MATERIALS SCIENCE MA(S)TERS

developing a new master's degree

IO2

Syllabuses

Part 2

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

NON-METALLIC MATERIALS

Code: **NM**

Field of study
Materials Science and Engineering

Level of study
Master Study

Semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours:
Lecture: 26h
Laboratory: 26h

ECTS
4

COURSE DESCRIPTION

The subject deals with the properties of non-metallic materials (ceramics, glass, plastics, composites), their production and processing technology, and their use for specific applications in technical practice.

The subject *Non-metallic materials* follows on the material subjects from the bachelor's study, namely: the subject *Materials 1*, which deals with the physical nature of technical materials, general knowledge about the structure and properties of materials and ways of influencing them (e.g. by heat treatment); subject *Materials 2*, which includes specific information about individual material groups (primarily metals, but also plastics, ceramics and composites), their structure, properties and use; the subject *Properties and testing of materials*, which deals in more detail with metal materials, their properties and use. The subject *Non-metallic materials* further expands the knowledge gained in these subjects, focusing on non-metallic materials such as ceramics, glass, plastics, composites and other non-metallic materials.

The lectures are intended for obtaining information about individual groups of non-metallic materials, their production and processing methods, properties and the use of these materials. Laboratory exercises are devoted to practicing the presented issues and specific experiments.

The total time requirement of the subject is 140 hours per semester, of which 52 hours (13 weeks x 2 hours of lectures + 13 weeks x 2 hours of laboratory exercises) are direct teaching and 88 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the subject *Non-metallic materials*, the student will be able to distinguish between individual types of non-metallic materials; describe and compare the characteristic properties of individual types of ceramics, glass, plastics and composite materials, their use and method of production; analyze and solve the issue of the appropriateness of using a specific non-metallic material, based on their specific properties.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Non-metallic materials*, it is necessary to complete the subjects *Materials 1* and *Materials 2*. The student should have general knowledge about specific types of non-metallic materials (plastics, ceramics and composites), their structure, properties and uses.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	He/ she has extended and in-depth knowledge in the field of general knowledge, which is the basis for understanding complex relationships in the processes of designing, manufacturing, testing and application of engineering materials.
MS_O_02	He/ she can use information from literature, databases and other available sources. He/ she is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve complex innovative problems. He/ she can solve practical engineering tasks that require the use of engineering standards and norms.
MS_O_03	He/ she is aware and knows the possibilities of further training and improving professional, personal and social competences. He/ she 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.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature	independent work
a_02	Preparation for classes	Self-study, preparation for exercises, processing reports	independent work and cooperation
a_03	Preparation of reports	Preparation and processing reports	independent work and cooperation

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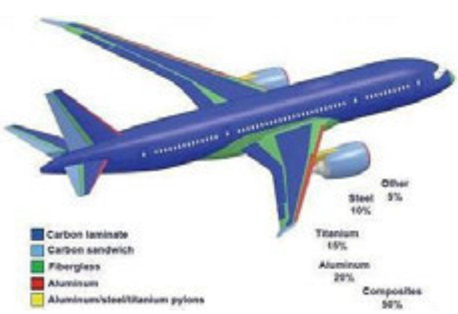
LEARNING OUTCOMES

By completing the subject *Non-metallic materials*, the student will be able to distinguish between individual types of non-metallic materials; describe and compare the characteristic properties of individual types of ceramics, glass, plastics and composite materials, their use and method of production; analyze and solve the issue of the appropriateness of using a specific non-metallic material, based on their specific properties.

LECTURER
Ing. Alan Vaško, PhD.

DO YOU KNOW
Non-metallic materials are used not only in mechanical engineering, but in all industries including automotive, aviation, aerospace or medicine.



Materials used in Boeing 787 Dreamliner

COURSE CONTENT – LECTURE

Topics 1

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)

Topics 2

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)

Topics 3

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)

Topics 4

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)

Topics 5

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)

LEARNING OUTCOMES

By completing the subject *Non-metallic materials*, the student will be able to distinguish between individual types of non-metallic materials; describe and compare the characteristic properties of individual types of ceramics, glass, plastics and composite materials, their use and method of production; analyze and solve the issue of the appropriateness of using a specific non-metallic material, based on their specific properties.

INSTRUCTOR
Ing. Lenka Markovičová, PhD.

DO YOU KNOW
Non-metallic materials are used not only in mechanical engineering, but in all industries including automotive, aviation, aerospace or medicine.

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Introduction to the laboratory exercises of *Non-metallic materials* (2 hours)

Topics 2

Transmission of water vapour and liquid water through the fabric (2 hours)

Topics 3

Identification of textile fibers (2 hours)

Topics 4

Determination of ceramic water absorption (2 hours)

Topics 5

Testing of soils for ceramic production (2 hours)

Topics 6

Determination of water hardness (2 hours)

Topics 7

Determination of the acetic acid content of vinegar – visual method (2 hours)

Topics 8

Determination of the acetic acid content of vinegar – potentiometric method (2 hours)

Topics 9

Red plant dyes as pH indicators (2 hours)

Topics 10

Refractometry (2 hours)

Topics 11

Conductivity of electrolytes (2 hours)

Topics 12

Phase equilibria of multicomponent systems – two-component system of sparingly soluble liquids (2 hours)

Topics 13

Semester thesis presentations (2 hours)

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Non-metallic materials*:

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

Optional recommended texts for a deeper understanding of the subject:

1. Skočovský, P. – Bokůvka, O. – Konečná, R. – Tillová, E.: *Materials science*, EDIS, Žilina, 2014. 349 s.

2. Skočovský, P. – Palček, P. – Konečná, R. – Várkoly, L.: *Construction materials*, EDIS, Žilina, 2000. 338 s.

3. Labaš, V. – Kubliha, M. – Minárik, S.: *Introduction to technological processes of non-metallic materials*, MtF STU, Trnava, 2006. 210 s.

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ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of non-metallic materials. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester)**:** paper continuously verifying knowledge of issues in the field of non-metallic materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of non-metallic materials.

GRADING POLICY

The subject Non-metallic materials is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + submitted reports (max. 3 points), i.e. j. 10 reports x 3 points = 30 points are evaluated; 1 semester paper (1 x 10 points = 10 points). The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
10 reports	25%
Semester paper	10%
Student portfolio	5%
Examination	60%
Total	100%

10 reports (max. 2 or 3 points each) – max. 25 points
Semester paper – max. 10 points
Independent work of student – max. 5 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

SELECTED CHAPTERS FROM PHASE TRANSFORMATIONS

Code: **SCPT**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Fundamental Aspects of Materials Science

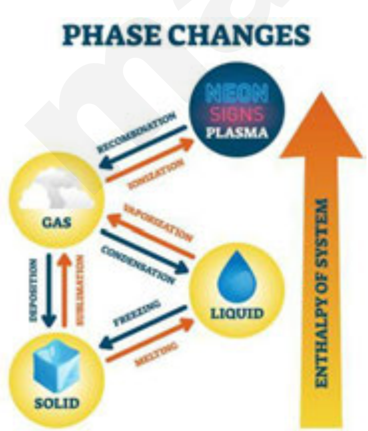
Form of tuition and number of hours:

Lecture: 26h

Laboratory: 26h

ECTS

4



COURSE DESCRIPTION

In chemistry, thermodynamics, engineering and other related fields, a phase transformation is the physical process of transformation between one state of a medium and another. Commonly the term is used to refer to changes among the basic states of matter: solid, liquid, gas, and in rare cases, plasma. A phase of a thermodynamic system and the states of matter have uniform physical properties.

An understanding of thermodynamics and phase diagrams is fundamental and essential to the study of materials science. Knowledge of the equilibrium state under a given set of conditions is the starting point in the description of any phenomenon or process. During a phase transformation of a given medium, certain properties of the medium change because of the change in external conditions, such as temperature or pressure.

This course presents fundamentals of the thermodynamics and kinetics of phase transformations from phenomenological and atomistic viewpoints. Phase transformations in ferrous and non-ferrous systems will be discussed. This course starts with the principles of thermodynamics, phase equilibriums, diffusion, and crystal interfaces. The topics include absolute reaction rate theory, thermodynamics of irreversible processes, thermodynamics of surfaces and interfaces, chemical kinetics, nucleation and growth, order-disorder transformations, diffusional transformations, and martensitic transformations. By the end of the semester, you will be able to understand key concepts, experimental techniques, and open questions in the transformation phenomena of various materials.

COURSE OBJECTIVES

By completing the *Selected Chapters from Phase Transformations* course, the student will be able to identify basic phase transformations and understand the regularities of processes in single-component and binary systems. Further, apply thermodynamic phenomena in the crystallization characteristics of metallic materials and solve problems in the field of heat treatment of metals. Finally, analyse the structure of metals using the Miller-Bravais indices and evaluate the solubility of additive elements in structural components of alloys.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Selected chapters from phase transformations*, a student should have a general knowledge of the various types of engineering materials, their structure, properties, heat-treatment fundamentals and applications.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge in the field of methods, processes of production and processing of engineering materials (ferrous and non-ferrous alloys) in connection with the application of knowledge in the field of phase transformations (thermodynamic and kinetic processes in phase transformations, nucleation and crystal growth mechanisms, phase transformations at cooling or heating of steels – austenitization, pearlitic, bainitic, and martensitic transformations, and etc.).
MS_O_02	Can use information from literature, He is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental phase transformations problems (calculation weight and atomic volume, application of Hume-Rothery laws in substitutional or interstitic solid solutions, lattices parameters calculations, diffusion processes, and etc.).
MS_O_03	He can plan and carry out experiments, including measurements, interpret the results and draw conclusions related to field of phase transformations.
MS_O_04	Can prepare a scientific study and present a presentation on the implementation of various phase transformation for research task, containing a critical analysis, conclusions with accent to optimization of selected phase transformation and its influence on overall mechanical properties. Able to work individually and in a team as well as interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; report; question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

LEARNING OUTCOMES

By completing the Selected chapters from Phase Transformations course, the student will be able to identify basic phase transformations. Next, understand the regularities of processes in single-component and binary systems, and apply thermodynamic phenomena in the crystallization characteristics of metallic materials. Identify the difference between phase transformations by applying kinetic phenomena in the crystallization of metallic materials. Finally, present the results of the assigned semester work.

COMMENTS

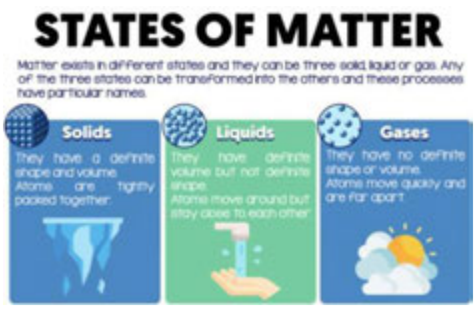
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER

Prof. Ing. Peter Palček, PhD.
Assoc. prof., Ing. Juraj Belan, PhD.

DO YOU KNOW

*A **phase transformation** is a change in the **states of matter**. As the states of matter, change from **solid** to **liquid** to **gas**, their composition changes as well. In a solid, the bonds are stronger than hydrogen bonds. That allows the solid substance to have a definite volume and shape. However, when the heat is added, the solid become a liquid, the bonds are considerably weaker. A liquid has a definite volume but not a definite shape, and it thus takes the shape of the container in which it is. When **more heat** is added, the liquid substance evaporates and becomes a gas, which has no bonds at all.*



States of matter brief description

COURSE CONTENT - LECTURE

Topics 1

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

Topics 2

Characteristics of elementary thermodynamic quantities. Thermodynamic phase transformations I. and II. of the kind - Ehrenfest distribution of phase transformations.

Topics 3

Relationship between thermodynamics and kinetics of phase transformation. Kinetics of phase transformations - nucleation, growth and rate of transformation.

Topics 4

Primary crystallization, polymorphic transformations. The disintegration of supersaturated solid solution, precipitation processes - segregation and hardening (artificial age hardening).

Topics 5

Phase transformations during heating of steel - austenitization. Phase transformations during cooling of steel-pearlitic transformation, transformations controlled by the shear mechanism, massive transformations, bainitic transformation and martensitic transformation.

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COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Case examples for calculation matter of state for engineering application. Calculation of atomic and mass percentages. Introduction to calculation of density of materials.

Topics 2

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.

Topics 3

Calculation of lattice parameters of metals. Relation between the atomic radii and the lattice parameters, calculation of octahedral and tetrahedral spaces in metal lattices.

Topics 4

Application of knowledge from crystallography with regard to the deformation of crystal lattices during phase transformations.

Topics 5

Phase transformations during cooling of homogeneous austenite. Application of T-T-T diagram at austenite cooling and explanation of pearlitic, bainite and martensite transformations and relation of transformation temperatures to chemical composition of steels.

LEARNING OUTCOMES

Based on the completed lectures, students should be able to apply the acquired knowledge when solving model examples aimed at calculating atomic and mass percentages; the application of the Hume-Rothery and Hägg rules in the determination of solid solutions; lattice parameters of metals; application of knowledge from crystallography with regard to deformation of crystal lattices during phase transformations and phase transformations during cooling of homogeneous austenite.

COMMENTS

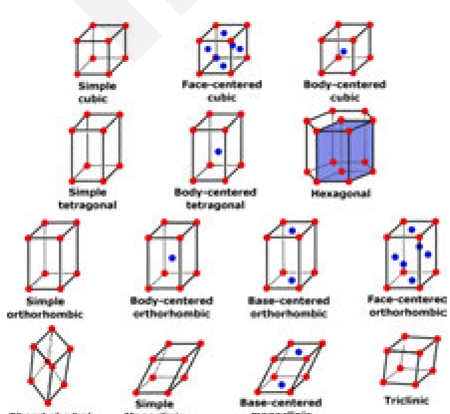
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

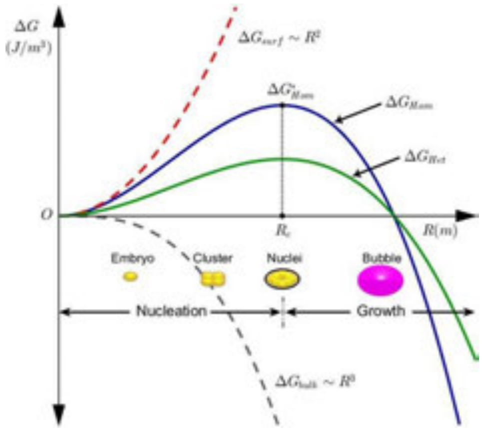
Assoc. prof., Ing. Juraj Belan, PhD.

DO YOU KNOW

The particles such as atoms are closely packed to one another in solids. This is to give the structure strength and rigidness. Furthermore, when we take a crystalline structured solid, the particles are close packed in a repeating pattern that is regularly ordered – crystal lattice. An interesting thing about crystal solids is that they contain an enormous number of different crystal structures and the same substance, which possesses more than one structure.



Crystal lattices of solids



Gibbs free energy change during bubble nucleation. The surface free energy G_{surf} (dashed red line), bulk free energy G bulk (dashed black line), homogeneous nucleation free energy G_{Hom} (blue line), and the heterogeneous nucleation free energy G_{Het} (green line) are presented as a function of the radius R.

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Selected chapters from Phase Transformation*:

1. Porter, David A., Easterling, Kenneth E., and Sherif, Mohamed Y.: *Phase Transformations in Metals and Alloys – Third eddition*. CRC Press, Taylor & Francis Group, 2009.
2. Callister JR., William, D., Rethwisch, David, G.: *Materials Science and Engineering – An Introduction – Tenth Edition*. John Wiley & Sons, Inc., 2018.

For a deeper understanding of the course subject matter, optional recommended texts include:

1. Gaskell, David, R., Laughlin, David, E.: *Introduction to the thermodynamics of materials – Sixths Edition*. CRC Press, Taylor & Francis Group, 2018.
2. Kittel, Charles: *Introduction to Solid State Physics – Eigth Edition*. John Wiley & Sons, Inc., 2005.
3. Kostorz, Gernot (Ed.): *Phase Transformations in Materials*. WILEY-VCH Verlag GmbH, 2001.

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of phase transformation. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper and laboratory work (during the semester)**:** paper and laboratory work continuously verifying knowledge of issues in the field of phase transformation.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of theory of phase transformation.

GRADING POLICY

Points evaluate the subject *Selected chapters from phase transformations*. The resulting points are the sum of the points that the student gets during the semester (on exercises) and the points that he gets on the exam.

During the exercises, the following are continuously evaluated: theoretical preparation (short tests at the beginning of the exercises as input for processing the report) + submitted reports (max. 2b), i.e. 5 reports x 2b = 10 points are evaluated; 1-semester paper (1 x 30 points = 30 points). The maximum number of points achieved in the exercises is 40.

