanced heat treatment techniques, including carburizing and nitriding, and their applications in enhancing material performance for specific engineering requirements.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Kuhn, H. - Medlin, D.: ASM Handbook, Volume 8: Mechanical Testing and Evaluation, ASM International, 2000, 998 p.
- Kyriakos, K.: Mechanical Testing of Engineering Materials, Univ Readers, 2017.
- ASM Handbook, Volume 10: Materials Characterization ASM International, 2019, 807 p.

6. Additional notes

- The topics will be covered in the next three lectures.

Topics 3

1. The subject of the lecture

Phase Transformations and Heat Treatment

2. Thematic scope of the lecture (abstract, maximum 500 words)

Uncover the fundamental principles underlying the physical properties of metals, their resistance to corrosion, and their mechanical behaviors under various loading conditions. Explore deformation mechanisms, fracture mechanics, and the phenomena of fatigue and creep, aiming to comprehend material failure mechanisms and enhance structural reliability.

3. Learning outcomes

Upon completing this lecture, students will possess a thorough understanding of the physical properties of metals, encompassing their mechanical behavior and resistance to corrosion. They will also acquire proficiency in analyzing deformation mechanisms and fracture mechanics to anticipate material failure, as well as insight into fatigue and creep phenomena for evaluating material performance under prolonged loading conditions. Ultimately, students will develop enhanced skills in identifying and mitigating failure mechanisms to bolster structural reliability in engineering applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. The lecture, films related to the discussed issues are presented.

e. During the lecture, there is a discussion with the students.

- The main topic will be continued for three more classes.

In the first week Students will *explore the physical properties of metals and their resistance to corrosion, alongside an analysis of deformation mechanisms and fracture mechanics.*

In the second week, students will delve deeper into fatigue and creep phenomena, understanding their implications on material performance under prolonged loading conditions.

In the third week, Students will focus on identifying and mitigating failure mechanisms to enhance structural reliability in engineering applications.

5.	Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.

6.	Additional notes

- The topics will be covered in the next three lectures.

Topics 4

1. The subject of the lecture

Advanced Materials and Alloys

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture will encompass the properties, heat treatment, and practical applications of technical iron alloys, carbon and low-alloy structural steels, as well as steels with special properties and their developmental trends. Additionally, it will delve into the characteristics and utilization of tool steels, casting steels, and non-ferrous metals, providing insights into the influencing properties of non-ferrous alloys and light metals. Finally, it will cover the significance of refractory alloys, alloys of refractory metals, and powder metallurgy techniques, along with an introduction to macromolecular chemistry and the structural influences on the properties of plastics.

3. Learning outcomes

Upon completing this lecture, students will attain proficiency in comprehending the properties, heat treatment, and practical applications of various technical iron alloys, carbon and low-alloy structural steels, and steels with special properties. They will also acquire the ability to analyze the developmental trends in structural steels, understand the characteristics and utilization of tool steels, casting steels, and non-ferrous metals, including their influencing properties. Moreover, they will gain insight into the significance of refractory alloys, alloys of refractory metals, and powder metallurgy techniques, alongside an introduction to macromolecular chemistry and its influence on material properties. Ultimately, students will develop enhanced skills in applying acquired knowledge to evaluate and select advanced materials for diverse engineering applications, considering their structural and performance requirements.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. The lecture, films related to the discussed issues are presented.

e. During the lecture, there is a discussion with the students.

- The main topic will be continued for three more classes.

In the first week Introduction to advanced materials, focusing on technical iron alloys, carbon and low-alloy structural steels, and steels with special properties.

In the second week, Exploration of tool steels, casting steels, and non-ferrous metals, including their properties and utilization in engineering applications.

In the third week, Students will focus In-depth study of refractory alloys, alloys of refractory metals, powder metallurgy techniques, and macromolecular chemistry, emphasizing their significance and applications in material engineering.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Ashby, M.F. - Jones, D.R.H.: Engineering Materials 1. An Introduction to Properties, Applications and Design. 4. edition, CPI, UK, 2015
- Lynch, Ch.T.: Handbook of Materials Science, Taylor & Francis Ltd, 2021, 448 p.
- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p..

6. Additional notes

- The topics will be covered in the next three lectures.

Topics 5

1. The subject of the lecture

Polymer and Composite Materials

2. Thematic scope of the lecture (abstract, maximum 500 words)

The Polymer and Composite Materials lecture delves into the realm of macromolecular chemistry, investigating the intricate structures and influencing factors on the properties of plastics. Additionally, it explores the diverse categories of thermoplastics, reactoplastics, and elastomers, elucidating their structural intricacies and characteristic properties.

3. Learning outcomes

Upon completing this lecture, students will acquire a comprehensive understanding of macromolecular chemistry and its application in materials engineering. They will develop the ability to analyze the structural characteristics of plastics and their effects on material properties. Furthermore, students will be proficient in differentiating between various types of polymers and composites, discerning their unique properties and potential engineering applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. The lecture, films related to the discussed issues are presented.

e. During the lecture, there is a discussion with the students.

- The main topic will be continued for two more classes.

In the first week Introduction to macromolecular chemistry and the structural analysis of plastics, emphasizing their properties and applications in materials engineering.

In the second week, In-depth exploration of thermoplastics, reactoplastics, and elastomers, focusing on their distinct structures, properties, and engineering utilization.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

- Ashby, M.F. - Jones, D.R.H.: Engineering Materials 1. An Introduction to Properties, Applications and Design. 4. edition, CPI, UK, 2015
- Lynch, Ch.T.: Handbook of Materials Science, Taylor & Francis Ltd, 2021, 448 p.
- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.

6. Additional notes

- The topics will be covered in the next two lectures.

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Crystallography and Equilibrium Diagrams

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to principles of crystallography, mastering the interpretation of equilibrium diagrams, and analyzing iron-carbon systems. Gain insights into the structural complexities of materials and their behavior under varying conditions, essential for material characterization and engineering applications.

3. Learning outcomes

Upon completing the Crystallography and Equilibrium Diagrams topic, students will demonstrate proficiency in crystallographic principles, equilibrium diagram interpretation, and iron-carbon system analysis, empowering them to predict material behavior and understand phase transformations in materials engineering.

4. Necessary equipment, materials, etc

- Physical-mathematical tables;
- Tables for materials, metals physical constants

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.

- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 1 **report** for **2 points**. **The sum of points achieved is 2.**

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Material Testing Techniques

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Develop proficiency in material testing methodologies, including tensile testing for mechanical properties, bending impact, and hardness tests. Acquire skills in fatigue testing, crucial for assessing material durability and performance in real-world applications.