The final assessment consists of points that the student gets during the semester (on exercises) and points that he gets on the exam. The points obtained in the exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	Percent
5 reports	10%
1-semester work	25%
Student portfolio	5%
Final examination	60%
Total	100%

5 reports (max. 2 points each) – max. 10 points
1-semester paper – max. 30 points

Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points	= A
85 – 92 points	= B
77 – 84 points	= C
69 – 76 points	= D
61 – 68 points	= E
0 – 60 points	= FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

GENERAL CHEMISTRY FOR TECHNICIANS

Code: **GCT**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Fundamental Aspects | of Materials Science

Form of tuition and number of hours:

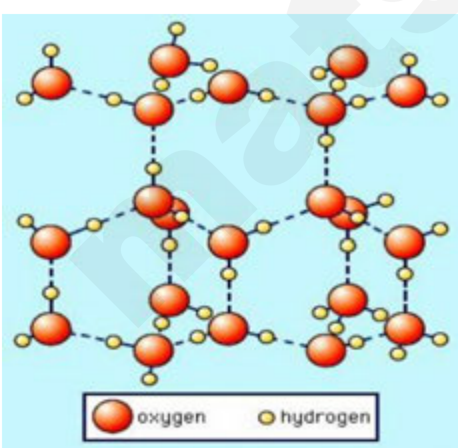
Lecture: 13h

Laboratory: 13h

Exercises: 13h

ECTS

4



Representation of ice structure

COURSE DESCRIPTION

The *General chemistry for technicians* course is dedicated to the all paths of master study. The course provides a foundation for understanding the behavior of matter at the atomic and molecular levels, as well as its applications in materials engineering. It broadens knowledge about the essence of the chemical properties of materials, deals with the relationships between chemical bonds, structure and physical properties of materials. It explains the energetic background of chemical reactions and the mechanisms of their realization. The course also identifies and summarize basic laboratory techniques.

Teaching is conducted in the form of lectures, theoretical classes and laboratory classes. In the lectures, students will learn the theoretical basics of the structure of atoms, chemical bonds, and chemical states of substances. They will also deal with thermodynamics and kinetics of chemical reactions, homogeneous and heterogeneous systems and oxidation-reduction processes. Theoretical exercises for the *General chemistry for technicians* course are focused on the nomenclature of inorganic compounds, stoichiometric calculations and calculations of the composition of solutions. During the laboratory exercises, students will learn about working with chemicals, assembling experimental apparatus for chemical processes and evaluation of the experiments.

COURSE OBJECTIVES

After finishing *General chemistry for technicians*, a student will be able to understand and to use the basic chemical terminology; know and explain the basic rules and laws in chemistry; assemble experimental equipment; calculate the amounts of chemical substances needed to perform the experiment using basic relations and rules; evaluate the experiments and verify the correctness of the results.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *General chemistry for technicians*, a student should have a general knowledge of physics and basic knowledge of various types, properties and applications of engineering materials.

Co-funded by the European Union

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Has extensive and in-depth substantive knowledge in the field of general chemistry - basic chemical terminology, basic rules and laws, structure of the atoms, periodic properties of the chemical elements, nature of chemical bonds, thermodynamics and kinetics of the chemical reactions.
MS_O_02	Can use information from literature and other available sources in the field of general chemistry, interpret and critically evaluate them.
MS_O_03	He can plan and carry out experiments - assemble experimental equipment, evaluate, summarize and interpret the results and draw conclusions.
MS_O_04	Able to work individually and in a team as well as interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Lectures:** lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	**Laboratory classes:** experiment demonstration; laboratory work; observation; problem teaching; debate	MS_O_03 MS_O_04
Meth_03	**Theoretical classes:** motivational demonstration; individual and team work; communicate on specialist topics, leading a debate.	MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	Lecture	13	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory classes	13	course work	MS_O_03 MS_O_04	Meth_02
FT_03	Theoretical classes	13	course work	MS_O_03 MS_O_04	Meth_03

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_02	Preparation for classes	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_03	Preparation of reports	Preparation and development of reports. Consultation.	YES

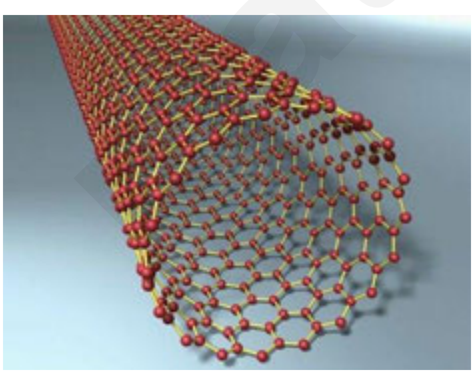
Co-funded by the European Union

LEARNING OUTCOMES

After finishing the General chemistry for technicians course, a student will be able to understand and to use the basic chemical terminology; know and explain the basic rules and laws in chemistry; assemble experimental equipment; calculate the amounts of chemical substances needed to perform the experiment using basic relations and rules; evaluate the experiments and verify the correctness of the results.

DO YOU KNOW

Nanotubes are one form of fullerens, which structure is based on hexagonal rings of carbon atoms joined by covalent bonds (a nanotube is like a layer of graphene, rolled into a cylinder). They are strong in tension and resist being stretched. They also conduct electricity because of the delocalised electrons in structure. These properties make nanotubes useful for nanotechnology, electronics and specialised materials.



Nanotube structure representation

COURSE CONTENT - LECTURE

Topics 1

General Chemistry: introduction, basic laws and atomic theory

In the introduction the subject of general chemistry, basic laws and concepts will be presented. Students will organize their knowledge about atomic structure, including actual conception on electron shell building and main principles of wave mechanics, quantum numbers, rules of building-up of the electron shell of the atom (2 hours).

Topics 2

Periodic relationships among the elements and chemical bonding

Students will learn about periodic law, characteristics of periods and groups and periodic relationships among the elements. They will indicate consequences of these relationships to the atomic electron structures. Students will learn and name nature and mechanism of covalent and ionic bonds, bonding in metals, intermolecular forces, hydrogen bond. Relationship between chemical bond and physical properties of materials will be explained (2 hours).

Topics 3

States of matter

Students will learn the most important aspects of solid state of matter - crystalline and amorphous substances, types of crystals according to the type of chemical bonds, polymorphism, isomorphism, liquid state of matter - surface tension, viscosity and gaseous state of matter - ideal gas, laws, equation of state, real gas, critical state. The principle rules of the matter states conversions will be also explained (2 hours).

Topics 4

Chemical reactions: thermodynamics and kinetics

The lecture is focused on the explanation of the bases of chemical thermodynamics – thermodynamic functions as internal energy, enthalpy, entropy, Gibbs free energy will be defined. Students will learn to identify spontaneity of chemical processes. The basic laws of chemical kinetics - dependence of reaction rate on the concentration of reaction species, on temperature and on the presence of catalysts will be presented. The kinetics of chemical equilibrium will be also described (3 hours).

Topics 5

Homogeneous systems: solutions

Students will learn the most important facts about liquid solutions - types of solvents, dissolution, solubility. Aqueous solutions – electrolytes will be described and pH, Bronsted and Lewis theory of acids and bases, acid-base indicators will be explained (2 hours).

Topics 6

Heterogeneous systems

Heterogeneous systems - phase, component, Gibbs law of phases, 1,2,3-component systems will be defined and explained. Students will identify the main aspects of oxidation-reduction reactions - oxidation, reduction, oxidation number, reactions of metals in water, acidic and basic solutions. Processes in heterogeneous electrochemical systems -electrode reactions, electrolysis and Faraday laws will be indicated and explained (2 hours).

LEARNING OUTCOMES

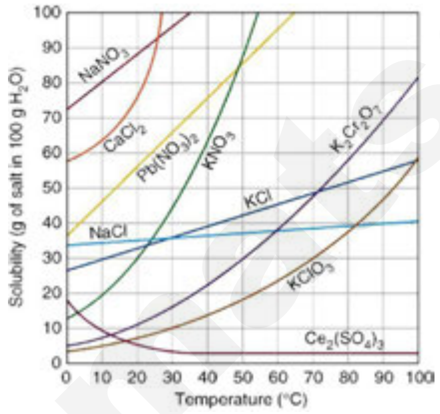
After finishing the General chemistry for technicians course, a student will be able to understand and to use the basic chemical terminology; calculate the amounts of chemical substances needed to perform the experiment using basic relations and rules. A student will be able to assemble experimental equipment; to measure needed quantities, evaluate and compare the obtained results and to verify their correctness.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Solid substances soluble in water have different dependence of solubility on temperature. Judge from the picture.



Solubility curves of inorganic salts

COURSE CONTENT – LABORATORY CLASSES

Topics 1

Electrolysis and galvanic plating
Students will perform electrolysis, they will verify Faraday's laws validity in experiment and, they will try galvanic copper plating of steel specimen. They will calculate the current yield of this process (3 hours).

Topics 2

Conductometry
Students will perform experiment for determination of NaCl solution molarity by measuring specific conductivity of three NaCl solutions with the defined concentration and using a calibration graph (2 hours).

Topics 3

Qualitative analysis of low alloy steels
The topics is related to the indicative analysis of low alloy steels based on simple reactions of conventional qualitative analytical chemistry (2 hours).

Topics 4

Quantitative analysis of waters
Students will carry out experimental determination of HCO_3^- and Ca^{2+}+Mg^{2+} concentration in drinking and utility waters. The determination of concentration will be based on titration techniques (2 hours)

Topics 5

Pycnometry
This topic is focused on pycnometric determination of the density of liquids and solids (2 hours).

Topics 6

Refractometry
Students will perform refractometric determination the content of solute by measurement of the refractive index of solutions with known concentration (2 hours).

COURSE CONTENT – THEORETICAL CLASSES

Topics 1

This topics deals with classification, summarization and application of nomenclature rules for inorganic compounds – binary compounds, acids, salts (3 hours).

Topics 2

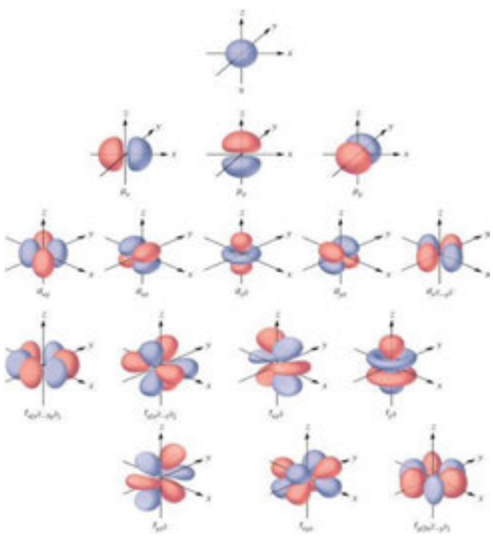
In this topics molar mass, amount of substance, mass of substance and their relations will be explained, discussed and exercised in various practical calculations related to engineering practice. (2 hours).

Topics 3

Students will perform stoichiometric calculations from chemical formulas and chemical equations connected to the solution of practical engineering problems (4hours).

Topics 4

Students will record methods of expression of the composition of solutions and they will perform the corresponding calculations resulting from engineering practice (4 hours).



Atomic orbitals

TEXTBOOK/READINGS

The mandatory reading for completing *General chemistry for technicians* course.

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

For a deeper understanding of the course subject matter, optional recommended texts include:

ATKINS, P. – DE PAULA, J. 2009. Atkins' Physical Chemistry , Oxford University Press 2009

ASSESMENT

Reports: Each report is related to the particular laboratory exercise. It contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion.

Semester paper (test during the semester)**:** Paper verifying knowledge of issues of theoretical classes (1 test focused on nomenclature, 1 test focused on calculations)

Exam (after the semester)**:** Written and oral exam verifying overall knowledge obtained in *Technical chemistry* course.

Assignment Weights	Percent
5 reports	24%
2 semester papers	16%
Examination	60%
Total	100%

GRADING POLICY

The *General chemistry for technicians* course is scored by points.

Laboratory classes: Submitted reports are evaluated (max. 4 points for each report), the maximum number of points achieved in the laboratory exercises is 24.
Theoretical classes: 2 semester papers (max. 8 points for each paper), the maximum number of points achieved in the theoretical exercises is 16.
The exam consists of a written (test) and an oral part (answers to individual questions).
The resulting points are the sum of the points that the student obtained during the semester (laboratory and theoretical classes, max. 40 points) and the points achieved on the exam (max. 60 points).

6 reports (max. 4 points each) – max. 24 points
Semester paper – max. 16 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

MATERIALS FOR BIOMEDICAL ENGINEERING

Code: **MBE**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Applied Materials Science

Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

4

COURSE DESCRIPTION

The course Materials for biomedical engineering deals with an overview of currently used biomaterials, new types of progressive biomaterials, e.g. metallic materials with shape memory, ceramic materials, application of plasma ceramic injections, e.g. Al2O3, TiO2, Ca10(PO4)6(OH)2 and also non-metallic polymeric materials. For a better understanding, the first part of the textbook focuses on the explanation of chemical bonding, the structure of solids and the properties that result from the internal structure of substances. A separate chapter deals with corrosion and corrosion resistance of biomaterials.

The subject Materials for biomedical engineering is a continuation of the material subjects from the bachelor's study, namely: the subject Materials 1, which deals with the physical nature of engineering materials, general knowledge of the structure and properties of materials and ways of their influence (e.g. The subject Materials 2, which contains specific information on the different groups of materials (mainly metals, but also plastics, ceramics and composites), their structure, properties and uses; the subject Technical Chemistry, which deals with types of chemical bonds, chemical reactions.

Laboratory exercises are devoted to the practice of the lecture topics and specific experiments.

The total time requirement of the subject is 140 hours per semester, of which 52 hours (13 weeks x 2 hours of lectures + 13 weeks x 2 hours of laboratory exercises) are direct teaching and 78 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the course Materials for Biomedical Engineering the student will be able to assess the suitability of a biomaterial in reconstructive surgery, post-trauma repair, in replacement of atrophied tissue, etc,, be able to apply intelligent biomaterials in the detection and management of congenital disorders of the body, to be able to assess the suitability of a material for a given aggressive environment, to apply smart materials for sensory activities, assess the suitability of materials for a given magnetic field and purpose of use

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Non-metallic materials*, it is necessary to complete the subjects *Materials 1* and *Materials 2*. The student should have general knowledge about specific types of non-metallic materials (plastics, ceramics and composites), their structure, properties and uses.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	By completing the course Materials for Biomedical Engineering the student will be able to: • assess the suitability of a biomaterial in reconstructive surgery, post-trauma repair, in replacement of atrophied tissue, etc, • be able to apply intelligent biomaterials in the detection and management of congenital disorders of the body. • to be able to assess the suitability of a material for a given aggressive environment, • to apply smart materials for sensory activities, • assess the suitability of materials for given magnetic fields and purpose of use, • use ceramic construction materials for selected applications, • analyse the type of corrosion damage, • analyse the influence of the environment on the corrosion of metallic materials used in the human body.
MS_O_02	Student will be able to communicate on topics related to sustainable composite materials with diverse audiences, including presentation of the results of their work/study or leading a debate.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; laboratory work; observation; problem teaching	MS_O_01 MS_O_02

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	course work	MS_O_01	Meth_01
FT_02	laboratory exercises	26	course work	MS_O_01	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Preparation for classes	Preparation for exercises, processing reports	independent work and cooperation
a_02	Reading literature	Preparation for exercises	independent work

LEARNING OUTCOMES

By completing the lecture of the subject Materials for Biomedical Engineering the student will be able to assess the suitability of a biomaterial in reconstructive surgery, post-trauma repair, in replacement of atrophied tissue, etc, be able to apply intelligent biomaterials in the detection and management of congenital disorders of the body, to be able to assess the suitability of a material for a given aggressive environment, to apply smart materials for sensory activities, assess the suitability of materials for given magnetic fields and purpose of, use ceramic construction materials for selected applications.

DO YOU KNOW
Spider silk is known for its exceptional properties, especially its excellent elasticity and strength. Scientists have long studied how it is possible that a fibre thousands of times thinner than a human hair is one of nature's strongest materials. The exceptional properties of the fibre are related to its molecular structure. In fact, each silk fibre is composed of parallel nanofibres that are at least one micron long. The hydrogen bonds in the fibre, which are very regularly arranged even at high densities, are considered to be crucial.