3. Learning outcomes

After completing the Material Testing Techniques topic, students will have acquired the skills to conduct and interpret results from various mechanical tests, including tensile, bending impact, and hardness tests, as well as fatigue testing methodologies, enabling them to evaluate material performance and integrity effectively in engineering applications.

4. Necessary equipment, materials, etc

- equipment for bending impact test
- hardness testers
- microscopes
- Strength machine

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes.

In the first week Students will immerse themselves in practical material testing techniques, including tensile testing for mechanical properties and bending impact and hardness tests, gaining hands-on experience in evaluating material behavior under various conditions.

In the second week, will focus on exploring fatigue testing methodologies, deepening their understanding of material fatigue and its implications in engineering applications.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.
- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 2 **report** for **2 points**. **The sum of points achieved is 4.**

- The topics will be covered in the next two lectures.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

Microstructure Analysis

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Master the fundamentals of light microscopy to analyze material microstructures effectively. Explore the intricacies of microstructures in steels and cast irons, examining changes post heat treatment. Gain expertise in microstructural evaluation, essential for understanding material properties and behavior.

3. Learning outcomes

After completing the Microstructure Analysis topic, students will be proficient in utilizing light microscopy to analyze material microstructures, particularly in steels and cast irons. They will also demonstrate an understanding of how microstructures evolve following heat treatment processes, facilitating informed decision-making in material selection and processing.

4. Necessary equipment, materials, etc

- microscopes
- Electron microscope

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes.

In the first week Students will focus on mastering the fundamentals of light microscopy for analyzing material microstructures, particularly in steels and cast irons.

- In the second week, they will delve into the examination of microstructures and explore how they evolve following various heat treatment processes.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.
- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 2 **report** for **2 points**. **The sum of points achieved is 4.**

- 1. continuous control written work – max.10 points **The sum of points achieved is 10 points.**

- The topics will be covered in the next two lectures.

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Non-Destructive Testing

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Learn the principles and applications of non-destructive testing methods, enabling evaluation of material structures without causing damage. Develop skills in employing various non-destructive techniques to assess material integrity and detect flaws or defects, ensuring reliability and safety in engineering applications.

3. Learning outcomes

Upon completing the Non-Destructive Testing topic, students will acquire proficiency in the principles of non-destructive testing methods, enabling them to evaluate material structures without causing damage and apply these techniques effectively in real-world scenarios.

4. Necessary equipment, materials, etc

- X-ray equipment
- ultrasound tests
- capillary tests

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes.

In the first week students will delve into the principles of non-destructive testing methods and their applications, gaining insight into evaluating material structures without causing damage.

- In the second week they will focus on real-world scenarios where non-destructive testing techniques are applied, honing their practical skills and problem-solving abilities.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.
- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 2 **report** for **2 points**. **The sum of points achieved is 4.**

- The topics will be covered in the next two lectures.

8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Advanced Material Applications

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Explore advanced material applications, including the application of metastable Fe-Fe3C systems and testing steels for welded structures. Dive into the analysis of alloys such as aluminium, titanium, and nickel, understanding their properties and suitability for specific engineering purposes.

3. Learning outcomes

After completing the Advanced Material Applications topic, students will demonstrate proficiency in applying the metastable Fe-Fe3C system, testing steels for welded structures, and analyzing alloys such as aluminium, titanium, and nickel. They will be equipped to employ these advanced materials effectively in various engineering applications, showcasing their understanding of material properties and their practical implications.

4. Necessary equipment, materials, etc

- Physical-mathematical tables;
- Tables for materials, metals physical constants

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes.

In the first week students will focus on understanding and applying the metastable Fe-Fe3C system, along with testing steels for welded structures.

-*The second week* will be dedicated to analyzing advanced alloys like aluminium, titanium, and nickel, exploring their properties and potential engineering applications.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.
- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 2 **report** for **2 points**. **The sum of points achieved is 4.**

- The topics will be covered in the next two lectures.

8. Optional information

NO

Topics 6

1. The subject of the laboratory classes

Material Standards and Importance

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

Understand the significance of material standards and specifications in ensuring quality and reliability in engineering. Explore ethical considerations in material selection and usage, emphasizing the importance of adherence to standards for safety, performance, and sustainability.

3. Learning outcomes

Upon completing the Material Standards and Importance topic, students will gain a comprehensive understanding of material standards and specifications, recognize the significance of materials engineering in various industries, and develop awareness of ethical considerations related to material selection and usage.

4. Necessary equipment, materials, etc

- Physical-mathematical tables;
- Tables for materials, metals physical constants

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- _During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyze the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.

- Callister, W.D. - Jordan, R. - Rethwisch, D.G.: Callister's Materials Science and Engineering, John Wiley & Sons, 2020, 944 p.
- Green, A.: Materials Science for Engineers, NY Research Press, 2016, 288 p.
- Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
- ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International, 1990, 1063 p.
- ASM Handbook Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, ASM International, 1990, 1328 p.
- Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.Students should prepare a theoretical introduction to the laboratories

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; 1 **report** for **2 points**. **The sum of points achieved is 2.**

- 1. continuous control written work – max.10 points **The sum of points achieved is 10 points.**

8. Optional information

NO

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Content preparation: Project Team of Materials Science Ma(s)ters, University of Žilina

Co-funded by the European Union

SUPPLEMENTARY MATERIALS

FOR THE FOUR-SEMESTER MASTER'S DEGREE PROGRAM

MATERIALS SCIENCE MA(S)TERS

TEACHERS' GUIDE

The Teachers' Guide is a supplement to the information contained in the course syllabus