COURSE CONTENT - LECTURE

Topics 1

Definition of biomedical engineering terms, biocompatibility. Biofunctionality, functional requirements for biomaterials (2 hours)

In the intricate realm of biomedical engineering, understanding the fundamental concepts is paramount to crafting innovative solutions that revolutionize healthcare. Among these concepts lie the pillars of biocompatibility, biofunctionality, and the functional requirements of biomaterials. Each term encapsulates essential aspects crucial for the development and application of biomedical technologies. Biocompatibility stands as a cornerstone, defining the ability of a material to perform its intended function within a biological environment without eliciting an adverse response. It encompasses a spectrum of interactions, from the cellular level to the systemic level, emphasizing the need for materials to seamlessly integrate with the body while maintaining structural integrity and functionality. (2 hours)

Topics 2

Classification of biomaterials. Internal structure and chemical bonding of materials (6 hours)

In the classification of biomaterials, the internal structure and chemical bonding of materials play crucial roles in defining their properties and suitability for biomedical applications. Biomaterials can be categorized based on various factors, including their composition, structure, and intended function within the biological environment. Chemical bonding within biomaterials refers to the interactions between atoms or molecules that hold the material together. The type and strength of chemical bonds profoundly impact the material's mechanical properties, stability, and biocompatibility. Biomaterials commonly utilize various types of chemical bonding, including covalent, ionic, metallic, and hydrogen bonds, among others. For instance, the covalent bonds in biodegradable polymers contribute to their stability and degradation kinetics, while the metallic bonds in titanium alloys provide excellent mechanical strength and corrosion resistance for orthopedic implants. Understanding the internal structure and chemical bonding of biomaterials enables researchers and engineers to tailor their properties to specific biomedical applications. By manipulating these parameters, biomaterials can be designed to exhibit desired characteristics such as biodegradability, bioactivity, mechanical strength, and tissue compatibility. This knowledge also informs the selection of appropriate materials for diverse biomedical devices and implants, ensuring optimal performance and biocompatibility in clinical settings. (6 hours)

Topics 3

Metal biomaterials. Corrosion characteristics of biomaterials (6 hours)

Metal biomaterials represent a significant category within the realm of biomaterials, finding widespread use in various medical applications, including orthopedic implants, dental prosthetics, and cardiovascular devices. However, one of the critical considerations when utilizing metal biomaterials is their corrosion characteristics, which can profoundly affect their performance and biocompatibility in vivo. Corrosion refers to the degradation of metals through chemical reactions with their surrounding environment, typically involving the formation of oxides or other compounds. In the context of biomaterials, corrosion can occur when metal implants are exposed to physiological fluids, such as blood or tissue fluids, leading to adverse effects such as material degradation, release of metal ions, inflammatory responses, and implant failure.

Topics 4

Stainless Steels. Cobalt alloys, titanium and titanium alloys (6 hours)

Stainless steels are widely used in biomedical applications due to their excellent mechanical properties, corrosion resistance, and affordability. They contain chromium, which forms a passive oxide layer on the surface, providing protection against corrosion. Cobalt-based alloys, such as Co-Cr-Mo alloys, are commonly employed in orthopedic implants, particularly for hip and knee replacements, due to their exceptional strength, wear resistance, and biocompatibility. These alloys form a stable oxide layer on the surface, which offers protection against corrosion. Titanium and its alloys are widely regarded as the gold standard in biomedical implants due to their exceptional corrosion resistance, biocompatibility, and low density. Titanium naturally forms a thin but robust oxide layer (titanium dioxide) on its surface, which provides excellent protection against corrosion in physiological environments. Additionally, titanium alloys, such as Ti-6Al-4V, offer superior mechanical properties while maintaining biocompatibility.

Topics 5

Metal materials with shape memory. Ceramics and bioactive glasses. Carbon (4 hours)

Metal alloys with shape memory properties, such as nickel-titanium (NiTi) alloys, exhibit the ability to return to a predetermined shape when subjected to specific temperature or stress conditions. While these alloys offer remarkable mechanical properties and biocompatibility, their corrosion behavior is a critical consideration in biomedical applications. Nickel-titanium alloys are generally corrosion-resistant in physiological environments; however, localized corrosion can occur under certain conditions, particularly in chloride-rich environments. Bioactive glasses, such as bioactive silicate glasses, have the unique ability to bond with living tissues, promoting osseointegration and bone regeneration. While ceramics and bioactive glasses are inherently resistant to corrosion, they may undergo degradation processes such as surface dissolution or phase transformation when exposed to physiological fluids. Understanding the degradation kinetics and biocompatibility of these materials is essential for designing implants and scaffolds for bone regeneration, dental restoration, and tissue engineering applications. Carbon-based materials, including carbon fibers, carbon nanotubes, and graphene, exhibit exceptional mechanical properties, chemical stability, and biocompatibility, making them promising candidates for biomedical applications.

Topics 6

Aerogels. Polymers (2 hours)

Aerogels are materials known for their low density and high porosity. They are sometimes referred to as "frozen smoke" or "solid smoke" due to their translucent appearance and extremely light weight. Aerogels are typically composed of a network of interconnected solid structures with gas-filled pores. The solid component is often made of silica, but aerogels can also be made from other materials such as carbon or metal oxides. Aerogels have a wide range of potential applications due to their unique combination of properties. Some common applications include thermal insulation in buildings and spacecraft, lightweight structural materials, acoustic insulation, absorbents for cleaning up oil spills, and as catalyst supports in chemical reactions. One of the most important characteristics of polymers used in biomedical applications is biocompatibility, meaning they do not cause harmful effects when in contact with biological systems. Many polymers have been extensively studied and developed to ensure they meet biocompatibility standards, making them suitable for use in medical devices, implants, and drug delivery systems. Polymers are utilized in tissue engineering to create scaffolds that mimic the extracellular matrix of tissues and organs. Examples include orthopedic implants, cardiovascular stents, dental materials, and prosthetic limbs.

LEARNING OUTCOMES

By completing the laboratory exercises of the Materials for Biomedical Engineering course, the student will be able to analyze the type of corrosion damage,
assess the dissolution rate of a solid,
evaluate the purity of a crystalline substance, using the melting point,
apply the appropriate methodology to assess the purity of waters,
analyze the influence of the environment on the corrosion of metallic materials used in the human body.

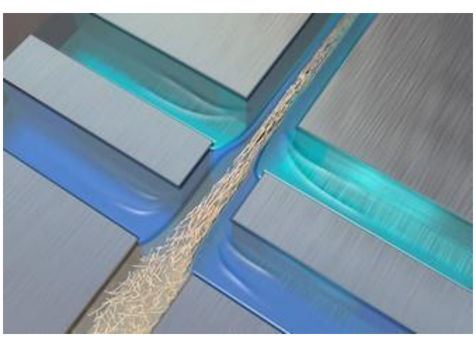
COMMENTS

INSTRUCTOR

DO YOU KNOW

Do you know that the strongest biomaterial in the world is cellulose?

By spinning one of nature's own building blocks, nanocellulose, into macroscale fibres, a material with extraordinary strength is achieved. The fibres are surpassing the strength of spider-silk, the long believed strongest biomaterial. Nanocellulose is the smallest fibrils in the plant cell wall and is usually extracted from wood pulp fibres. A typical nanocellulose fibril is 5 – 20 nm in width but has a length in the micrometer scale and an excellent strength of each individual nanofibril. By aligning (arranging) the nanofibrils in a spinning process, it is possible to get a macroscale material with a strength of 1.57 GPa – stronger than spider silk.



COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Mechanical tests – tensile test, impact test. (2 hours)

Mechanical testing, including tensile testing and impact testing, is essential in materials science and engineering to assess the mechanical properties and behavior of materials under different loading conditions. Both tensile testing and impact testing provide valuable information about the mechanical behavior of materials, helping engineers and researchers make informed decisions regarding material selection, design optimization, and quality assurance.

Topics 2

Mechanical tests – harness. (2 hours)

The hardness test is important mechanical test used to assess the resistance of a material to deformation, particularly plastic deformation, indentation, or scratching. Hardness is not a fundamental material property but rather a measure of a material's response to a specific type of mechanical loading. Students will implement and evaluate the Brinell, Vickers, and Rockwell hardness test.

Topics 3

Methods of studying the structure – microstructure of iron and carbon alloys. (2 hours)

By utilizing a method such as optical microscopy, researchers and engineers can gain a comprehensive understanding of the microstructure-property relationships in iron-carbon alloys, leading to improved alloy design, processing, and property optimization for specific applications such as steelmaking, heat treatment, and alloy development. Optical microscopy involves using visible light to examine the microstructure of materials. Specimens are typically prepared by grinding, polishing, and etching to reveal the microstructural features.

Topics 4

Ti and Ni alloys. assessment of dendricity. (2 hours)

The evaluation of dendritic structures in titanium (Ti) and nickel (Ni) alloys is key to understanding their microstructural properties, mechanical properties and processing conditions. Dendritic structures are formed during solidification processes and can significantly affect the properties of the alloys. For example, optical microscopy can be used to assess dendriticity in Ti and Ni alloys. Specimens are prepared by polishing and etching to reveal the microstructural features, including dendrites.

Topics 5

Dissolving a solid. (2 hours)

The rate of dissolution of a solid material refers to the speed at which the solid dissolves in a solvent to form a solution. This process is influenced by several factors, including the properties of the solid, the properties of the solvent, and the conditions of the dissolution process. Understanding the factors that influence the rate of dissolution is essential for various applications, including pharmaceuticals, chemical processes, environmental remediation, and material science.

Topics 6

Chemical resistance of glass. (2 hours)

The chemical resistance of glass refers to its ability to withstand exposure to various chemicals without undergoing significant deterioration, such as corrosion, leaching, or degradation. Glass is generally known for its excellent chemical resistance, but its resistance can vary depending on the type of glass and the specific chemical involved. Testing and compatibility assessments are often conducted to ensure the performance and longevity of glass components in various chemical environments.

Topic 7

Measurement of heat capacity of materials. (2 hours)

The heat capacity, is a measure of its ability to store thermal energy. It represents the amount of heat required to raise the temperature of a given quantity of material by one degree Celsius or Kelvin. Calorimetry, for example, is commonly used to measure the heat capacity of materials. Calorimetry involves measuring the heat exchanged between a sample and its surroundings under controlled conditions. The heat capacity of the sample can be calculated based on the heat exchange and the temperature change.

Topic 8

Electrolysis. (2 hours)

Electrolysis is a chemical process that involves using an electric current to drive a non-spontaneous chemical reaction. It typically occurs in an electrolytic cell, where an electric current is passed through an electrolyte, causing the electrolyte to undergo chemical decomposition or transformation. Electrolysis is widely used for electroplating metals onto surfaces to improve their appearance, corrosion resistance, or conductivity. Common examples include electroplating of chromium, nickel, copper, and gold onto metal objects.

Topic 9

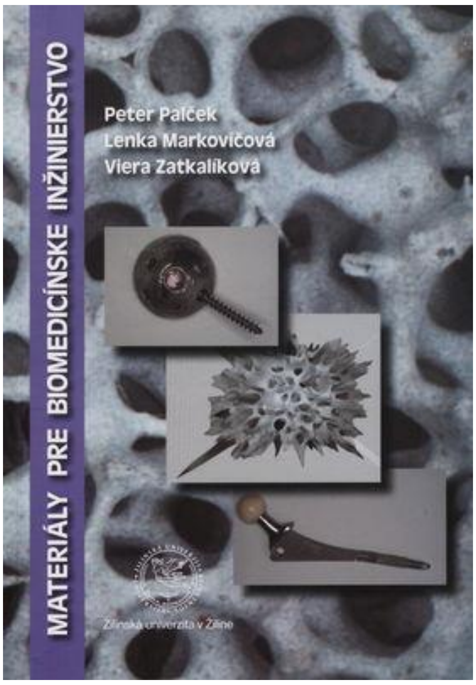
Corrosion properties of stainless steels. (2 hours)

Stainless steels are renowned for their excellent corrosion resistance, which is one of the main reasons for their widespread use in a variety of industries including construction, automotive, aerospace and food processing. The corrosion resistance of stainless steels is attributed to their unique alloy composition, passive film formation and surface properties. The corrosion resistance of stainless steels is evaluated by immersion testing.

Topic 10

Identification of polymers – flame test and pyrolytic test. (2 hours)

Both flame test and pyrolysis are valuable tools for the identification and characterization of polymers in various applications, including forensic analysis, quality control, and material recycling. While the flame test offers a quick and simple screening method, pyrolysis provides more detailed information about the polymer composition and structure.



TEXTBOOK/READINGS

The mandatory reading for completing the subject *Non-metallic materials*:

1. Encyclopedic handbook of biomaterials and bioengineering, Part A, B: Applications, Volume 1, 2, M. Dekker, NY, 1995
2. Encyclopedic Handbook of Biomaterials and Bioengineering: Part A: Materials, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8
3. Encyclopedic Handbook of Biomaterials and Bioengineering: Part B: Applicationss, Volume 1, Marcel Dekker Inc. 1997, ISBN 0-8247-9593-8
4. Peter Palček – Lenka Markovičová – Viera Zatkalíková: Materiály pre biomedicínske inťinierstvo, EDIS – Žilinská univerzita, Žilina 2015, ISBN 978-80-554-0988-7

Optional recommended texts for a deeper understanding of the subject:

1. Petr Skočovský- Peter Palček - Radomila Konečná – Ladislav Várkoly: Konštrukčné materiály, EDIS- ŽU v Žiline, 2000
2. Viera Zatkalíková – Tatiana Liptáková:: Základy chémie pre technikov. EDIS – Žilinská univerzita, Žilina 2013, ISBN 978-80-554-0812-5
3. Peter Filip: Progresivní typy biomateriálů, VŠB TU Ostrava, 1995
4. Branislav Hadzima – Tatiana Liptáková: Základy elektrochemickej korózie kovov. EDIS - Žilinská univerzita, Žilina 2008

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of Materials for biomedical engineering. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester)**:** paper continuously verifying knowledge of issues in the field of non-metallic materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of non-metallic materials.

GRADING POLICY

The subject Non-metallic materials is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + submitted reports (max. 3 points), i.e. j. 10 reports x 3 points = 30 points are evaluated; 1 semester paper (1 x 10 points = 10 points). The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
10 reports	25%
Semester paper	10%
Student portfolio	5%
Examination	60%
Total	100%

10 reports (max. 2 or 3 points each) – max. 25 points
Semester paper – max. 10 points
Independent work of student – max. 5 points
Final exam – max. 60 points

Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

PROPERTIES, PROCESSING AND USING OF PLASTICS

Code: **PPUP**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Advanced Engineering Materials

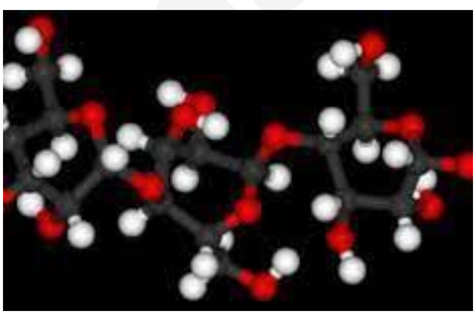
Form of tuition and number of hours:

Lecture: 26h

Laboratory: 26h

ECTS

6



cellulose

COURSE DESCRIPTION

This course deals with the properties of engineering polymers, which are closely related to their structure, which is often determined by the way in which they are produced. It is the links between production, structure, properties and the resulting applications that are the focus of the course.

The course focuses not only on the range of polymers produced, but also describes progressive, modern materials. Polymers are arranged according to chemical affinity, which makes it easier to understand all the connections. The course describes and compares the properties that are most important in terms of applications. The course *Properties, Processing and Using of Plas*tics extends the knowledge acquired in the field of materials distribution, the study of the structure and properties of materials and focuses on polymeric materials. The lectures are designed to provide information on the different groups of polymers, their production and processing methods, properties and applications of these materials. Laboratory exercises are devoted to the practice of the lecture topics and specific experiments.

The total time intensity of the course is 140 hours per semester, of which 52 hours (13 weeks x 2 hours of lectures + 13 weeks x 2 hours of laboratory exercises) are direct teaching and 73 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the course *Properties, Processing and Using of Plas*tics, the student will be able to understand the chemical composition and its influence on the structure and properties of macromolecular substances, on the basis of their properties and material characteristics to design an application.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of subject *Properties, Processing and Using of Plastics*, a student should have a general knowledge of the various types of engineering materials, their structure, properties and applications.

Co-funded by the European Union

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	He has extensive and in-depth substantive knowledge in this area of polymer properties, processing and applications.
MS_O_02	They can use information from literature and other available sources, interpret and critically evaluate it, draw conclusions and formulate and solve problems related to the production and use of polymeric materials.
MS_O_03	He can plan and conduct experiments, interpret results and draw conclusions regarding production issues and the use of properties.
MS_O_04	He can produce a scientific paper and present the possible uses of plastics based on their properties, structure and environmental resistance, including critical analysis, synthesis and conclusions. He can work independently and in a team and lead discussion.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Lectures:** lectures with problem-based interpretation, interactive lectures with discussion, lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	**Laboratory exercises:** motivational demonstration; laboratory work; observation; problem-based learning.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02 Meth_03

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Preparation for classes	Preparation for exercises, processing reports.	Independent work and cooperation
a_02	Reading literature	Preparation for exercises.	Independent work

Co-funded by the European Union

LEARNING OUTCOMES

By completing the lecture from the subject *Properties, Processing and Using of Plastics*, the student will be able to distinguish between individual types of polymers; describe and compare the characteristic properties of individual types of polymers, their use and method of production; analyse and solve the issue of the appropriateness of using specific polymers, based on their specific properties.

COMMENTS

LECTURER

DO YOU KNOW

Cellophane is not plastic Although cellophane may look like plastic at first glance, it is not plastic. It is made from chemically regenerated cellulose. As it is impermeable to both water and air, it is used, for example, for food packaging. The material was discovered by the Swiss chemist Jacques Brandenberger in 1912. He derived the name from the French words cellulose and diaphan (transparent).

COURSE CONTENT - FORM OF TUITION (e.g. lecture)

Topics 1

Introduction to the subject *Properties, Processing and Using of Plastics* (2 hours).