SURFACE TREATMENT OF ADVANCED ENGINEERING MATERIALS

Code: STAEM

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

Course content – lecture

Topics 1

1. The subject of the lecture

Introduction to thermo-chemical treatment – in general

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture will cover the fundamental principles and practical applications of thermochemical surface modification processes, focusing on the metastable Fe-Fe3C system and the associated T-T-T (time-temperature transformation) and C-C-T (continuous cooling transformation) diagrams. It is important to recognise the complexity of these topics and the potential of differing perspectives, but the information presented here is intended to provide a balanced and informative overview. The lecture will provide students with a comprehensive understanding of various techniques used to modify the surface properties of materials. It will begin with an overview of thermochemical surface modification processes, including methods such as carburising, nitriding, and boriding. These methods are crucial in enhancing material properties such as hardness, wear, and corrosion resistance. The lecture will emphasize the significance of surface treatments in the field of materials science and engineering, displaying the speaker's expertise and knowledge on the subject. The lecture emphasizes the importance of surface treatments in extending the lifespan of components exposed to harsh environments, improving overall performance, and ensuring material reliability across various industries. Additionally, a significant portion of the lecture is dedicated to the Fe-Fe3C phase diagram, which is an essential tool in metallurgy. This diagram provides valuable insight into the relationships between temperature, composition, and phases present in iron-carbon alloys. A thorough understanding of the phase diagram is crucial for accurately predicting material behaviour during heat treatment processes, especially in the context of a metastable system. Additionally, the lecture's content is further enriched by the introduction of T-T-T and C-C-T diagrams. These diagrams are highly effective tools for accurately predicting microstructural transformations in materials under specific time-temperature conditions. By expertly illustrating how to construct and interpret these diagrams, students can confidently predict the evolution of microstructures during different heat treatment scenarios. The lecture also thoughtfully explores the numerous applications of T-T-T and C-C-T diagrams in the context of heat treatment. It shows how these diagrams guide engineers and metallurgists in controlling the final properties of materials through precise manipulation of heat treatment parameters. The ability to predict and control microstructural changes is crucial in tailoring materials to meet the requirements of various engineering applications. This talk introduces thermochemical surface processing, highlighting the importance of the Fe-Fe3C phase diagram. Additionally, it offers practical insights into the use of T-T-T and C-C-T diagrams to predict and control microstructural changes during heat treatment processes. This fundamental knowledge equips students with a strong foundation for further exploration and application in the field of materials engineering.

3. Learning outcomes

The first lecture on thermo-chemical surface modification processes covers essential principles and applications, focusing on the Fe-Fe3C system and T-T-T and C-C-T diagrams. It provides a comprehensive understanding of techniques like carburising, nitriding, and boriding to enhance material properties such as hardness and corrosion resistance. Emphasizing the importance of surface treatments in materials science, it extends component lifespan in harsh environments and improves performance across industries. The lecture delves into the Fe-Fe3C phase diagram crucial in metallurgy, aiding in predicting material behaviour during heat treatment processes. Additionally, it introduces T-T-T and C-C-T diagrams to predict microstructural changes accurately under specific conditions, guiding engineers in controlling material properties through heat treatment parameters. This foundational knowledge equips students with a strong basis for further exploration in materials engineering.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for two more classes.

<u>In the first week</u>, lecture will cover the fundamental principles and practical applications of thermo-chemical surface modification processes, focusing on the metastable Fe-Fe3C system and the associated T-T-T (time-temperature transformation) and C-C-T (continuous cooling transformation) diagrams.

<u>In the second week</u>, Students will learn about techniques like carburising, nitriding, and boriding to enhance material properties such as hardness and corrosion resistance - in general. Emphasizing the importance of surface treatments in materials science, it extends component lifespan in harsh environments and improves performance across industries.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.

- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

6. Additional notes

The topics will be covered in the next two lectures.

Topics 2

1. The subject of the lecture

Diffusion in metals and alloys, Fick's Laws

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on diffusion in metals and alloys with a focus on Fick's Law encompasses a broad thematic scope that includes fundamental aspects of diffusion in these materials, an explanation of Fick's laws of diffusion, and the importance of diffusion in thermo-chemical surface treatment processes. Fundamentals of diffusion in metals and alloys are extensively covered, providing students with a deep understanding of how atoms move within these materials, influencing their properties. The lecture elucidates the mechanisms of diffusion, highlighting its impact on the structural and mechanical characteristics of metals and alloys. The lecture also delves into a detailed explanation of Fick's laws of diffusion, which govern mass transport in solids, liquids, and gases. By comprehensively exploring these laws, students gain insights into how diffusion phenomena occur in metals and alloys, enabling them to predict and analyse diffusion processes accurately. Moreover, the thematic scope includes emphasizing the importance of diffusion in thermo-chemical surface treatment processes. Students learn how diffusion plays a crucial role in modifying material properties through processes like carburizing, nitriding, and boriding. Understanding the significance of diffusion in these treatments is essential for enhancing material properties such as hardness, wear resistance, and corrosion resistance. In summary, this lecture provides a comprehensive overview of diffusion in metals and alloys by covering fundamental principles, explaining Fick's laws of diffusion, and highlighting the critical role of diffusion in thermo-chemical surface treatment processes. This knowledge equips students with a solid foundation to comprehend and manipulate diffusion processes for tailored material performance in various industrial applications.

3. Learning outcomes

Students who engage with this lecture can expect deep understanding of diffusion fundamentals by exploring the mechanisms of diffusion in metals and alloys, students will develop a profound comprehension of how atoms move within materials, influencing their structural and mechanical properties. Through a detailed explanation of Fick's first and second laws of diffusion, students will gain insights into mass transport in solids and analyse diffusion processes accurately. In summary, the lecture on diffusion in metals and alloys offers a robust educational experience that equips students with a strong foundation in understanding diffusion phenomena, applying Fick's laws of diffusion, and recognizing the critical role of diffusion in surface treatment processes and material engineering applications.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

At this point, we also specify the form of conducting classes.

- The main topic will be continued for two more classes.

In the first week, the first lesson, delves into the fundamental aspects of diffusion in metals and alloys, exploring how atoms move through the crystalline lattice. This lesson covers two main types of diffusion in solids: interstitial diffusion and substitutional diffusion. It also explains Fick's first and second laws of diffusion, emphasizing various applications of the latter. Students will gain insights into the temperature dependence of diffusion, intrinsic diffusion coefficients (Kirkendall effect), and high diffusion paths.

In the second week, the second lesson focuses on the critical role of diffusion in thermo-chemical surface treatment processes for metals and alloys. Students will learn how diffusion influences processes like carburizing, nitriding, and boriding, which are essential for modifying material properties such as hardness, wear resistance, and corrosion resistance. Understanding the significance of diffusion in these treatments equips students with the knowledge to enhance material performance effectively in various industrial applications.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

6. Additional notes

The topics will be covered in the next two lectures.