The history of materials and technologies dates back to ancient times when humans utilized naturally occurring materials like wood, stone, and metals for various purposes. Over millennia, advancements in metallurgy, ceramics, and polymers have led to the development of new materials and technologies, driving progress in civilizations and industries. The distribution of materials varies globally based on factors such as geological formations, industrial infrastructure, and economic factors, leading to regional specialization in material production and trade. Polymers are large molecules composed of repeating units called monomers, linked together through chemical bonds. The chemical composition of polymers dictates their properties and performance characteristics. For example, the presence of different functional groups or side chains can influence properties like flexibility, strength, and chemical resistance. Polymer structure refers to the arrangement of monomer units in the polymer chain, including factors like branching, cross-linking, and stereochemistry. The molecular weight distribution of polymers refers to the range of molecular weights present in a polymer sample. It impacts properties such as viscosity, melt flow, and mechanical strength. Chemical properties of polymers include their resistance to chemical attack, reactivity with other substances, and stability under various environmental conditions. Physical properties encompass characteristics such as density, melting point, glass transition temperature, and optical transparency. Mechanical properties of polymers include tensile strength, elongation at break, modulus of elasticity, toughness, and hardness. These properties govern the material's behavior under applied forces and deformation.

Topics 2

Construction reactions of polymers - chain and step reactions; Types of polymer additives and processing methods (forming, moulding, welding, casting). (6 hours)

Chain polymerization involves the repeated addition of monomer units to a growing polymer chain. Examples include radical polymerization, where free radicals initiate chain growth, and anionic or cationic polymerization, where initiation occurs via anionic or cationic species. Step polymerization involves the formation of covalent bonds between monomer units through condensation or addition-elimination reactions. Examples include polycondensation, where monomers with functional groups react to form polymer chains and release small molecules such as water or alcohol. Polymer additives such as stabilizers, plasticizers, fillers and reinforcements, dyes and retarders will be presented in the lecture. Polymer processing technologies such as shaping, molding, welding, casting will be explained

Topics 3

Division of polymers, properties and uses of structural polymer materials; Properties and uses of selected thermoplastics, reactoplastics and elastomers. (6 hours)

Polymers can be divided into several categories based on their structure, behavior and properties. One common classification divides polymers into thermoplastics, thermosetting plastics (reactoplastics), and elastomers based on their response to heat and mechanical stress. Thermoplastics can be melted and reshaped several times without undergoing a chemical change. Thermosetting plastics, also known as reactive plastics, undergo irreversible chemical reactions when heated and usually harden and harden when cured. Elastomers exhibit rubber-like elasticity and can return to their original shape after deformation. Next, the properties and use of structural polymer materials will be described. Understanding the properties and applications of structural polymeric materials, thermoplastics, thermoplastics, and elastomers is essential for materials engineers, designers, and manufacturers in selecting the most appropriate materials for specific applications based on their performance requirements, cost factors, and environmental factors.

Topics 4

Composite materials - composition structure; Composite materials - properties and applications. (6 hours)

Composite materials are technical materials composed of two or more basic materials with significantly different physical or chemical properties. The components of composite materials are usually classified as matrix and reinforcement. The matrix material binds the reinforcement together and transfers the load between the phases of the reinforcement. It is often polymer, metal or ceramic. The reinforcement phase, also known as filler or reinforcement, provides strength, stiffness and other specific properties to the composite. It can be in the form of fibers, particles or flakes. Common types of reinforcing materials include carbon fibers, glass fibers, aramid fibers, natural fibers (eg bamboo, jute) and particulate fillers (eg silica, alumina). Key properties of composite materials include high strength-to-weight ratio, stiffness, impact resistance, corrosion resistance, thermal stability, and adaptability of properties. Composite materials find applications in a variety of industries, including aerospace, automotive, marine, construction, sports and recreation, and electronics. Composite materials offer engineers and designers a versatile and customizable solution to achieve specific performance requirements in a wide variety of applications. Their unique combination of properties makes them increasingly attractive for use in industries where lightweight, durable and high-performance materials are essential.

Topics 5

Plastics processing - division of technologies, technical parameters, possible production errors and their elimination. (4 hours)

Plastics processing includes various technologies used to shape and form plastic materials into finished products. Injection molding involves injecting molten plastic into a mold cavity where it solidifies and forms the desired shape. It is widely used for the production of complex and high-volume parts such as automotive components, consumer goods and medical devices. Extrusion involves forcing molten plastic through a die to form continuous profiles with a consistent cross-section. It is used for the production of pipes, tubes, profiles and flat materials. Blow molding involves inflating a hollow plastic preform or preform inside a mold cavity to create a hollow part. It is commonly used to make bottles, containers and hollow shapes. Thermoforming involves heating a thermoplastic film until it softens and then forming it over a mold using vacuum forming, pressure forming, or mechanical forming techniques. It is used for the production of packaging, trays and single-use products. Molding involves placing a pre-measured amount of plastic material into a heated mold cavity and compressing it under high pressure until it solidifies. It is used for the production of composite materials, electrical components and automotive parts. Key technical parameters in plastic processing include temperature, pressure, cooling rate, cycle time, injection speed (in injection), screw speed (in extrusion) and mold design. Possible manufacturing defects will be classified and the possibilities of their removal will be explained. By understanding the breakdown of plastics processing technologies, controlling key technical parameters, and identifying and addressing potential manufacturing errors, manufacturers can ensure high-quality and efficient production of plastic components and products.

Topics 6

Nanocomposites - characterisation and applications; Recycling of plastic waste. (2 hours)

Nanocomposites are materials composed of a polymer matrix reinforced with nanoscale filler materials such as nanoparticles or nanofibers. Nanocomposites offer improved mechanical, thermal, electrical and barrier properties compared to traditional polymer materials. They are used in a variety of industries including automotive, aerospace, electronics, packaging and biomedical. Examples of applications include lightweight and high-strength components in the automotive and aerospace industries, conductive films and coatings for electronics, barrier films for food packaging, and biocompatible scaffolds for tissue engineering. Plastic waste poses significant environmental challenges due to its persistence in the environment and its impact on ecosystems and wildlife. Traditional methods of plastic disposal, such as landfilling and incineration, contribute to pollution and resource depletion. During the lecture, methods of recycling will be presented, such as: mechanical recycling, chemical recycling, biological recycling. Recycling plastic waste saves resources, reduces energy consumption and greenhouse gas emissions associated with the production of new plastics, and reduces pollution and litter.

Co-funded by the European Union

LEARNING OUTCOMES

By completing the laboratory exercises from the subject *Properties, Processing and Using of Plastics*, the student will be able to classify individual polymers using identification tests, evaluate the flammability of polymers based on the results of fire characteristics of polymers, design an experiment in accordance with STN standards and identify the change in material properties, interpret independently/team the results of laboratory work, including leading a discussion.

COMMENTS

INSTRUCTOR

DO YOU KNOW

There are caterpillars that eat plastic waste. The discovery was made by chance. A Spanish scientist and amateur beekeeper, Federica Bertocchini, collected the parasites, the wax-eating caterpillars of the honeycomb caterpillar, from her hives and put them in a plastic bag. She forgot about the caterpillars left in the bag. When she returned to the plastic bag, however, she found that the creatures had chewed their way out of it and into freedom. The scientist began to wonder whether this was just a sign of self-preservation or whether the centimeter-long caterpillars were able to actively digest the plastic material.

COURSE CONTENT - FORM OF TUITION (e.g. laboratory classes)

Topics 1

Identification of polymers on the basis of their density. (2 hours)

Identification of polymers based on their density is a common technique used in the characterization and analysis of polymers. Each polymer has a characteristic density that can be determined experimentally and compared to known values to identify the polymer. By measuring the density of a polymer sample and comparing it to reference values for known polymers, the type of polymer can be identified. Once the polymer density is determined, it can be compared to reference values or databases of known polymer densities. A polymer is identified by comparing its density to the nearest reference value for a known polymer.

Topics 2

Polymer identification - flame test. (2 hours)

The flame test is a simple and rapid qualitative method used to identify certain types of polymers based on their characteristic behavior when exposed to flame. Different polymers exhibit different flame behavior, including flame color, flame spread, smoke generation, and odor, due to changes in their chemical composition and structure. By observing these flame characteristics, it is possible to infer the type of polymer being tested and to distinguish between different types of polymers. The flame test is a qualitative method and may not always provide definitive identification, especially in the case of complex polymer mixtures or formulations. Care must be taken to perform the flame test in a controlled environment to ensure safety and accurate observations. If necessary, it is important to supplement the flame test with other analytical techniques for comprehensive polymer identification. The flame test is a useful preliminary screening method to identify certain types of polymers based on their characteristic flame behavior. However, it should be used in conjunction with other analytical techniques to reliably identify polymers, especially in cases where multiple polymers or polymer mixtures are present.

Topics 3

Polymer identification - pyrolysis test. (2 hours)

The pyrolysis test is a technique used to identify polymers based on their behavior when exposed to high temperatures in an inert atmosphere. Pyrolysis involves the thermal decomposition of organic materials in the absence of oxygen. Different polymers have characteristic decomposition temperatures and decomposition products, which allows their identification based on analysis of pyrolysis products. Pyrolysis gases are collected and analyzed using techniques such as gas chromatography-mass spectrometry (GC-MS) or Fourier transform infrared spectroscopy (FTIR) to identify the chemical composition of the decomposition products. Comparison of pyrolysis results with known pyrolysis profiles or polymer pyrolysis product databases allows polymer identification.

Topics 4

Determination of the solidification curve. (2 hours)

Solidification curve determination is a process used in materials science and metallurgy to characterize the solidification behavior of metals and alloys during cooling from the liquid state to the solid state. The solidification curve provides valuable information about the solidification process, including the temperature range over which solidification occurs and the phases present during solidification. Solidification curve determination typically involves heating a metal or alloy sample to its melting point and then cooling it at a controlled rate. The solidification curve can be analyzed to determine important parameters such as the solidus temperature (the temperature at which solidification begins), the liquidus temperature (the temperature at which solidification is complete), and the solidification range (the temperature range over which solidification occurs). The solidification curve can also provide insight into the microstructure and phase transformation behavior of the material during solidification.

Topics 5

Determination of fire characteristics. (2 hours)

Determining the fire characteristics of materials is key to assessing their fire-safety properties and understanding their behavior in fire situations. Several methods and tests are used to evaluate various aspects of a material's response to fire. Ignition properties refer to the susceptibility of a material to ignite when exposed to an external heat source. Combustibility refers to the ability of a material to sustain burning after ignition. Smoke production refers to the amount of smoke generated by a material during combustion. Flame spread refers to the speed at which fire spreads across the surface of a material. Fire resistance measures the ability of a material to withstand fire without significant loss of structural integrity or insulating properties. Determining the fire characteristics of materials involves a combination of experimental testing, analysis and modeling to evaluate ignition, flammability, heat release rate, smoke production, toxic gas emissions, flame spread and fire resistance. These assessments are necessary to ensure the fire safety of buildings, products and materials in various applications.

Topics 6

Viscosity measurement with the Ubbelohde viscometer. (2 hours)

Viscosity measurement using the Ubbelohde viscometer is a widely used technique for determining the viscosity of liquids, especially Newtonian liquids such as oils, polymers and solutions. Ubbelohde's viscometer works on the principle of capillary flow. When a liquid flows through a capillary, the flow rate is inversely proportional to the viscosity of the liquid. The Ubbelohde viscometer consists of a glass capillary with a precisely defined diameter and length. The liquid to be tested is allowed to flow through the capillary under the influence of gravity. Viscosity measurements can be repeated at different temperatures to investigate the temperature dependence of viscosity and to determine the activation energy of the liquid. Experimental data can also be compared with theoretical models or empirical correlations to validate viscosity measurement results.

Topics 7

Mechanical properties of polymers. (2 hours)

The mechanical properties of polymers refer to their behavior under applied forces or loads, including how they deform, break, and resist external stresses. Understanding these properties is crucial for the design and construction of polymer-based materials for specific applications. Tensile strength is the maximum stress a polymer can withstand before it breaks under stress. Tensile strength is a basic parameter for assessing the structural integrity and load-bearing capacity of polymeric materials. Elongation at break is the percentage increase in the length of a polymer sample at the point of failure compared to its original length. It represents the ductility or elasticity of the polymer and indicates its ability to deform plastically before breaking. Materials with high tensile strength are more flexible and less brittle. Young's modulus is a measure of a polymer's stiffness or resistance to deformation under tensile stress. It represents the slope of the linear part of the stress-strain curve in the elastic region. Bending strength is the maximum stress a polymer can withstand before it breaks in bending. Impact resistance measures the ability of a polymer to withstand sudden or dynamic loads without cracking. It is assessed using impact testing methods such as Izod and Charpy impact tests, where a standardized impactor strikes a notched specimen.

Topics 8

Determination of recyclate properties. (2 hours)

Determining the properties of recyclates is essential for evaluating the quality, performance and potential applications of recycled materials obtained from waste. Recycled samples are obtained from recycled materials, which may include plastics, metals, glass, paper or other materials. Samples are usually collected from recycling facilities, sorted, cleaned and processed to remove contaminants and impurities. Various analytical and testing techniques are used to evaluate the properties of recyclates, including: physical properties, chemical composition, mechanical properties, thermal properties, environmental properties. Based on the identified properties, recycled materials can be used in various applications, including manufacturing, construction, packaging, the automotive industry, and consumer goods.

Topics 9

Determination of melting point. (2 hours)

Melting point determination is a fundamental characterization technique used to evaluate the thermal properties of materials, including polymers, metals, and organic compounds. The melting point is the temperature at which a solid changes to its liquid phase under atmospheric pressure. A common laboratory apparatus specially designed for measuring the melting point of solids consists of a heating block with a heating element, a sample holder (capillary tube or sample well), and a magnifying lens to observe the sample during heating. The temperature is gradually increased at a controlled rate, typically 1-2 degrees Celsius per minute, while the sample is observed visually. As the temperature approaches the melting point, the sample begins to soften, liquefy and eventually form a clear liquid phase. The temperature at which the first drop of liquid is observed is recorded as the melting point.

Topics 10

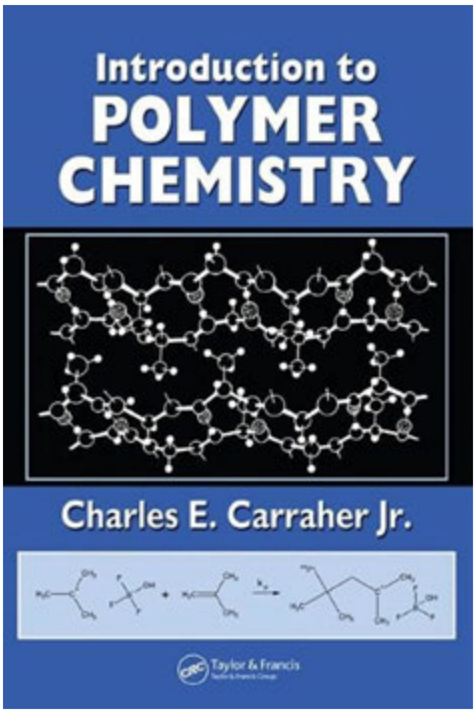
Chemical resistance of polymers. (2 hours)

Chemical resistance is an important property of polymers that determines their suitability for various applications where exposure to various chemicals is expected. Chemical resistance refers to the ability of a polymer to withstand exposure to chemicals without significant degradation, dissolution, or other adverse effects. Chemical resistance is influenced by factors such as the chemical composition of the polymer, its molecular structure and the specific properties of the chemicals to which it is exposed. Depending on the application, polymers can be exposed to a variety of chemicals including acids, bases, solvents, fuels, oils and industrial chemicals. Different polymers show different degrees of resistance to different types of chemicals. After exposure, samples are evaluated for changes in weight, dimensions, appearance, mechanical properties and other relevant parameters to assess the extent of degradation or damage.

Topics 11

Corrosion of polymers. (2 hours)

Polymer corrosion, also known as chemical degradation or degradation in aggressive environments, refers to the deterioration of polymeric materials due to exposure to corrosive substances such as acids, bases, solvents, oxidizing agents, and environmental factors such as UV radiation and moisture. While polymers are generally more resistant to corrosion compared to metals, they are not immune to degradation. Exposure to corrosive chemicals can lead to chemical degradation of polymers, which can cause changes in molecular structure, loss of mechanical properties and eventual failure. Environmental factors such as UV radiation, heat, humidity, and atmospheric pollutants can contribute to polymer degradation through processes such as photooxidation, thermal degradation, and hydrolysis. Water molecules can penetrate the polymer matrix, break the chemical bonds and cause chain scission. Hydrolytic degradation is common in polymers such as polyesters and polyamides. Oxygen or oxidizing agents can react with the polymer chains, leading to the formation of free radicals and oxidative cleavage of the chain. Oxidative degradation is accelerated by factors such as heat, light and exposure to air. UV radiation can induce photochemical reactions in polymers, causing cross-linking, chain scission and discoloration. Degradation by UV radiation is a significant problem in outdoor applications. High temperatures can accelerate chemical reactions in polymers, leading to thermal degradation, loss of mechanical properties and changes in morphology.



Topics 12

Determination of chemical resistance of PVC. (2 hours)

Determining the chemical resistance of polyvinyl chloride (PVC) involves evaluating its ability to withstand exposure to various chemicals without significant degradation or damage. PVC is a widely used thermoplastic polymer known for its excellent chemical resistance in many applications. Before performing chemical resistance testing, it is essential to identify the specific chemicals to which PVC may be exposed in its intended use. Chemical resistance testing typically involves exposure to a range of common chemicals including acids, bases, solvents, oils and other industrial chemicals. PVC test samples are prepared according to relevant standards or protocols, typically in the form of plates, foils or molded parts.

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Properties, Processing and Using of Plastics*:

Charles E. Carraher 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

Tatiana Liptáková – Pavol Alexy – Ernest Gondár – Viera Khunová: Polymérne konštrukčné materiály. 1. vyd. Žilina: EDIS, 2012. 189 s. ISBN 978-80-554-0505-6

Optional recommended texts for a deeper understanding of the subject *Technology of processing and properties of plastics*:

Joel Fried: Polymer Science and Technology, Pearson; 3rd edition, 2014, ISBN-13: 978-0137039555

Lubomír Zeman: Vstřikování plastů. Praha 2009. 248 s. ISBN 978-80-7300-250-3

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of non-metallic materials. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester)**:** paper continuously verifying knowledge of issues in the field of non-metallic materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of non-metallic materials.

Assignment Weights	**Percent**
10 reports	20%
Semester paper	15%
Student portfolio	5%
Examination	60%
Total	100%

10 reports (max.2 or 3 points each) – max. 25 points
Semester paper – max. 10 points
Independent work of student – max. 5 points
Final exam – max. 60 points

Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

GRADING POLICY

The subject *Properties, Processing and Using of Plas*tics is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + submitted reports (max. 3 points), i.e. j. 10 reports x 3 points = 30 points are evaluated; 1 semester paper (1 x 10 points = 10 points). The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

CORROSION AND SURFACE TREATMENTS

Code: **CST**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Applied Materials Science

Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

6

Corroded car body

COURSE DESCRIPTION

The *Corrosion and surface treatments* course is dedicated to the *AIEMPS - Advances in Innovative Engineering Materials and Processes for Sustainability* path. It delves into the mechanisms, prevention, and mitigation of corrosion, which is the gradual deterioration of materials due to chemical and physic-chemical reactions with the environment. The course is focused on explaining the nature of corrosion processes, distinguishing between individual forms of corrosion, and learning the methods of corrosion resistance evaluating. The subject also deals with the possibilities of increasing the corrosion resistance of metals and alloys using various mechanical, chemical and electrochemical surface treatments. Students learn about the selection and application of these treatments based on material properties, environmental conditions, and desired performance characteristics. Through theoretical knowledge and practical applications, students gain insights into preserving the integrity and longevity of materials in various industrial and engineering contexts.

Teaching is divided into lectures and laboratory exercises. In the lectures, students will learn to understand the theoretical bases of corrosion processes. During laboratory exercises, students will learn and try exposure and electrochemical methods for evaluating the corrosion resistance of metals and alloys. They will also learn to perform various mechanical and electrochemical surface treatments and learn how these treatments affect the corrosion resistance of metals and alloys.

COURSE OBJECTIVES

After finishing *Corrosion and surface treatments,* a student will be able to distinguish main types of corrosion attack; assess the suitability of different types of metals and their alloys for use in environments with different aggressiveness; prevent the corrosion degradation of materials by appropriate interventions in constructions; suggest and perform suitable surface treatments and to evaluate the corrosion resistance by exposure and electrochemical corrosion tests.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Corrosion and surface treatments*, a student should have a basic knowledge of general and inorganic chemistry and general knowledge of various types, properties, microstructure and applications of engineering materials.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Has extensive and in-depth substantive knowledge in the field corrosion processes theory – mechanism and various types of corrosion attack, suitability of using different types of metals and their alloys for environments with different aggressiveness, suggestions of suitable surface treatment for improvement of corrosion resistance
MS_O_02	Can use information from literature and other available sources in the field of general chemistry, interpret and critically evaluate them.
MS_O_03	Can plan and carry out experiments, interpret the results and draw conclusions regarding the corrosion properties of the materials and their surface treatments.
MS_O_04	Can prepare and present results of corrosion resistance tests, including critical analysis, synthesis and conclusions. Able to work individually and in a team, and lead a debate.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Lectures:** lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	**Laboratory classes:** experiment demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	Lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_02	Preparation for classes	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_03	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

After finishing the subject *Corrosion and surface treatments* a student will be able to distinguish the main types of corrosion attack, to assess the suitability of different types of metals and their alloys for use in environments with different aggressiveness, to prevent the corrosion degradation of materials by appropriate interventions in constructions, to suggest and perform suitable surface treatments and to evaluate the corrosion resistance by exposure and electrochemical corrosion tests.

DO YOU KNOW

Stainless steels are susceptible to the local pitting corrosion in chloride solutions. The results of 24-hours exposure of Cr-Ni-Mo stainless steel in low pH $FeCl_3$ solution (at 50 °C) can be seen in the following picture.

Pitting corrosion on Cr-Ni-Mo stainless steel

COURSE CONTENT - LECTURE

Topics 1

Corrosion: Introduction: basic definitions and mechanisms
In the introduction the definition of corrosion and historical and economic aspects of corrosion and corrosion protection will be described and explained. Students will summarize their knowledge about basic mechanisms of corrosion, oxidation, reduction, chemical and electrochemical corrosion. (4 hours).

Topics 2

Thermodynamics of corrosion processes
In this lecture the basic thermodynamic quantities as internal energy, enthalpy, entropy, Gibbs's energy, Electrode potential, standard potential will be defined and explained. Students will learn to apply their knowledge about Pourbaix E – pH diagrams of various metals and alloys (4 hours).

Topics 3

Kinetics of electrochemical corrosion
Students will learn most important facts of kinetics of electrochemical corrosion – derivation of corrosion rate from Faradays law, anodic and cathodic coupled reactions, polarization curves, explanation of corrosion potential and corrosion current density. They will organize their knowledge about immunity, activity, passivity, transpassivity, polarization curves of passivating metal, pitting potential, repassivation potential (5 hours).

Topics 4

Corrosion factors and corrosion types
This lecture deals with identification of substantial internal and external factors affecting corrosion properties of metals and alloys. Corrosion types as general corrosion, galvanic corrosion, pitting and crevice corrosion, intergranular corrosion, selective corrosion attack will be also defined and summarized (4 hours).

Topics 5

Corrosion in various environments
The lecture summarizes important characteristic features of corrosion in various environments - corrosion in electrolytes, in waters, atmospheric corrosion, corrosion in soils. Students will also learn to indicate effects of mechanical stresses on corrosive properties of alloys. Corrosive cracking, corrosion fatigue as special forms of corrosions will be discussed (4 hours).

Topics 6

Corrosion protection by coatings
The lecture is focused on preparation of the metal surfaces before the exposure in a corrosive environment. Students will organize their knowledge about non-metallic protective coatings and their typical corrosion properties, metal coatings and methods of their application, and corrosion protection by adjusting the environment by inhibitors (5 hours).

LEARNING OUTCOMES

After finishing the subject *Corrosion and surface treatments* a student will be able to distinguish the main types of corrosion attack, to assess the suitability of different types of metals and their alloys for use in environments with different aggressiveness, to prevent the corrosion degradation of materials by appropriate interventions in constructions, to suggest and perform suitable surface treatments and to evaluate the corrosion resistance by exposure and electrochemical corrosion tests.

COMMENTS

INSTRUCTOR

DO YOU KNOW

If two metals/alloys are directly connected in a conductive medium, galvanic corrosion occurs - the metal with lower thermodynamic stability (with the lower corrosion potential) corrodes in preference to another metal/alloy.

Copper alloy fitting connected to a galvanized iron fitting

COURSE CONTENT – LABORATORY CLASSES

Topics 1

Introduction to the laboratory classes

Introduction to the laboratory classes will contain instruction on laboratory order and safety at work. Students will recognize the basic principles of exposure and electrochemical methods of the corrosion resistance testing. They will become familiar with the device for electrochemical testing and with detailed procedure of measurement (4 hours).

Topics 2

Exposure corrosion test

This topics deals with determination of corrosion resistance of chosen metal/alloy by rapid exposure corrosion test performed in an aggressive acid solution at the room temperature. Students will calculate the average corrosion rate and they will evaluate macroscopically the corrosion damage of the samples. (4 hours).

Topics 3

Potentiodynamic polarization test

Students will carry out determination of corrosion resistance of chosen non-passivating metal/alloy by electrochemical potentiodynamic polarization method in sodium chloride solution. They will determine and asses the basic potentiodynamic parameters as corrosion potential and corrosion current density(4 hours).

Topics 4

Electrochemical impedance spectroscopy (EIS)

Students will perform determination of a stainless steel passive surface film quality by electrochemical impedance spectroscopy (EIS) measurement in chloride solution at room temperature. The passive film quality will be evaluate by polarization resistance determined from Nyquist diagram. 4 hours).

Topics 5

Electrochemical polishing

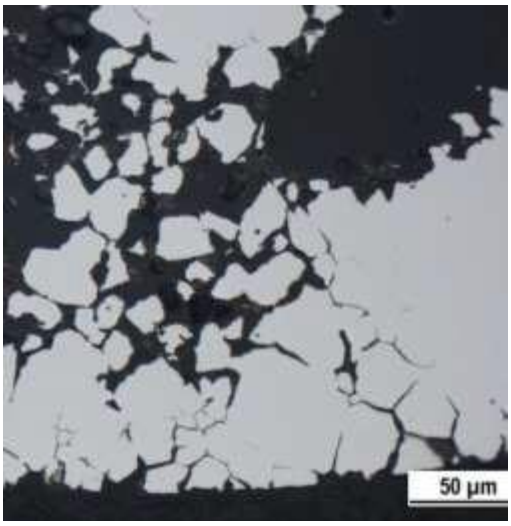
This laboratory exercise is focused on electrochemical polishing of stainless steel performed in the mixture of inorganic acids (phosphoric and sulfuric acids). Students will evaluate the quality of prepared surface by cyclic potentiodynamic polarization method and by determination of the pitting and the repassivation potentials as the basic parameters of cyclic polarization curves (4 hours).

Topics 6

Anodic oxidation

Studentst will carry out anodic oxidation of Al alloy by electrolysis in H_2SO_4 solution. The corrosion resistance of the prepared surface will be evaluated by potentiodynamic polarization method in sodium chloride solution and by determined electrochemical parameters - corrosion potential, corrosion current density and corrosion rate (4 hours).

TEXTBOOK/READINGS



Inter-granular corrosion of Cr-Ni stainless steel

The mandatory reading for completing *Corrosion and surface treatments* course.

POPOV, B.N.: Corrosion Engineering Principles and Solved Problems. Elsevier 2015, 774 s., ISBN 978-0-444-62722-3.

SCHWEITZER, P.A.: Fundamentals of Corrosion: Mechanisms, Causes, and Preventative Methods. CRC Press, York 2009, 416 s.

For a deeper understanding of the course subject matter, optional recommended texts include:

BARD, A.J. - FAULKNER, L.R.: Electrochemical methods: fundamentals and applications. Wiley, New York 2002.

ASSESEMENT

Reports: Each report is related to the particular laboratory exercise. It contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion. A brief oral presentation of the obtained result is also included in the scoring of the report.

Semester paper (test during the semester)**:** Paper verifying knowledge of issues of the subject

Exam (after the semester)**:** Written and oral exam verifying overall knowledge obtained in *Corrosion and surface treatments* course.

Assignment Weights	Percent
5 reports	30%
semester paper	10%
Examination	60%
Total	100%

GRADING POLICY

The subject *Corrosion and surface treatments* is evaluated by points.

Laboratory exercises: Submitted reports (max. 6 points for each report) and semester paper are evaluated. The maximum number of points achieved in the laboratory exercises is 40.
The resulting points are the sum of the points that the student obtained during the semester (laboratory exercises, max. 40 points) and the points he/she achieved on the exam (max. 60 points).

5 reports (max. 6 points each) – max. 30 points
Semester paper – max. 10 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

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PROJECT STUDY

Code: **PS**

Field of study

Materials Science and Engineering

Level of study

master study

Semester

4

Language

English

Thematic block

Research Project - Master Thesis

Form of tuition and number of hours:

Exercises: 13h

ECTS

4

COURSE DESCRIPTION

The Project study course is focused on the processing and presentation of professional topics for demonstrating the ability of the students to apply the knowledge and skills acquired during the master study in solving specific professional problems. Students manifest their ability to explain independently the problem and present obtained results. They also learn to lead professional discussion both individually and in a team.

Each student works on a professional topic that is related closely to the topic of the diploma thesis.

COURSE OBJECTIVES

By completing the *Project study* course, the student will be able to apply knowledge and skills acquired during master study in solving a specific problem, to prepare individually the presentation, present it for a professional audience and also lead a professional discussion.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the *Project study course,* a student should have a broad knowledge in the field of Materials Engineering.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_02	Can use information from literature and other available sources in the field of materials engineering, interpret and critically evaluate them.
MS_O_04	Can prepare presentation and present the theory and results of performed experiments related to the topic of diploma thesis including critical analysis, synthesis and conclusions. Able to work individually and in a team, and lead a debate.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Team project**: critical analysis, synthesis and conclusions; individual and team work, communicate on specialist topics, leading a debate.	MS_O_02 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	Exercise	13	course work	MS_O_02 MS_O_04	Meth_01

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_02	Preparation for classes	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_03	Preparation of presentations	Preparation and development of presentations	YES

LEARNING OUTCOMES

By completing the subject Project study, the student will be able to apply knowledge and skills acquired during master study in solving a specific problem, to prepare individually the presentation and to present it in English and also lead a professional discussion (in English)

COURSE CONTENT - EXERCISES

Topics 1

Introduction to project study
The first exercise will start with a short introduction (curriculum vitae) of each student in English and it will continue by the assignment of project study topic for each student (according to the Diploma thesis). Then the objectives and outputs of the project study will be defined and discussed (1 hour).

Topics 2

Preparation of a technical professional terms dictionary
In the frame of this topics students will work with English technical documentation and with scientific articles in the field of material engineering and a technical professional terms dictionary, at least 30 terms from the field of material engineering according to the topic of diploma thesis will be prepared (3 hours).

Topics 3

Theoretical foundations of the project study topics
In this lesson students will identify, prepare and present (in English) theoretical foundations of the topic selected for the project study according to the diploma thesis (4 hours).

Topics 4

Experimental part of the project study
Students will name and define their used experimental methods. They will summarize, evaluate and present results of the experiments performed in the frame of Diploma thesis in cca 15 min oral speech with consequent discussion. (5 hours).

TEXTBOOK/READINGS

The mandatory reading for completing *Project study* course:

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.

For a deeper understanding of the course subject matter, optional recommended texts include:

Pearson Education Limited: BTEC Engineering. 294 S. ISBN 978-1-4469-0243-1.

ASSESMENT

Presentations: Two spoken presentations (one related to the theoretical foundations, one related to the explanation and evaluation of the experiments). Assessed is expert knowledge, work with professional literature, self-study, individual work, data processing and analysis in English, presentation skills.

GRADING POLICY

The subject *Project study* is scored with points.

Exercises: 2 spoken presentations (max. 50 points for each presentation), the maximum number of points achieved is 100.

Assignment Weights	Percent
Presentation 1	50%
Presentation 2	50%
Total	100%

2 presentations

Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

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QUALITY CONTROL OF MATERIALS

Code: **QCM**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Advanced Methods for Materials Characterisation

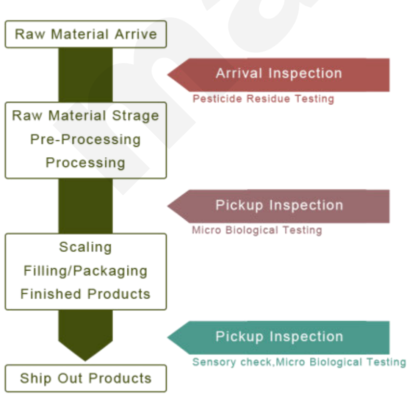
Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

4



COURSE DESCRIPTION

Quality control of materials is guided by various quality assurance standards and certifications, such as ISO 9001. These standards outline requirements for quality management systems and provide a framework for ensuring consistent quality in materials, processes, and products. Compliance with these standards helps organizations demonstrate their commitment to quality control. Many industries require material certification to ensure the quality and traceability of materials used in their products. Material certification involves providing documentation and evidence that the materials meet specific standards and specifications. This helps maintain consistency and reliability in the supply chain and ensures compliance with regulatory requirements. Quality control includes the analysis of material failures to determine the root causes and prevent a recurrence. Failure analysis involves investigating the factors that led to material degradation, structural failures, or performance issues. This knowledge is crucial for improving material design, manufacturing processes, and quality control measures. Quality control of materials often involves non-destructive testing (NDT) techniques, which allow for the evaluation and inspection of materials without causing damage.