Topics 3

1. The subject of the lecture

Steel austenitization

2. Thematic scope of the lecture (abstract, maximum 500 words)

Steel austenitization is a critical process in the production of steel, as it significantly affects the microstructure and mechanical properties of the final product. This lecture will cover the definition and significance of austenitization, the differences between hypo- and hyper-eutectoid steels in terms of austenitization behaviour, and the effects of austenitization on the microstructure and mechanical properties of steels. Austenitization is the process of transforming steel from its original state to austenite, a stable phase at high temperatures. This process is essential for the production of high-strength steels, as it allows for the formation of microstructures that enhance the mechanical properties of the steel. The significance of austenitization lies in its ability to produce steels with improved strength, ductility, and toughness, which are essential for various applications, such as automotive, aerospace, and construction industries.

The lecture will then discuss the differences between hypo- and hyper-eutectoid steels in terms of their austenitization behaviour. Hypo-eutectoid steels are those with less than 0.765% carbon, while hyper-eutectoid steels have more than 0.765% carbon. The austenitization behaviour of these steels will be compared, highlighting the differences in their response to heat treatment and the resulting microstructures. Hypo-eutectoid steels typically exhibit a uniform microstructure, while hyper-eutectoid steels may have a more complex microstructure due to the presence of carbides and other phases. The lecture will also explore the effects of austenitization on the microstructure and mechanical properties of steels. This will include a discussion of how austenitization can lead to the formation of different microstructures, such as ferrite, pearlite, and bainite. The microstructure of the steel will affect its mechanical properties, such as strength, ductility, and toughness. For example, steels with a high percentage of ferrite will have good ductility but lower strength, while steels with a high percentage of pearlite will have good strength but lower ductility. The lecture will also discuss how austenitization can lead to the formation of carbides, which can improve the strength and hardness of the steel.

3. Learning outcomes

For master's degree students, this lecture will provide a more in-depth understanding of the process and its impact on steel properties, which will be essential for their future careers in the steel industry or related fields. It is possible to point out a few main outcomes from lecture: i) understanding the definition and significance of austenitization in steel production; ii) knowledge of the differences between hypo- and hyper-eutectoid steels in terms of austenitization behaviour; iii) ability to explain the effects of austenitization on the microstructure and mechanical properties of steels; iv) understanding the impact of austenitization on the formation of different microstructures, such as ferrite, pearlite, bainite and martensite; v) knowledge of how austenitization can lead to the formation of carbides and their impact on the strength and hardness of the steel.

Overall, this lecture supports ability to apply this knowledge to the design and production of high-quality steel products.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

At this point, we also specify the form of conducting classes.

- The main topic will be continued for three more classes.

In the first week, students become familiar with an introduction to Steel Austenitization. This lesson will introduce the concept of austenitization, its significance in steel production, and the impact of austenitization on the microstructure and mechanical properties of steels. The lecture will also cover the differences between hypo- and hyper-eutectoid steels in terms of austenitization behaviour.

In the second week, the effects of austenitization on microstructure and mechanical properties will be main topic. This lesson will focus on the effects of austenitization on the formation of different microstructures, such as ferrite, pearlite, bainite and martensite, and how these microstructures affect the mechanical properties of steels, including strength, ductility, and toughness. The lecture will also discuss the formation of carbides and their impact on the strength and hardness of the steel.

In the third week, we focus on the application of austenitization in steel production. The final lesson will apply the knowledge gained in the previous lessons to the design and production of high-quality steel products. The lecture will discuss how austenitization can be used to produce steels with improved strength, ductility, and toughness, which are essential for various applications, such as automotive, aerospace, and construction industries.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.

- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

6. Additional notes

The topics will be covered in the next three lectures.

Topics 4

1. The subject of the lecture

Thermo-chemical processing and methods of surface enhancement

2. Thematic scope of the lecture (abstract, maximum 500 words)

This lecture provide students with a comprehensive understanding of thermo-chemical processing techniques, methods for enhancing material surfaces, specific thermo-chemical processes like carburizing and nitriding, selection criteria for steels suitable for treatment, and examples of steels commonly used in these processes. This knowledge is essential for students pursuing advanced studies in materials science, metallurgy, or related fields where surface engineering plays a crucial role in material performance enhancement. In more detail, we goes through various topics such as: *1) Introduction to thermo-chemical processing techniques.* This section will provide an overview of thermo-chemical processing techniques used to modify the surface properties of materials. It will cover the principles and applications of processes like carburizing, nitro-cementing, nitriding, carbonitriding, boriding, and diffused alitizing. *2) Methods for increasing mechanical, physical, and chemical properties of material surfaces.* This part of the lecture will focus on methods aimed at enhancing the mechanical, physical, and chemical properties of material surfaces through thermo-chemical treatments. These methods play a crucial role in improving wear resistance, hardness, and corrosion resistance of steel components. *3) Focus on specific thermo-chemical processes*. This topic will delve into specific thermo-chemical processes such as carburizing (introducing carbon), nitro-cementing (adding nitrogen and carbon), nitriding (adding nitrogen), carbonitriding (adding carbon and nitrogen), boriding (adding boron), and diffused alitizing. Each process will be explained in terms of its purpose, mechanism, and effects on material properties. *4) Selection criteria for steels suitable for thermo-chemical treatment*. This part will discuss the criteria for selecting steels suitable for thermo-chemical treatment, considering factors like alloy composition, hardenability, and intended application. The influence of alloy composition on the response to heat treatment will be explored to understand how different steels behave under thermo-chemical processes. Finally, *5) Examples of steels commonly used in thermo-chemical surface treatment processes.* This part of the lecture continuous of part (4) and will provide examples of steels commonly used in thermo-chemical surface treatment processes, highlighting their specific properties and applications. Students will learn about the characteristics that make certain steels well suited for carburizing, nitriding, or other surface enhancement techniques.

3. Learning outcomes

The learning outcomes from the lesson on thermo-chemical processing techniques for master's degree students in materials science include:

1. Comprehensive understanding of thermo-chemical processing techniques. Students will gain an in-depth knowledge of techniques used to modify material surfaces, such as carburizing, nitro-cementing, nitriding, carbonitriding, boriding, and diffused alitizing.
2. Enhancing mechanical, physical, and chemical properties. Students will learn methods to enhance surface properties like wear resistance, hardness, and corrosion resistance through thermo-chemical treatments.
3. Specific thermo-chemical processes. Understanding specific processes like carburizing, nitro-cementing, nitriding, carbonitriding, boriding, and diffused alitizing in terms of purpose, mechanism, and effects on material properties.
4. Selection criteria for steels suitable for treatment. Students will grasp the criteria for selecting steels suitable for thermo-chemical treatment based on alloy composition, hardenability, and intended application.
5. Examples of steels for thermo-chemical treatment. Identifying steels commonly used in surface treatment processes and understanding their properties that make them suitable for techniques like carburizing and nitriding.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

At this point, we also specify the form of conducting classes.

- The main topic will be continued for three more classes.

In the first week, Introduction to thermo-chemical processing techniques and Methods for surface enhancement - this lesson provides an overview of thermo-chemical processing techniques used to modify material surfaces, including carburizing, nitro-cementing, nitriding, carbonitriding, boriding, and diffused alitizing. Students will also learn methods to enhance mechanical, physical, and chemical properties of material surfaces through thermo-chemical treatments.

In the second week, Focus on specific thermo-chemical processes - in this lesson, students delve into specific thermo-chemical processes such as carburizing (introducing carbon), nitro-cementing (adding nitrogen and carbon), nitriding (adding nitrogen), carbonitriding (adding carbon and nitrogen), boriding (adding boron), and diffused alitizing. Each process is explained in terms of its purpose, mechanism, and effects on material properties.

In the third week, Selection criteria for steels suitable for thermo-chemical treatment - the final lesson discusses the criteria for selecting steels suitable for thermo-chemical treatment based on factors like alloy composition, hardenability, and intended application. The influence of *alloy composition on the response to heat treatment is explored, along with examples of steels commonly used in thermo-chemical surface treatment processes.*

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

6. Additional notes

The topics will be covered in the next three lectures.

Topics 5

1. The subject of the lecture

Thermophysical PVD and thermochemical CVD coatings

2. Thematic scope of the lecture (abstract, maximum 500 words)

The lecture on "Thermophysical PVD and thermochemical CVD coatings" for master's degree students in materials science is structured to provide a comprehensive and detailed understanding of advanced surface coating techniques. This lecture aims to equip students with the knowledge and skills necessary to comprehend, evaluate, and apply thermophysical PVD and thermochemical CVD coatings effectively in materials science research and industrial applications. Is divided into three main, or key subtopics: 1) Explanation of Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) Techniques. Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) are fundamental techniques used in thin film deposition processes. PVD involves the physical transfer of material from a source to a substrate through evaporation or sputtering, while CVD relies on chemical reactions to deposit thin films. Understanding the principles, equipment, deposition mechanisms, and material compatibility of PVD and CVD is crucial for mastering surface coating technologies. 2) Overview of thermophysical PVD and thermochemical CVD coatings. Thermophysical PVD coatings are characterized by their high purity, uniform thickness, excellent adhesion to substrates, and precise control over film properties. These coatings are often used to enhance wear resistance, corrosion protection, and thermal stability of surfaces. On the other hand, thermochemical CVD coatings involve chemical reactions at the substrate surface to form coatings with tailored properties such as hardness, lubricity, and chemical inertness. Exploring the unique characteristics and applications of thermophysical PVD and thermochemical CVD coatings provides insights into their role in surface engineering. 3) Discussion of Thermophysical Physical Vapour Deposition (PVD) and Thermochemical Chemical Vapour Deposition (CVD) coatings for surface enhancement. Analysing the impact of thermophysical PVD coatings on surface properties reveals their ability to improve mechanical strength, tribological performance, and resistance to environmental degradation. These coatings find applications in aerospace, automotive, cutting tools, and medical devices where enhanced surface properties are critical. Thermochemical CVD coatings offer tailored solutions for specific applications by controlling the composition, structure, and properties of deposited films. Understanding how these coatings modify surface characteristics enables students to appreciate their significance in achieving desired material performance enhancements.

By exploring the intricacies of thermophysical PVD and thermochemical CVD coatings in this lecture, master's degree students will gain a profound understanding of these advanced surface-coating techniques essential for materials science research and industrial applications. The detailed examination of deposition processes, coating properties, applications, and performance benefits will empower students to leverage these technologies effectively in their academic pursuits and professional endeavours.

3. Learning outcomes

The learning outcomes from the lecture are as follows:

1) Comprehensive understanding of PVD and CVD techniques. Mastery of the principles, processes, and equipment involved in Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) techniques. Ability to differentiate between PVD and CVD methods, understanding their deposition mechanisms, material compatibility, and applications in surface engineering.
2) In-depth knowledge of thermophysical PVD and thermochemical CVD coatings. Proficiency in analysing thermophysical PVD coatings, including their characteristics such as high purity, uniform thickness, and adhesion to substrates. Understanding the properties and applications of thermochemical CVD coatings for tailored surface enhancements like hardness, lubricity, and chemical inertness.
3) Application of coatings for surface enhancement. Capability to evaluate the role of thermophysical PVD coatings in improving mechanical strength, wear resistance, corrosion protection, and thermal stability of surfaces. Profound understanding of how thermochemical CVD coatings modify surface characteristics to meet specific application requirements effectively.
4) Critical analysis skills. Ability critically analyse the impact of thermophysical PVD and thermochemical CVD coatings on material properties and performance. Proficiency in evaluating the advantages and limitations of these advanced coating technologies for diverse industrial applications.
5) Practical application skills. Skill development in selecting appropriate coating techniques based on material requirements, performance objectives, and environmental conditions. Proficiency in applying thermophysical PVD and thermochemical CVD coatings to enhance the functionality, durability, and reliability of materials.

4. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

a. Lecture conducted with a traditional board or an interactive board.

b. Lecture conducted with the use of multimedia.

c. Problem–based lecture. During the lecture, presentations of experiments illustrating the discussed topics are made.

d. Discussion with the students about the presented topic during the lesson.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be continued for three more classes.

<u>In the first week</u>, students will delve into the fundamental techniques of thin film deposition processes through Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD). They will learn about the physical transfer of material in PVD via evaporation or sputtering and the chemical reactions involved in CVD for depositing thin films. Understanding the

principles, equipment, deposition mechanisms, and material compatibility of PVD and CVD will be emphasized to provide a solid foundation for mastering surface coating technologies.

In the second week, this lesson will focus on exploring thermophysical PVD coatings known for their high purity, uniform thickness, and excellent adhesion to substrates, and precise control over film properties. Students will also study thermochemical CVD coatings that involve chemical reactions at the substrate surface to create coatings with tailored properties like hardness, lubricity, and chemical inertness. By examining the unique characteristics and applications of these coatings, students will gain insights into their significance in surface engineering.

In the third week, in the final lesson, students will analyse the impact of thermophysical PVD coatings on surface properties, focusing on improvements in mechanical strength, tribological performance, and resistance to environmental degradation. They will also explore how thermochemical CVD coatings offer tailored solutions for specific applications by controlling the composition, structure, and properties of deposited films. Understanding how these coatings modify surface characteristics will enable students to appreciate their role in achieving desired material performance enhancements.

5. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

3. Additional notes

Course content – laboratory classes

Topics 1

1. The subject of the laboratory classes

Introduction to thermo-chemical surface treatment

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The topics of the laboratory classes are related to lecture topic No. 1. By familiarizing with the basic equipment used in thermo-chemical surface treatment and understanding the principles and techniques involved, master's degree students will be able to apply these surface treatment methods effectively in various industries, such as aerospace, automotive, and medical devices, to enhance the performance and durability of materials. The laboratory and exercise work involves the following thematic scope: 1) Overview of thermo-chemical surface treatment. Understanding the principles of thermo-chemical surface treatment, which involves the use of heat and chemical reactions to modify the surface properties of materials. Learning about the various types of thermo-chemical surface treatments, such as annealing, heat treatment, and chemical vapour deposition (CVD). 2) Familiarization with basic equipment. Learning about the basic equipment used in thermo-chemical surface treatment, including furnaces, heat treatment ovens, and CVD reactors. Understanding the operation and maintenance of this equipment to ensure safe and effective use. 3) Surface modification techniques. Learning about the various surface modification techniques used in thermo-chemical surface treatment, such as oxidation, carburization, and nitriding. Understanding the effects of these techniques on the surface properties of materials, such as hardness, wear resistance, and corrosion resistance. 4) Material selection and process optimization. Learning about the selection of materials for thermo-chemical surface treatment, considering factors such as material properties, desired surface properties, and process constraints. Understanding the optimization of thermo-chemical surface treatment processes to achieve the desired surface properties efficiently and cost-effectively. 5) Quality control and inspection. Learning about the quality control and inspection techniques used in thermo-chemical surface treatment, such as microscopy, spectroscopy, and mechanical testing. Understanding the importance of quality control in ensuring the consistency and reliability of the surface treatment process.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge in the field of understanding of thermo-chemical surface treatment principles (Gain a comprehensive understanding of the principles behind thermo-chemical surface treatment methods involving heat and chemical reactions to modify material surfaces.), proficiency in equipment operation, application of surface modification techniques (Apply various surface modification techniques like oxidation, carburization, and nitriding learned during the laboratory work to alter material properties.), material selection and process optimization skills (Develop skills in optimizing thermo-chemical treatment processes to achieve desired surface modifications efficiently while considering material constraints.), and quality control and inspection proficiency.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator; Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.

- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **2 reports**, each for **2 points**. **The sum of points achieved is 4.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 2

1. The subject of the laboratory classes

Application of metastable system Fe – Fe3C: T-T-T and C-C-T diagrams

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The laboratory work is designed to provide students with a comprehensive understanding of austenitization in hypo- and hyper-eutectoid steels, focusing on practical calculations and applications. The thematic scope includes:

Definition and significance of austenitization:

Understanding the process of austenitization, which involves the transformation of steel to austenite for subsequent phase transformations. Learning about the significance of austenitization in altering material properties.

Differences between hypo- and hyper-eutectoid steels:

Exploring the differences in austenitization behaviour between hypo- and hyper-eutectoid steels, highlighting how composition influences phase changes. Understanding how the presence of Fe3C (iron carbide) affects the austenitization process.

Effects of austenitization on microstructure and mechanical properties:

Analysing the impact of austenitization on microstructural evolution and mechanical properties, emphasizing the role of phase transformations in determining steel characteristics. Learning about the effects of austenitization on the formation of pearlitic, bainitic, and martensitic microstructures.

Overview of pearlitic, bainitic, and martensitic transformations:

Studying the mechanisms behind pearlitic, bainitic, and martensitic transformations, understanding how these transformations occur during cooling. Learning about the factors that influence the formation of these microstructures during cooling.

Relationship between cooling rate and microstructure:

Investigating the relationship between cooling rate and resulting microstructure in steels, understanding how cooling rates influence the formation of pearlitic, bainitic, and martensitic microstructures.

Construction of T-T-T and C-C-T Diagrams:

Learning to construct T-T-T (time-temperature-transformation) and C-C-T (continuous-cooling-transformation) diagrams based on experimental data. Understanding the importance of these diagrams in predicting microstructural transformations accurately.

Interpretation of diagrams:

Interpreting T-T-T and C-C-T diagrams to predict microstructural transformations, enabling students to optimize heat treatment processes for specific material applications. Learning to identify the appropriate cooling rate and time for a given steel composition to achieve the desired microstructure and mechanical properties.

By engaging in these laboratory activities, master's degree students will develop a comprehensive understanding of austenitization in hypo- and hyper-eutectoid steels, the differences in austenitization behaviour between these steels, the effects of austenitization on microstructure and mechanical properties, the mechanisms behind pearlitic, bainitic, and martensitic transformations, the relationship between cooling rate and microstructure, and the construction and interpretation of T-T-T and C-C-T diagrams. These skills will equip students to optimize heat treatment processes for specific material applications, tailoring material properties effectively for various engineering needs.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about austenitization. Can also use information from literature, databases and other available sources. The laboratory work focusing on the "Application of metastable system Fe – Fe3C: T-T-T and C-C-T diagrams" offers several key learning outcomes for master's degree students. By engaging in this practical application of phase transformations in steel systems, students will develop a deep understanding of austenitization in hypo- and hyper-eutectoid steels, gaining proficiency in analysing the differences in austenitization behaviour between these steel types. They will also enhance their ability to assess the effects of austenitization on microstructural evolution and mechanical properties, enabling them to make informed decisions regarding material processing and heat treatment. Through constructing T-T-T and C-C-T diagrams based on experimental data, students will sharpen their skills in predicting and interpreting microstructural transformations accurately, a critical aspect of optimizing heat treatment processes for specific material applications. Additionally, students will learn to identify the relationship between cooling rates and resulting microstructures in steels, providing them with valuable insights into controlling material properties through tailored heat treatment procedures. Overall, mastering these concepts and techniques will empower students to apply their knowledge effectively in materials science research and industrial settings, equipping them with the skills needed to manipulate material properties through controlled phase transformations for diverse engineering applications. They are aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;

- Tables for materials, metals physical constants
- Calculator; Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **2 reports**, each for **2 points**. **The sum of points achieved is 4.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 3

1. The subject of the laboratory classes

Diffusion in metals and alloys: Fick's Law and its application

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The laboratory work on "Diffusion in metals and alloys: Fick's Law and its application" encompasses a detailed exploration of the fundamentals of diffusion in metals and alloys, an elucidation of Fick's laws of diffusion, and an examination of the significance of diffusion in thermo-chemical surface treatment processes. The thematic scope of this laboratory work is structured to provide students with a profound understanding of temperature dependence of diffusion, diffusion mechanisms, the application of Fick's laws, examples of diffusion calculations in various materials, and the distinctions between substitutional and interstitial mechanisms of diffusion.