COURSE OBJECTIVES

By completing the *Quality Control of Materials* course, the student will be able to describe the necessary documentation requirements according to ISO 9001:2015; define and describe the basic methods and tools of statistical quality control applied in the input and output control of products; design a system and describe the methodology of selection and sampling; using the acquired knowledge, apply appropriate methods of determining basic material characteristics and use them independently; using the acquired knowledge to explain the characteristics and methods of quality assessment (destructive and non-destructive control), distinguish and reproduce the methods of non-destructive testing; identify the most frequently occurring types of wear, corrosion damage, defects in weld joints, defects in bearing steels and changes in the structure of steels after inappropriate heat treatment and propose possible solutions; analyze data from research activities, evaluate results and process acceptance protocols (input/output) of individual methods to maintain the required quality of product material - individually and in a team; appropriately present the results of research activities.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Quality Control of Materials*, a student should have a general knowledge of the various types of engineering materials, their structure, properties, heat-treatment fundamentals and applications.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge in the field of methods, processes of production and processing of engineering materials (steels, cast irons, aluminium, titanium, and nickel based alloys – cast and wrought) in connection with the application of knowledge in the field of quality control of materials (ISO standards, mechanical properties vs. quality relations, destructive and non-destructive testing of ferrous and non-ferrous alloys).
MS_O_02	Can use information from literature, He can integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental materials testing (using of destructiveor NDT methods, metallography evaluation) and its quality assurance problems.
MS_O_03	He can plan and carry out experiments, including measurements (metallography samples preparation, mechanical testing – hardness, UTS, Charpy impact tests, NDT methods application), interpret the results and draw conclusions related to the field of quality control of materials.
MS_O_04	Can prepare a scientific study (semester work, lessons reports, etc.) and present a presentation on the implementation of various materials testing methods for research tasks, containing a critical analysis, and conclusions with an accent on materials quality and its influence on overall mechanical properties. Able to work individually and in a team as well as interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; report; question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, and self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

By completing the *Quality Control of Materials* course, the student will be able to describe the necessary documentation requirements according to ISO 9001:2015; define and describe the basic methods and tools of statistical quality control applied in the input and output control of products; design a system and describe the methodology of selection and sampling; using the acquired knowledge to explain the characteristics and methods of quality assessment (destructive and non-destructive control), distinguish and reproduce the methods of non-destructive testing; identify the most frequently occurring types of wear, corrosion damage, defects in weld joints, defects in bearing steels and changes in the structure of steels after inappropriate heat treatment and propose possible solutions and etc.

COMMENTS
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER
Prof. Ing. Eva Tillová, PhD.
Assoc. prof. Ing. Lenka Kuchariková, PhD.
Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW
***Quality Engineers** work to ensure the overall quality of manufactured products. They test processes, monitor quality standards, create documentation, devise quality tests and define the criteria a test result should meet. **Quality Engineers** monitor the quality of a process and play a key role in fixing issues when they arise. **Quality Engineers** work within a wider team of professionals to ensure that the final products are safe, reliable and meet customer expectations while keeping the manufacturing process as effective and cost-efficient as possible.*

COURSE CONTENT - LECTURE

Topics 1

Introduction. Quality - basic concepts, signs and methods of quality assessment. Development of quality management systems.

Topics 2

Legal regulations, conformity marks, quality certificate, quality manual, ISO 9001 documents.

Topics 3

Visual control. Metallographic assessment – preparation of metallographic specimens. Developing and etching of the structure. Microscopes - selection of magnification.

Topics 4

Structure control - macroscopic and microscopic evaluation. Metallography samples preparation for macroscopy and microscopy observation, importance of proper magnification selection.

Topics 5

Reliability and diagnostics. Malfunctions - distribution, causes of component damage. Fault analysis.

Topics 6

Structure of the weld joint - macro, micro, measurement of microhardness. Classification of weld joint defects.

Topics 7

Quantitative assessment of structural components. Evaluation of bearing steels.

Topics 8

Assessment of corrosion resistance. Basic types of corrosion damage. Possibilities of corrosion resistance improving via coatings and alloying.

Topics 9

Non-destructive testing (NDT). Basic concepts, classification of defects. NDT – surface defects and methodology description. NDT – internal defects and methodology description.

Topics 10

Control of properties - fundamental testing (measurement) of design materials' mechanical properties.

Topics 11

Damage of railway materials - rails, track tops. Introduction to railway materials, proper railway materials selection, case studies.

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LEARNING OUTCOMES

Based on the completed lectures, students should be able to apply the acquired knowledge when solving model examples aimed at data analyzes from research activities, evaluate results and process acceptance protocols (input/output) of individual methods to maintain the required quality of product material - individually and in a team; appropriately present the results of research activities etc.

COMMENTS

Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

Assoc. prof. Ing. Lenka Kuchariková, PhD.
Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW

***Materials engineers** are frequently involved in research, manufacturing, and materials development activities for a wide range of industries, teaching students, training researchers, and undertaking management duties like monitoring budgets, estimating costs and supervising technicians.*
***The duties of a materials engineer** will differ according to working environment and job requirements, but will typically involve the use of mathematic and scientific principles to investigate, understand, modify and control how substances behave and interact with each other. This knowledge allows engineers to select materials for specific products and develop prototypes, as well as developing materials production and processing procedures. At the same time, engineers will need to consider other factors such as costs, production times, energy use, material availability and logistics.*

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Safety and health protection at work. Conditions for evaluation and completion of the course. Materials quality assessment tools.

Topics 2

Application of Fe-Fe3C 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.

Topics 3

Evaluation of the macrostructure and microstructures of metallic materials. This topic is divided into five subtopics and will be implemented during the next 5 classes. The subtopics are: 1. Evaluation of the macrostructure of metallic materials. and 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.

Topics 4

Non-destructive testing of materials – indication and evaluation of surface defects. Penetration tests and Magnetic particles testing – practical applications.

Non-destructive testing of materials – indication and evaluation of internal defects. RTG films presentations and Ultrasonic testing application on ferrous and non-ferrous alloys.

Topics 5

Use of mechanical tests (tensile test, hardness testing, Charpy test) for material identification. Creation of transfer protocols.

Topics 6

Excursion in production factories.

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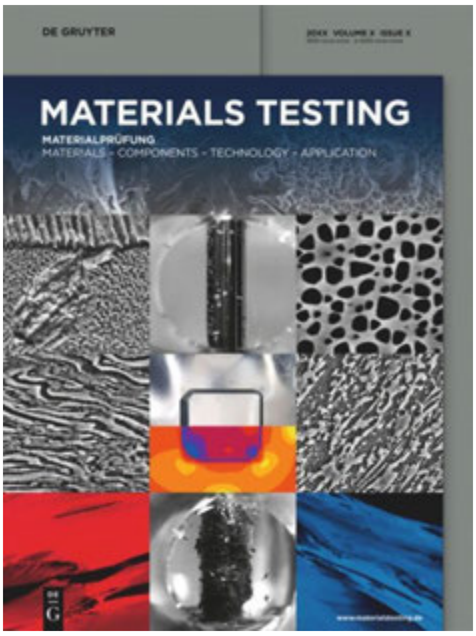

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Quality Control of Materials*:

1. ASM Handbook, Volume 11, Failure Analysis and Prevention. 2002.
2. ASM Handbook, Volume 17, Nondestructive Evaluation and Quality Control. 1997.

For a deeper understanding of the course subject matter, optional recommended texts include:

1. Mechanical Engineers' Handbook, Volume 1: Materials and Engineering Mechanics, 4th Edition, by Myer Kutz (Editor), ISBN-10 1118112822, ISBN-13 978-1118112823, Publisher: Wiley, 1040 pages.
2. Mechanical Engineers' Handbook, Volume 2: Design, Instrumentation, and Controls, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112830, Publisher: Wiley, 982 pages.
3. Mechanical Engineers' Handbook, Volume 3: Manufacturing and Management, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112847, Publisher: Wiley, 817 pages.
4. Mechanical Engineers' Handbook, Volume 4: Energy and Power, 4th Edition, by Myer Kutz (Editor), ISBN-13 978-1118112854, Publisher: Wiley, 1174 pages.

ASSESSMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of quality control. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester)**:** paper and laboratory work continuously verifying knowledge of issues in the field of quality control of materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge about quality assurance of products (materials) in mechanical engineering.

GRADING POLICY

Points evaluate the subject *Quality Control of Materials*. The resulting points are the sum of the points that the student gets during the semester (on exercises) and the points that he gets on the exam.

During the exercises, the following are continuously evaluated: theoretical preparation + submitted reports (max. 3 points), i.e. 11 reports x 3p = 33 points are evaluated; 1-semester paper (1 x 2 points = 2 points), excursion in production factory (1 x 5 points = 5 points). The maximum number of points achieved in the exercises is 40.

The final assessment consists of points that the student gets during the semester (on exercises) and points that he gets on the exam. The points obtained in the exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	Percent
11 reports	25%
1-semester work	10%
Student portfolio	5%
Final examination	60%
Total	100%

11 reports (max. 3 points each) – max. 33 points
1-semester paper – max. 2 points
Excursion – max. 5 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points	= A
85 – 92 points	= B
77 – 84 points	= C
69 – 76 points	= D
61 – 68 points	= E
0 – 60 points	= FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

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ADVANCED CONSTRUCTION MATERIALS

Code: **ACM**

Field of study
Materials Science and Engineering

Level of study
Master Study

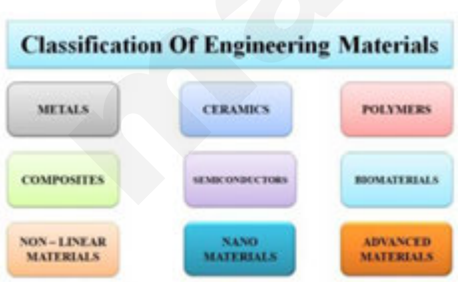
Semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours*:
Lecture: 26h
Exercises: 13h
Laboratory: 13h

ECTS
4



COURSE DESCRIPTION

Advanced construction materials are specialized materials that offer improved performance, durability, sustainability, and efficiency in the engineering industry. These materials are designed to overcome the limitations of traditional construction materials and contribute to the development of more advanced and innovative structures. They are often developed through advanced research, engineering, and manufacturing techniques.

Advanced construction materials deal with addressing the challenges and requirements of modern technologies and applications. These materials are developed to provide solutions for a wide range of engineering fields and industries. Here are some key areas where advanced engineering materials are utilized: i) Aerospace and Aviation (carbon fibre composites, titanium alloys, and ceramic matrix composites); ii) Automotive Industry (aluminium alloys, high-strength steels, and carbon fibre composites); iii) Energy Generation and Storage (silicon for solar cells, superalloys for gas turbines, and advanced ceramics for thermal barrier coatings); iv) Electronics and Telecommunications (materials with specific electrical, magnetic, and optical properties, semiconductor materials); v) Biomedical Engineering (biocompatible metals (titanium), polymers, and ceramics); vi) Construction and Infrastructure; vii) Environmental and Sustainable Technologies; viii) Defence and Security, etc.

COURSE OBJECTIVES

By completing the *Advanced Construction Materials* subject, the student will be able to explain the principles of dividing construction materials with emphasis on new development trends; distinguish and reproduce the principles in modelling the structure and properties of structural materials in relation to production technologies and the real use of structural materials in practice; compare and apply based on the chemical composition, mechanical properties, preparation/production process and heat treatment of the selected group of materials in relation to specific products; using the acquired knowledge, apply methods (qualitative and quantitative) of analysis of construction materials, recognize the appropriateness of using individual methods and use them independently; adjust the conditions of production of materials; analyse data from research activities, describe, evaluate and document the microstructure of steels, cast irons, non-ferrous metal alloys and create a research report independently and in a team.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Advanced Construction Materials*, a student should have a general knowledge of the various types of engineering materials, their structure, properties, heat-treatment fundamentals and applications.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge in the field of methods, processes of production and processing of engineering materials (steels, cast irons, aluminium, titanium, and nickel-based alloys – cast and wrought, Additive Manufacturing materials, Ceramics, etc.) in connection with the application of knowledge about advanced construction materials (AHS, HSLA, QM, TWIP, TRIP and automotive industry steels, aluminium, titanium, manganese, and nickel alloys).
MS_O_02	Can use information from literature, He can integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental materials testing and its quality assurance problems.
MS_O_03	He can plan and carry out experiments (metallography evaluation and quantitative metallography evaluation methods applied on advanced materials alloys, grain size evaluation, microstructure features evaluation, relation heat-treatment vs. microstructure vs. mechanical properties), including measurements, interpret the results and draw conclusions related to the field of advanced construction materials.
MS_O_04	Can prepare a scientific study (semester work, lessons reports, etc.) and present a presentation on the implementation of various materials testing methods for research tasks, containing a critical analysis, and conclusions with an accent on materials quality and its influence on overall mechanical properties. Able to work individually and in a team as well as interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory work + Exercises: motivational demonstration; report; question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory work + Exercises	13 + 13	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, and self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

By completing the *Advanced Construction Materials* subject, the student will be able to explain the principles of dividing construction materials with emphasis on new development trends; distinguish and reproduce the principles in modelling the structure and properties of structural materials in relation to production technologies and the real use of structural materials in practice; compare and apply based on the chemical composition, mechanical properties, preparation/production process and heat treatment of the selected group of materials in relation to specific products; adjust the conditions of production of materials; analyse data from research activities, describe, evaluate and document the microstructure of steels, cast irons, non-ferrous metal alloys, and etc.

COMMENTS

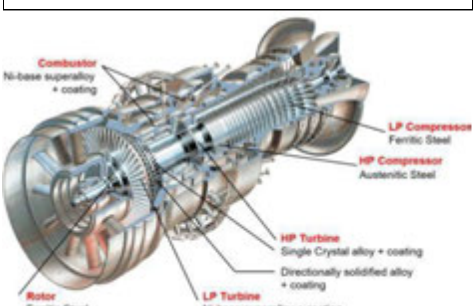
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER

Prof. Ing. Eva Tillová, PhD.
Assoc. prof. Ing. Lenka Kuchariková, PhD.
Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW

Advanced engineering materials *refer to a category of materials that possess superior properties and performance characteristics compared to traditional materials. These materials are specifically designed or engineered to meet the demands of modern technologies and applications. They are developed through innovative manufacturing processes, novel compositions, and advanced material science principles. Examples of* ***advanced engineering materials*** *include: i) Composites; ii) High-Performance Alloys; iii) Ceramics; iv) Polymers; and v) Smart Materials.*



COURSE CONTENT - LECTURE

Topics 1

Introduction to Advanced Construction Materials. Graphite cast iron; Austempered ductile cast irons, Ni-resist cast irons. Presence and perspective in iron development in automotive industry point of view.

Topics 2

Unalloyed and alloyed steels and their development trends. Steel for the production of sheet metal; high-strength steel.

Topics 3

High-strength steels (TRIP, TWIP, Maraging steels) and thermo-mechanical treatment of carbon and alloyed steels.

Topics 4

AHS, QM, IF, IF BH and HSLA steels used in automotive industry. Steels for work at low temperatures and special environments.

Topics 5

Development trends of corrosion-resistant (stainless) steels. High-temperature and refractory steels. Steels for nuclear reactors.

Topics 6

Light metal alloys for castings – Al-based alloys and Mg-based alloys. The topic will be conducted for 2 weeks.

Topics 7

Ti-based (fundamentals about homogenous alpha and beta titanium alloys, near alpha alloys and heterogeneous alpha+beta alloys, heat-treatment and alloys application) and Co-based alloys (alloys with high ferromagnetic properties, extremely hard alloys and Co-based superalloys). Biocompatible materials.

Topics 8

High-strength alloys – Ni-based alloys (binary alloys, Monel alloys, alloys with specific properties – magnetic, electric resistance alloys) and superalloys (polyedric, directionally solidified and monocrystalline alloys). Alloys with shape memory effect. Superplasticity.

Topics 9

Materials and alloys produced by additive manufacturing (AM-alloys). Additive manufacturing fundamentals and processes.

Topics 10

Advanced ceramics for engineering practice.

Topics 11

Advanced composites. Metal glasses and nanocrystalline materials.

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LEARNING OUTCOMES

Based on the completed lectures, students should be able to apply the acquired knowledge when solving model examples aimed at data analyzes from research activities, evaluate results and process acceptance protocols (input/output) of individual methods to maintain the required quality of product material - individually and in a team; appropriately present the results of research activities etc.

COMMENTS

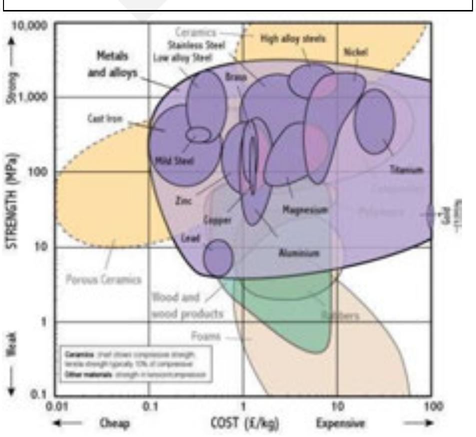
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

Assoc. prof. Ing. Lenka Kuchariková, PhD.
Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW

*The key features of **advanced engineering materials** include: Enhanced Strength and Stiffness (superior mechanical properties such as high strength, stiffness, and toughness), Improved Heat Resistance (excellent thermal stability and can withstand high temperatures without significant degradation), Superior Chemical Resistance (often exhibit high resistance to corrosion, oxidation, and chemical attack), Lightweight and High Specific Strength (can be lightweight while maintaining high strength, which is desirable in industries such as aerospace and automotive), Electrical and Magnetic Properties (possess unique electrical or magnetic properties, such as high conductivity, superconductivity, or magnetism).*



COURSE CONTENT – LABORATORY EXERCISES

Topics 1
Introduction. Safety and health protection at work. Basic development trends in the field of materials engineering.