Temperature dependence of diffusion:

The diffusion coefficient, which measures the rate of diffusion, is significantly influenced by temperature. As temperature increases, the diffusion coefficient typically rises due to the greater thermal energy available for atomic movement. Higher temperatures provide atoms with increased kinetic energy, enabling them to overcome energy barriers more easily and diffuse through the material at a faster rate.

Application of Fick's Laws with temperature variation:

When applying Fick's laws of diffusion, it is essential to consider the temperature dependence of the diffusion coefficient. Changes in temperature can alter the diffusion rate and affect the overall diffusion process in metals and alloys. By incorporating temperature variations into diffusion calculations using Fick's laws, students can better predict how diffusion behaviour evolves under different thermal conditions.

Examples of diffusion calculation with temperature effects:

Through practical examples and simulations, students can explore how diffusion calculations change with varying temperatures. They can observe how different materials respond to heat treatments at different temperatures and predict the resulting diffusion profiles within the material. Understanding the relationship between temperature and diffusion behaviour allows students to make informed decisions when designing heat treatment processes for specific material applications.

Differences between substitutional and interstitial mechanisms with temperature variation:

The influence of temperature on substitutional and interstitial mechanisms of diffusion varies. Temperature changes can affect vacancy concentrations, lattice vibrations, and atomic mobility differently in these mechanisms. By studying how temperature affects these mechanisms, students can gain insights into how diffusion pathways are altered under different thermal conditions, leading to variations in material properties.

By considering the influence of temperature on diffusion processes, applying Fick's laws with temperature variations, exploring examples of diffusion calculations at different temperatures, and understanding how temperature affects substitutional and interstitial mechanisms of diffusion, master's degree students will enhance their ability to analyse and optimize thermo-chemical surface treatment processes effectively in metals and alloys.

3. Learning outcomes

Completing this topic the student has extensive and in-depth substantive knowledge about diffusion as itself. Can also use information from literature, databases and other available sources. The learning outcomes related to the laboratory topic with a focus on the influence of temperature encompass a comprehensive understanding of how temperature affects diffusion processes. Students will develop proficiency in analysing diffusion behaviour with varying temperatures, applying Fick's laws of diffusion while considering temperature dependencies, and conducting diffusion calculations to predict material behaviour accurately. By exploring examples of diffusion calculations at different temperatures and discerning the differences between substitutional and interstitial mechanisms under varying thermal conditions, students will enhance their ability to optimize thermo-chemical surface treatment processes effectively. Additionally, they will gain insights into the significance of temperature on diffusion coefficients, diffusion rates, and material properties, enabling them to make informed decisions when designing heat treatment processes for metals and alloys. Overall, mastering the influence of temperature on diffusion in metals and alloys will equip students with valuable skills in materials science research and industrial applications, enhancing their capabilities in analysing and manipulating material properties through controlled diffusion processes. They are aware of the responsibility for his work and takes responsibility for the tasks carried out in the team.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator; Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content

of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.

- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

At this point, we also specify the form of conducting classes.

- The main topic will be implemented during 2 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- ASSESSMENT – students complete the reports; **1 report**, each for **2 points**. **The sum of points achieved is 2.**

- The topics will be implemented during 2 classes.

8. Optional information

NO

Topics 4

1. The subject of the laboratory classes

Thermo-chemical processing and methods of surface enhancement

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The laboratory exercise focusing on thermo-chemical processing and methods of surface enhancement, specifically carburizing, nitriding, boriding, measurement of surface properties, and microstructural analysis, is designed to provide a comprehensive understanding of how these treatments affect material properties. Here is a detailed thematic scope of the laboratory work:

Carburizing, Nitriding, and Boriding treatments - understanding the process and effects of carburizing, nitriding, and boriding on materials like steel. Analysing the changes in crystallographic structures induced by these treatments.

Measurement of surface properties - conducting measurements to evaluate surface hardness, wear resistance, and other relevant properties post-treatment. Utilizing techniques like microhardness testing to quantify changes in material properties.

Microstructural analysis - observing and analysing microstructural changes in treated samples using methods like optical microscopy and X-ray diffraction. Identifying the presence of specific compounds in the treated layers and measuring layer thickness.

Enhancement of wear resistance - investigating methods to improve wear resistance of metal parts through surface modifications. Comparing wear resistance before and after modification.

Recrystallization and grain growth phenomena - studying the impact of thermo-mechanical processes on steels' microstructural features. Analysing recrystallization and grain growth phenomena to predict mechanical properties.

Corrosion resistance evaluation - assessing the corrosion resistance of treated steels through immersion tests in corrosive solutions. Demonstrating the beneficial effects of nitriding and boriding treatments on corrosion resistance.

Calculation of diffusion coefficients - calculating diffusion coefficients to understand the rate of diffusion of elements in materials during various treatments. This information is crucial for predicting mechanical properties and performance post-treatment.

In summary, this laboratory exercise provides a hands-on opportunity for master's degree students to explore processes of thermo-chemical surface treatments, measurement of surface properties, and microstructural analysis to enhance their understanding of material behaviour and performance post-treatment.

3. Learning outcomes

The laboratory exercise focusing on thermo-chemical processing and methods of surface enhancement, specifically carburizing, nitriding, boriding, measurement of surface properties, and microstructural analysis, is designed to provide a comprehensive understanding of how these treatments affect material properties. The specific course or field of study related to these learning outcomes is materials science include: i) understanding the process and effects of carburizing, nitriding, and boriding on materials like steel, including the changes in crystallographic structures induced by these treatments; ii) conducting measurements to evaluate surface hardness, wear resistance, and other relevant properties post-treatment, utilizing techniques like microhardness testing to quantify changes in material properties, bserving and analyzing microstructural changes in treated samples using methods like optical microscopy and X-ray diffraction, identifying the presence of specific compounds in the treated layers and measuring layer thickness; iii) studying the impact of thermo-mechanical processes on steels' microstructural features, analysing recrystallization and grain growth phenomena to predict mechanical properties.

These learning outcomes are designed to provide master's degree students in materials science with a comprehensive understanding of thermo-chemical surface treatments and their impact on material properties, enabling them to apply this knowledge in various industries, such as aerospace, automotive, and energy production.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
- Tables for materials, metals physical constants
- Calculator; Tables of metals constants supplemented by the lecturer.

5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

- During laboratory classes, students work in a group, sharing tasks and working together to establish a work plan, analyse the results and draw conclusions.
- During laboratory classes, students use the method of the practical application of knowledge; implemented in three phases: noticing the problem caused by the content of the task, formulating the problem and attempting to solve it independently with the assessment of the effects.
- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes.</u>

- The main topic will be implemented during 3 classes in the form of a project task, in which students will design the assumptions and plan of the experiment on their own. The reports from the task are evaluated and assigned points. The grading policy is detailed in the related syllabus

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

- Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
- Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
- ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

Students should prepare a theoretical introduction to the laboratories.

7. Additional notes

- The topics will be implemented during 3 classes.

8. Optional information

NO

Topics 5

1. The subject of the laboratory classes

Proposal of the thermo-chemical procedure – a semester work (project)

2. Thematic scope of the laboratory classes (abstract, maximum 500 words)

The students will implement the knowledge gained from the topics of exercises 1 to 4 when solving a semester project focused on thermo-chemical surface treatment of steels. The thematic scope of this work includes:

Calculation of tetrahedral and octahedral spaces in crystallographic lattices - calculating the tetrahedral and octahedral spaces in various crystallographic lattices to understand the available sites for diffusion of elements during thermo-chemical treatments.

Diffusion coefficients and diffusion conditions - calculating diffusion coefficients as a function of temperature and time to understand the rate of diffusion of elements in materials during various treatments.

Proposal of a technological procedure - based on the knowledge gained, propose a technological procedure for the thermo-chemical treatment of steel. This procedure should include the selection of appropriate treatment parameters, such as temperature, time, and atmosphere, to achieve the desired material properties.

Consultations with the teacher - regular consultations with the teacher to discuss the progress of the work and receive guidance on the proposed technological procedure.

Presentation and defense of the work - present and defend the proposed technological procedure in front of a panel of experts or other students taking the same subject. This will help students to refine their understanding of the thermo-chemical processes and their impact on material properties and improve their presentation skills as well.

The work will also help students develop critical thinking and problem-solving skills, as they will need to propose a technological procedure based on the knowledge gained and consultations with the teacher.

An example of a semester work assignment using the knowledge from lectures and exercises in the course:

1. Calculate the number of C/N atoms that can be excluded in the octahedral and tetrahedral spaces of the K8/K12 lattice.
2. Using your knowledge of interstitial and substitutional solid solution formation, decide what type of solid solution will form C/N in the corresponding steel and what type of major alloying elements (e.g., Al, Si, Cr, Mn, Mo, V, W, ...)
3. Calculate the thermo-chemical treatment conditions:

   Carburizing: concentration of C in the atmosphere = 2.5%C (may vary), what will be the concentration of C in the layer thickness: h = 0.05; 0.15; 0.5 and 1.5 mm; cementation temperature t = 950°C (may vary), after cementation time 10 and 15 hours (may vary).

Nitriding: concentration of N in the atmosphere = 1,5%N (may vary), what concentration of N will be in the layer thickness: h = 0,05; 0,1; 0,25 and 0,5 mm; nitriding temperature t = 550°C (may vary), after nitriding time 10 and 15 hours (may vary).

4. Evaluation of the thermo-chemical and post heat-treatment process (e.g. in carburizing, is considered to be correctly performed if we achieve 0.4%C in our desired cementation layer depth and hardness after post heat-treatment of about 550HV, etc.), whether the chosen treatment was successful and fulfilled its purpose.
5. Proposal for optimization of thermo-chemical parameters, possible "pitfalls" of the chosen process (e.g. influence on the initial structure, etc.).

3. Learning outcomes

The learning outcomes of the laboratory work focusing on the proposal of a thermo-chemical procedure for the treatment of steel are multifaceted and aimed at providing students with a deep understanding of thermo-chemical processes and their implications on material properties. Firstly, students will gain knowledge about carburizing, nitriding, and boriding treatments on materials like steel, enabling them to comprehend the alterations in crystallographic structures induced by these treatments. Secondly, through the calculation of tetrahedral and octahedral spaces in crystallographic lattices, students will develop a grasp of the available sites for element diffusion during thermo-chemical treatments. Thirdly, by calculating diffusion coefficients as a function of temperature and time, students will understand the rate of element diffusion in materials during various treatments and analyse the influence of temperature and time on the diffusion process. Moreover, students will be able to propose a technological procedure for the thermo-chemical treatment of steel based on their acquired knowledge, including selecting appropriate treatment parameters like temperature, time, and atmosphere to achieve desired material properties. Regular consultations with the teacher will provide guidance and feedback on their proposed technological procedure, fostering critical thinking and problem-solving skills. Lastly, presenting and defending the proposed technological procedure in front of experts enhancing their ability to apply theoretical knowledge to practical scenarios effectively. The laboratory work is meticulously designed to offer master's degree students a hands-on opportunity to learn complex thermo-chemical surface treatments, measurement of surface properties, and microstructural analysis, thereby equipping them with essential skills for addressing real-world challenges in materials science and engineering.

4. Necessary equipment, materials, etc

- Periodic table of elements;
- Physical-mathematical tables;
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5. Didactic methods used (description of student/teacher activities in the classroom/laboratory, taking into account didactic/teaching methods)

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- During laboratory classes, students work using a textbook structured to cover part or all of the curriculum of a module with a specific form of content study; including work with a subject textbook, atlas, catalogue, workbook or using websites in any way or according to the rules set by the teacher.

<u>At this point, we also specify the form of conducting classes, i.e.</u>

- The main topic will be implemented during 4 classes in the form of a project task, in which students will design the heat-treatment process. The semester project will be handed in at the end of the semester and evaluated according to the criteria specified in the relevant syllabus; the maximum number of 30 points is for the semester project. During the mentioned 4 weeks, it is possible to consult with the teacher about problems arising during the solution of the project.

6. Recommended reading, pre-lesson preparation (required knowledge of students on the topics)

Students are expected to read below texts related to the lecture:

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- Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
- Mittemeijer, Eric, J., Somers, Marcel, A., J.: Thermochemical Surface Engineering of Steels, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.
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- Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

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7. Additional notes

- ASSESSMENT – after completing the semester project students receive a maximum of 30 points

- The topics will be covered in the 4 classes with the teacher consultations on demand.

8. Optional information

NO

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