Topics 2
The effect of chemical composition on the mechanical properties of ductile cast iron. Report No. 1.

Topics 3
The effect of heat treatment on the mechanical properties of Austempered Ductile cast irons. Report No. 2.

Topics 4
Wrought pure Cu grain size evaluation. Using and application of ASTM E112 standard for grain size evaluation – planimetric or Hayne methods. Report No. 3.

Topics 5
Tool steels – heat-treatment (quenching temperature, dwell time and cooling speed) to microstructure relation. Report No. 4.

Topics 6
CVD, PVD and diffusion layers applications and evaluation. Mercedes test applied at adhesion of surface layer evaluation. Report No. 5.

Topics 7
Quantitative evaluation of the fracture profile. Report No. 6. and Half-Semester test No. 1.

Topics 8
Metallography of stainless and corrosion-resistant steels. Practical application of Shaeffler diagram for microstructure prediction. Report No. 7.

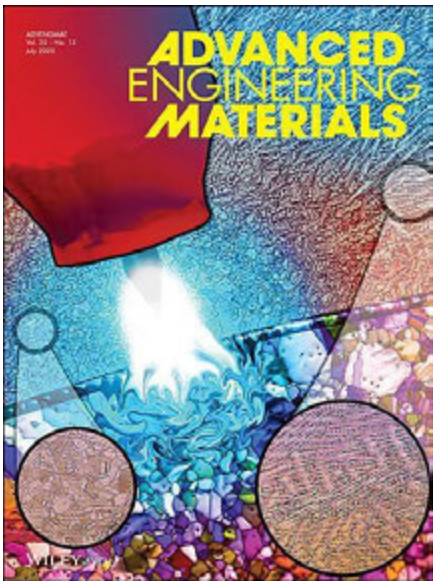
Topics 9
Metallographic assessment of corrosion attack on metals – stainless steel, manganese alloys. Report No. 8

Topics 10
Structural analysis of Al-based cast AlSi10MgMn alloy – Part I – SDAS calculation and evaluation of primary alpha solid solution. Report No. 9.

Topics 11
Structural analysis of Al-based cast AlSi10MgMn alloy – Part II – considering the influence of Fe-rich intermetallic phase on mechanical properties. Report No. 10.

Topics 12
Quantitative evaluation of Ni-based superalloy structure parameters (gamma prime evaluation, carbide distribution evaluation – with coherent testing grids application). Report No. 11.

Topics 13
Final-Semester test No. 2.



TEXTBOOK/READINGS

The mandatory reading for completing the subject *Advanced Construction Materials*:

1. Behera, A. (2021) *Advanced Materials: An Introduction to Modern Materials Science*, 1st edition, Springer Cham, ISBN 978-3-030-80358-2, 748 p.
2. *Handbook of Advanced Materials: Enabling New Designs*, James K. Wessel (editor), a John Wiley & Sons, Inc., 2004, ISBN 0-471-45475-3, 656 p.

For a deeper understanding of the course subject matter, optional recommended texts include:

3. ASM Handbook, Volume 15, *Casting*, 1998, ISBN 0 - 87170-007-7
4. ASM Handbook, Volume 21, *Composites*, 1998, ISBN 0 - 87170-703-9
5. ASM Handbook, Volume 07, *Powder Metal Technologies and Applications*, 1998, ISBN 0 - 87170-387-4

ASSESSMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of phase transformation. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester test (during the semester)**:** test continuously verifying knowledge of issues in the field of advanced construction materials – questions are related to exercises and laboratory exercises.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of advanced engineering materials.

GRADING POLICY

The subject *Advanced Construction Materials* is evaluated by points. The resulting points are the sum of the points that the student gets during the semester (on exercises and laboratory exercises) and the points that he gets on the exam. It is possible to get max. 100 points, of which 40 points were in the exercises and 60 points in the exam.

During the exercises and laboratory exercises, the following are continuously evaluated: theoretical preparation for the exercise, submitted reports (max. 2b.), i.e. is evaluated max. 11 reports x 2p. = 22 points; 2 Semester tests - 2 x 9p = 18 points.

Students who have completed exercises and laboratory exercises, handed in all reports, completed 2 semester tests and obtained min. 21 points out of 40. The points obtained in the exercises (max. 40) are added to the points obtained during the exam (max. 60) and the final assessment of the completed subject is determined by their sum.

Assignment Weights	**Percent**
11 reports	25%
2-semester tests	10%
Student portfolio	5%
Final examination	60%
Total	100%

11 reports (max. 2 points each) – max. 22 points
2-semester tests – max. 18 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

PROFESSIONAL PRACTICE

Code: **PP**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Professional Practice

Form of tuition and number of hours*:

Professional Training - 160h

ECTS

10

COURSE DESCRIPTION

Through professional practice the student gains practical experience and verifies his/her ability to apply knowledge acquired during their studies. The student completes the professional practice at a workplace approved by the authorized person approved for the specific study programme. Place of professional practice (organization, company, enterprise, ...) may be offered to students by the department, but the student may also propose it himself/herself. Students have the possibility to complete their professional practice also at the workplaces of the Faculty of Mechanical Engineering, if the topic of the practice is related to the research carried out at the selected workplace of the Faculty of Mechanical Engineering; or they can complete their professional practice abroad, e.g. in the framework of ERAZMUS+ internship. In the case of professional practice abroad (e.g. during ERASMUS+ internship), the data on the practice are also registered at the Foreign Relations Department of the Faculty of Mechanical Engineering. The total time intensity of the course is 250 hours per semester, of which 160 hours is professional practice (research) in a selected company (organization) and 90 hours is independent study and independent creative activity of the student.

COURSE OBJECTIVES

Through professional practice (research), the student gains practical experience and verifies his/her ability to apply the knowledge acquired during his/her studies. The student completes his/her professional practice at a workplace approved by the head of the department with a focus on his/her study programme (or field of study), while the content of his/her work must be known in advance. The student consults the choice of the company (company, enterprise, organization, ...) in which he/she will do his/her internship with the person in charge of the internship at the department (the subject teacher) and after the approval he/she can do the internship there.

PREREQUISITES FOR TAKING THE COURSE

No previous courses are required.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	By completing the Professional Practice course, the student will be able to: ▪ to identify the real application of the graduate of the study programme in practice;; ▪ characterize the importance of theoretical and practical knowledge in the field of engineering technologies, heat treatment, structural materials, etc., acquired during the study in practice; ▪ apply the acquired theoretical knowledge in practice; ▪ analyse and evaluate the potential of the knowledge in practice; ▪ discuss, alone or in a team, professional problems; ▪ work on real projects, consult and present results.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the module
Meth_01	Direct contact with practice; observation; question and answer method; problem-based learning; presentation; multimedia presentation	MS_O_01

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	exercise	160	course work	MS_O_01	Meth_01

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature; professional articles	Preparation for exercises	independent work

LEARNING OUTCOMES

Confrontation of the theoretical knowledge and skills acquired during the study with their application in conditions industrial practice

DO YOU KNOW
The survey says that gaining practical experience during their studies is considered by students to be one of the most important factors in their readiness for life after school. However, if work experience is absent in their studies, students do not feel competent in the field they are studying. At the same time, they consider themselves unattractive to employers and thus enter the labour market with uncertainty.

COURSE CONTENT – THEORETICAL EXERCISES

Professional practice: choice/proposal of the place of professional practice (organisation, company, enterprise, ...). Implementation professional practice - confrontation of theoretical knowledge with concrete practical experience. Collection of knowledge before, during and after the implementation of the professional practice. Evaluation of the results of the internship - elaboration of the Practice report. The exercises are carried out according to the needs of the student. The contents of the meetings are topics such as:

Topics 1

Introduction to the subject.

Introduction to the subject professional practice usually provides students with an overview of the practical aspects of the chosen field of study or profession. The introduction emphasizes the importance of professional practice in bridging the gap between theoretical knowledge acquired in an academic setting and real-world applications in a professional setting. Emphasizes the importance of professional skills, ethics and behavior in achieving success and meaningful contributions in engineering. The objectives of the professional practice course are outlined, detailing what students are expected to learn and achieve at the end of the course. Learning outcomes may include developing technical skills, improving communication and teamwork skills, understanding professional ethics and gaining practical experience in this field of engineering.

Topics 2

Information survey.

Information inquiry in the context of professional engineering practice involves the collection and analysis of relevant data, sources, and insights to inform decision-making, problem-solving, and project planning within the engineering profession. The first step in conducting information research is to identify the specific information needs or goals of a given project, task, or problem. This may include defining the scope of the survey, identifying the key questions to be answered and clarifying the purpose and objectives of the information gathering process. A variety of methods can be used to gather information, including: reviews of relevant books, journals, articles, reports, and other publications to gather existing knowledge and research findings related to the topic. Access online databases, archives, and academic journals to search for scholarly articles, research papers, and technical reports.

Topics 3

Implementation of research.

The implementation of research in professional practice involves the application of findings, methodologies and knowledge from research studies to real situations within a specific professional context. The first step in implementing research into professional practice is identifying research studies or findings that are relevant and applicable to a particular field or discipline. This may include reviewing academic literature, research journals, industry publications, and other sources to identify research studies, methodologies, theories, and best practices that are consistent with the goals and objectives of professional practice. Once relevant research studies have been identified, the findings are critically appraised to assess their credibility, reliability, validity and applicability in a professional context. Research results are translated into practical insights, strategies or recommendations that can be used to address specific challenges, opportunities or goals within professional practice. Successful implementation of research into professional practice often involves sharing knowledge, lessons learned and best practices with relevant stakeholders, colleagues, clients and the wider professional community.

Topics 4

Partial reporting.

Partial reporting refers to the incomplete or selective disclosure of research findings, methodologies, or results, which may distort the overall understanding of the study's results or implications. Researchers report only certain results or findings from a study while omitting others, especially if they are incomplete or inconclusive. Researchers selectively present certain data points or results that support their hypotheses or conclusions, ignoring conflicting or negative data.

Topics 5

Preparation of the final report.

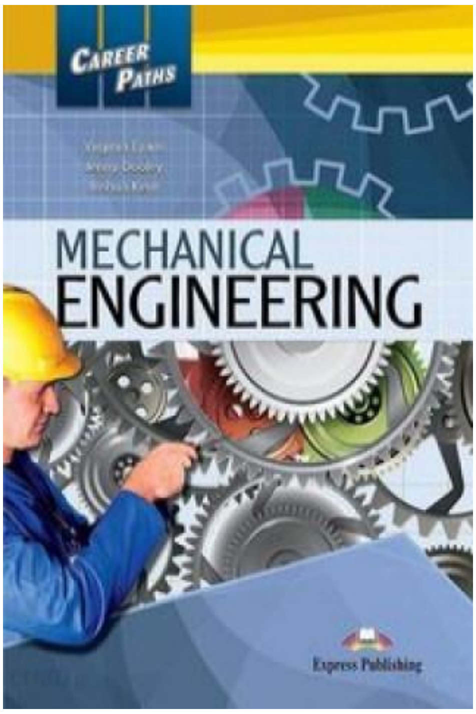
Preparing a final report is a critical step in many projects, research studies, or professional endeavors. It serves to document the findings, results, conclusions and recommendations of the work performed. There is a need to critically review the project goals, objectives and scope to ensure that the final report adequately addresses all aspects of the work undertaken. The structure and organization of the report should be determined, including sections, subsections, headings and any appendices or supplementary materials. Parts of the final report include:
- abstract: brief overview of the project, objectives, key findings and recommendations.
- introduction: basic information, context, objectives and scope of the project.
- methodology: description of used research methods, data collection procedures and analytical techniques.
- results: presentation and analysis of findings, data, observations or results.
- discussion: interpretation of results, implications, limitations and comparisons with existing literature or benchmarks.
- conclusions: summary of key findings, benefits and implications for practice or further research.
- recommendations: suggestions or proposals based on the findings and conclusions of the project.
- references: citations and bibliographic information for sources cited in the report.

Topics 6

The presentation of a final report.

The presentation of a final report in the context of professional practice involves documenting the results, insights and recommendations derived from a specific project, task or professional engagement. Begin by understanding the purpose and objectives of the final report. What is the intended audience and what do they need to know or understand from the message? Clarification of these aspects will guide the content and structure of the report. Organize information logically according to a clear structure that is consistent with the objectives of the report and makes it easy for the reader to understand. Write clearly, concisely and professionally, using language appropriate for your intended audience. Avoid jargon or technical terms that may be unfamiliar to readers. Format the report according to professional standards and follow specific guidelines or templates provided by the organization or industry.

TEXTBOOK/READINGS



Scientific journals related to the study program, university textbooks, scientific monographs.

Professional publications in the field of the subject, professional journals

Internal company guidelines and standards

ASSESMENT

Registration form: Upon entering the internship, the student must fill in a registration form, which is completed and signed by the company where the work experience is to be carried out and also by the person in charge of the specific study program.

Final report: At the end of the traineeship, the student shall hand over the registration form to the person in charge with a certificate of completion of the professional practice and an evaluation by the company where the practice was carried out; and draw up a "Report of the internship".

Assignment Weights	Percent
Final report	50%
Registration form	50%
Total	100%

GRADING POLICY

Upon entering the internship, the student must fill in a registration form, which is completed and signed by the company where the work experience is to be carried out and also by the person in charge of the specific study program, which the student is studying. At the end of the traineeship, the student shall hand over the registration form to the person in charge with a certificate of completion of the professional practice and an evaluation by the company where the practice was carried out; and draw up a "Report of the internship". Evaluation of the company where the traineeship was carried out and the content and formality of the traineeship of the internship report add up to a maximum of 100 points.

Grading Scale

93 – 100 points = A

85 – 92 points = B

77 – 84 points = C

69 – 76 points = D

61 – 68 points = E

0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
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DEGRADATION PROCESSES AND LIMIT CONDITIONS OF MATERIALS

Code: **DPLCM**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

2

Language

English

Thematic block

Materials Testing Methods and Failure Analysis

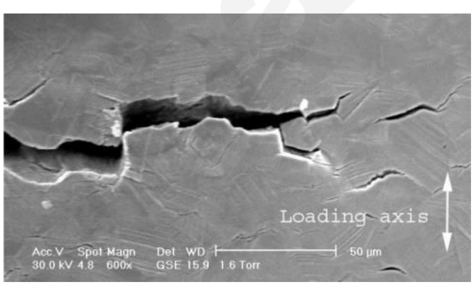
Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

4



Crack propagation

COURSE DESCRIPTION

This course comprehensively examines degradation processes and the concept of limit states in various engineering and scientific contexts. It explores the factors and mechanisms that lead to the deterioration of materials, structures, and systems over time, and the critical importance of defining and maintaining limit states to ensure safety, reliability, and durability. The course combines theoretical knowledge with practical applications to address real-life conditions.

The course is designed to familiarize students with the fundamental mechanisms of production and operation degradation of the properties of engineering materials, in particular steels and other metals. The knowledge obtained will provide, on the one hand, a more accurate determination of the limit state and a more effective exploitation of the materials used and, on the other hand, a qualified estimate of the causes of failure.

The course is taught through lectures explaining the basic principles and theory of the discipline. Exercises are focused on practical topics presented in lectures, and a final project or presentation is required. According to the course instructions, the total number of hours the student must spend achieving the learning outcomes is 125.

COURSE OBJECTIVES

Upon completing the course, students will thoroughly understand the different degradation processes and their causes. They will learn to analyze real-world case studies related to degradation and propose effective solutions to overcome those challenges.

PREREQUISITES FOR TAKING THE COURSE

Basic knowledge in the field of materials engineering and related manufacturing technologies (metallurgy, foundry engineering, metal forming, and welding). The knowledge of the following experimental methods is also assumed: metallography, scanning microscopy, and mechanical testing.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Students will be able to demonstrate the mechanical properties of technical materials in practice while considering dependability, safety, economics, and the environment.
MS_O_02	Can gain proficiency in analyzing specific forms of material degradation and addressing individual degradation mechanisms, including understanding the limit states of structural materials utilized in component and structure construction.
MS_O_02	Has in-depth, theoretically based, and structured knowledge of modern techniques and research methods in manufacturing metal and non-metal materials.
MS_O_03	Can gain proficiency in applying findings obtained through actual engineering practice and disseminating learned information to the technical public, both in person and online.
MS_O_04	Can plan and carry out experiments and measurements, interpret the results and draw conclusions.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Exercises: motivational demonstration, report, question, and answer method.	MS_O_03 S_03 S_03_eng

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of Conducting Classes
FT_01	lectures	2h × 13 weeks	Oral Exam	MS_O_01 MS_O_02	Meth_01 Meth_02
FT_02	exercises	2h × 13 weeks	Oral Exam	MS_O_01	Meth_03

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Preparation for classes	Query of instructions and review of topics and activities necessary to participate in classes	NO
a_02	Preparation for presentation	Researching the topic and reviewing the literature necessary to participate in classes.	YES
a_03	Consultations	Preparation and development of presentations. Consultation of a selected topic.	YES

Co-funded by the European Union

LEARNING OUTCOMES

The study of degradation processes and limit conditions of materials in materials science and engineering is essential for a comprehensive understanding of how materials behave and interact with their environments. Learn how to select materials based on their properties, performance, and resistance to specific degradation processes. Consider factors like material composition, structure, and environmental conditions.

COMMENTS

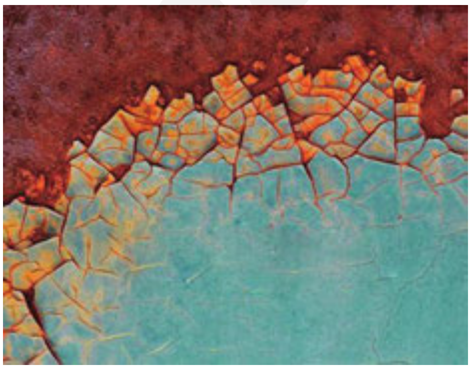
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER

Prof. Ing. Otakar Bokůvka, PhD.

DO YOU KNOW...

Materials can degrade through various mechanisms, including corrosion, fatigue, creep, wear, and environmental factors. Each mechanism has its unique characteristics and causes. Familiarize yourself with industry-specific regulations and standards related to material selection and performance.



Materials corrosion (freepik.com)

COURSE CONTENT - LECTURE

1st lecture: Degradation and limit conditions
Defining degradation in the context of materials and structures.

2nd lecture: Elastic and plastic deformation
Analyzing the behaviour of materials under elastic loading, stress, and strain relationships. Understanding the transition from elastic to plastic deformation.

3rd lecture: Brittle and ductile fracture
Analyzing the mechanics and causes of brittle fracture. Examining the mechanisms and factors influencing ductile fracture, including plastic deformation.

4th lecture: Linear and elastoplastic fracture mechanics
Study the behaviour of materials under combined elastic and plastic deformation, particularly near the crack tip.

5th lecture: Creep failure, impact load failure
Understand the different mechanisms of creep, such as primary, secondary, and tertiary creep, and the factors influencing each mechanism.

6th lecture: Fatigue fracture
Understand the fundamental mechanisms of fatigue, which involve cyclic loading leading to crack initiation and propagation in materials.

7th lecture: Fatigue fracture propagation
Understand how fatigue cracks begin, typically at the material's stress concentration points, defects, or microstructural features.

8th lecture: Creep and fatigue, thermal fatigue, thermo-mechanical fatigue
Understand the fatigue fracture propagation to understand how materials and structures deteriorate over time due to cyclic loading.

9th lecture: Hydrogen-induced degradation
Explanation of the phenomenon called hydrogen embrittlement, where the presence of hydrogen in a material makes it susceptible to brittle fracture, reducing its ductility and toughness.

10th lecture: Corrosion-induced degradation
Understanding the various corrosion mechanisms, including uniform corrosion, pitting corrosion, crevice corrosion, and stress corrosion cracking.

11th lecture: Degradation by adhesion, abrasion, erosion, cavitation
Learn about the adhesion, abrasion, and erosion mechanisms. Exploration of materials and coating and testing methods.

12th lecture: Degradation by radiation and energy fields
Understanding the radiation damage mechanisms, such as displacement damage, sputtering, and transmutation, which result in changes to the material's structure and properties.

13th lecture: Degradation by tearing, liquid metal, and welds
Understand different modes of tearing, such as ductile tearing and brittle tearing. Study the metallurgical changes that occur in the heat-affected zone (HAZ) and the weld zone during welding, affecting the material's properties.

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 directly contributing 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 comprehensively explain the chosen topic, enabling a thorough understanding of the subject matter within the given time frame. This exercise fosters in-depth knowledge and hone the student's presentation and communication skills, an essential aspect of academic and professional growth.

LEARNING OUTCOMES

The student will have the opportunity to attend a presentation that is specifically tailored to their final thesis topic. This presentation will be approximately 20 minutes in length and is intended to provide valuable insights and information to support the student's academic pursuits. Presenting a lecture topic as a student can yield several valuable learning outcomes, extending beyond just understanding the subject matter. It not only benefits students' understanding of the material but also hones a range of skills that are highly transferable and valuable in academic, professional, and personal contexts. The course is divided into several modules, that may help to organize the structure of the final presentation.

COMMENTS

Exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

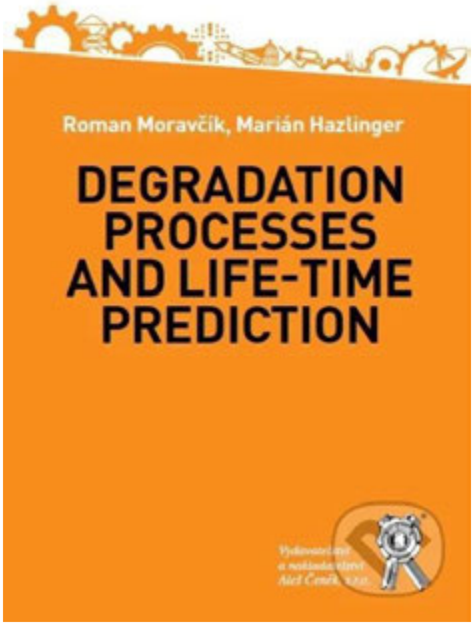
INSTRUCTORs

Ing. Denisa Straková, PhD.
Ing. Martin Vicen, PhD.

DO YOU KNOW...

Creating an effective presentation for a topic from a lecture can be a valuable tool for deepening your understanding of the subject matter. Building a presentation often involves critical thinking and analysis. You may need to evaluate various sources, arguments, or evidence related to your topic, which can expand your comprehension.

Presenting in front of students



Recomended literature

TEXTBOOK/READINGS

The current monograph is designed for the students at technical universities and higher education institutions and for the staff in technical practice. Degradation processes have different influences on materials since the latter are highly diverse. This publication can help to understand some types of degradation processes performed on different materials. Theoretical findings are complemented by a variety of real-life examples of various damaged components and structures. Listed are also solutions to the problems in terms of prediction of the service life of materials. Knowledge about degradation processes on materials is very important for the appropriate design of functional parts exploited under various loads, environments, or temperatures that limit the usability of materials for some applications. Currently, there is a wide scope of knowledge and analytical techniques that can be used in the optimization of material solutions for specific parts.

Moravcik, R., Hazlinger, M.: Degradation processes and life-time prediction. Čenek, s.r.o., 2017.

ASSESSMENT

Lecture presentation:

Exam (after the semester)**:** oral presentation in person (or online) and verifying overall knowledge carried out via discussion of presented topic.

GRADING POLICY

Points evaluate the subject *DEGRADATION PROCESSES AND LIMIT CONDITIONS OF MATERIALS*. The resulting points are the sum of the points the student gets during the semester (on exercises) and the points he gets on the exam.

The maximum number of points achieved in the exercises is 50 and includes students' activity during the exercises, class participation, and final presentation of a given topic in front of classmates.

The final assessment consists of points that the student gets during the semester (on exercises) and points that he gets on the exam. The points obtained in the exercises (max. 50) are added to the points obtained in the exam (max. 50) and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
Class Participation	15
Students Activity	5
Presentation	30
Final	50
Total	100%

Presentation – max. 50 points
Final exam – max. 50 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

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Co-funded by the European Union

METHODS OF STRUCTURE ANALYSIS

Code: **MSA**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Advanced Methods for Materials Characterisation

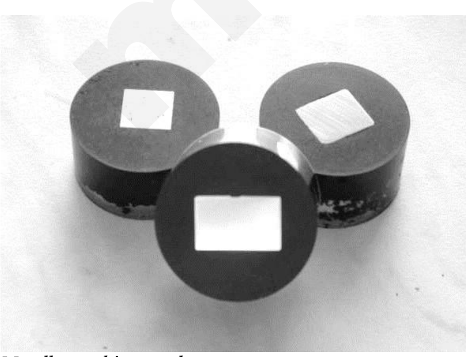
Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

4



Metallographic samples

COURSE DESCRIPTION

The subject deals with the preparation of metallographic samples (cutting the sample, grinding, polishing and etching), metallographic analysis using classic black&white contrast and colour contrast, various methods of quantitative metallography (evaluation of microstructure according to standards, measurement of structural parameters using coherent test grids and image analysis) and light metallographic microscopes.

The subject *Methods of structure analysis* follows on the material subjects from the bachelor's study, such as the subject *Materials 1*, which deals with the physical nature of technical materials, general knowledge about the structure and properties of materials and ways of influencing them; the subject *Materials 2*, which includes specific information about individual material groups (metals, plastics, ceramics and composites), their structure, properties and use; the subject *Properties and testing of materials*, which deals in more detail with metal materials, their properties and use, etc. The subject *Methods of structure analysis* further expands the knowledge gained in these subjects with a focus on the preparation of metallographic samples, metallographic analysis and various methods of quantitative metallography.

The lectures are intended for obtaining information on metallographic analysis, methods of sample preparation and structure evaluation and its influence on mechanical properties. Laboratory exercises are dedicated to practicing the presented issues on specific technical materials.

The total time requirement of the subject is 140 hours per semester, of which 52 hours (13 weeks x 2 hours of lectures + 13 weeks x 2 hours of laboratory exercises) are direct teaching and 88 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the subject *Methods of structure analysis*, the student will be able to independently prepare metallographic samples of various materials, work with a light metallographic microscope, describe and evaluate the microstructure of various materials according to standards, quantitatively evaluate basic structural parameters using image analysis.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject Methods of Structure Analysis, it is necessary for the student to have a general knowledge of specific types of metal materials, including their structure, properties, and applications.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	He/ she has extended and in-depth knowledge in the field of general knowledge, which is the basis for understanding complex relationships in the processes of designing, manufacturing, testing and application of engineering materials.
MS_O_02	He/ she can use information from literature, databases and other available sources. He/ she is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve complex innovative problems. He/ she can solve practical engineering tasks that require the use of engineering standards and norms.
MS_O_03	He/ she is aware and knows the possibilities of further training and improving professional, personal and social competences. He/ she 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.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature	independent work
a_02	Preparation for classes	Self-study, preparation for exercises, processing reports	independent work and cooperation
a_03	Preparation of reports	Preparation and processing reports	independent work and cooperation

Co-funded by the European Union

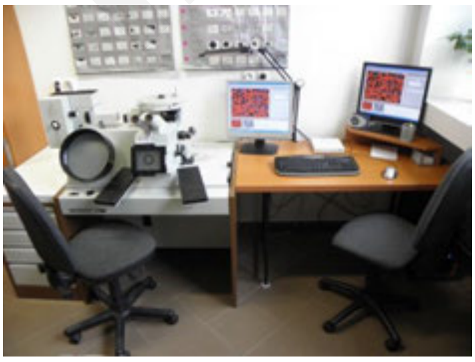
LEARNING OUTCOMES

By completing the subject *Methods of structure analysis*, the student will be able to independently prepare metallographic samples of various materials (e.g. steels, cast irons, non-ferrous metal alloys), work with a light metallographic microscope, describe and evaluate the microstructure of various materials, work with standards for evaluating the structure of materials, analyze macro and microstructure of materials, quantitatively evaluate basic structural parameters using image analysis, prepare, present and discuss a metallographic report.

COMMENTS

LECTURER
prof. Ing. Radomila Konečná, PhD.

DO YOU KNOW
The microstructure of the material has a direct influence on its mechanical properties, therefore it is necessary to know the connection between the chemical composition of the material, the way of production, its structure and properties.



Metallographic analysis

COURSE CONTENT – LECTURE

Topics 1

Sampling methodology (2 hours)

Topics 2

Theoretical preparation of metallographic samples (2 hours)

Topics 3

Practical preparation of metallographic samples (2 hours)

Topics 4

Methods of sample etching (2 hours)

Topics 5

Colour contrast in metallography (2 hours)

Topics 6

Light metallographic microscopes (2 hours)

Topics 7

Methodology of structure evaluation (2 hours)

Topics 8

Metallographic analysis (2 hours)

Topics 9

Evaluation of structure according to standards (2 hours)

Topics 10

Quantitative metallography (2 hours)

Topics 11

Quantitative evaluation of structural parameters (2 hours)

Topics 12

Methodology of metallographic report processing (2 hours)

Topics 13

Preparation of the final metallographic report (2 hours)

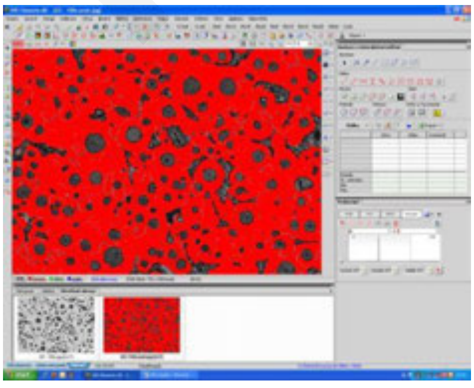
LEARNING OUTCOMES

By completing the subject *Methods of structure analysis*, the student will be able to independently prepare metallographic samples of various materials (e.g. steels, cast irons, non-ferrous metal alloys), work with a light metallographic microscope, describe and evaluate the microstructure of various materials, work with standards for evaluating the structure of materials, analyze macro and microstructure of materials, quantitatively evaluate basic structural parameters using image analysis, prepare, present and discuss a metallographic report.

COMMENTS

INSTRUCTOR
prof. Ing. Radomila Konečná, PhD.

DO YOU KNOW
The microstructure of the material has a direct influence on its mechanical properties, therefore it is necessary to know the connection between the chemical composition of the material, the way of production, its structure and properties.



Quantitative metallography

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Introduction to the laboratory exercises of *Methods of structure analysis* (2 hours)

Topics 2

Cutting of metallographic samples (2 hours)

Topics 3

Practical preparation of metallographic samples (2 hours)

Topics 4

Sample etching (2 hours)

Topics 5

Working with a microscope (2 hours)

Topics 6

Analysis of material structure (2 hours)

Topics 7

Photo documentation of the analysed structure (2 hours)

Topics 8

Working with standards (2 hours)

Topics 9

Evaluation of structure according to standards (2 hours)

Topics 10

Quantitative metallography (2 hours)

Topics 11

Quantitative evaluation of structural parameters (2 hours)

Topics 12

Design of a specific application of the analysed material (2 hours)

Topics 13

Defense of the metallographic report (2 hours)

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Methods of structure analysis*:

Konečná, R.: Practical metallography. http://kmi2.uniza.sk/wp-content/uploads/2010/10/Prakticka_Metalografia.pdf.

Optional recommended texts for a deeper understanding of the subject:

1. Murakami, Y.: Metal Fatigue: Effects of small defects and nonmetallic inclusions. Elsevier, Oxford, 2002.

2. Vander Voort, G. F.: Metallography. Principles and practice, McGraw-Hill, ASM Interational, 2004.

3. Geels, K.: Metallographic and materialographic. ASTM International, 2007.

4. Wojnar, L.: Image analysis. CRC Press Washington, D.C., 1999.

5. Skočovský, P. – Podrábský, T.: Colour metallography of ferrous alloys, EDIS Žilina, 2001.

ASSESMENT

Semester paper (during the semester)**:** paper verifying knowledge of issues in the field of preparation of metallographic samples, metallographic analysis using classic black&white contrast and colour contrast and various methods of quantitative metallography (evaluation of microstructure according to standards, measurement of structural parameters using coherent test grids and image analysis).

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of metallographic analysis.

GRADING POLICY

The subject *Methods of structure analysis* is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + 1 semester paper (40 points) are evaluated. The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	Percent
Semester paper	35%
Student portfolio	5%
Examination	60%
Total	100%

Semester paper – max. 35 points
Independent work of student – max. 5 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

FRACTOGRAPHY

Code: **FRAC**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

2

Language

English

Thematic block

Materials Testing Methods and Failure Analysis

Form of tuition and number of hours:

Lecture: 16h

Laboratory: 16h

ECTS

6

Microscope for fractographic analysis

COURSE DESCRIPTION

The subject deals with classification of fractures according to various criteria, micromechanisms of failure, methods of study of fracture surfaces and microfractographic analysis of specific samples.

The subject *Fractography* follows on the material subjects from the bachelor's study, such as the subject *Materials 1*, which deals with the physical nature of technical materials, general knowledge about the structure and properties of materials and ways of influencing them; the subject *Materials 2*, which includes specific information about individual material groups (metals, plastics, ceramics and composites), their structure, properties and use; but above all the subject *Methods of structure analysis*, which deals with the preparation of metallographic samples, metallographic analysis and various methods of quantitative metallography. The subject *Fractography* further expands the knowledge gained in these subjects with a focus on the study of fracture surfaces, micromechanisms of failure and microfractographic analysis of samples.

The lectures are intended for obtaining information about the basis and importance of fractography, classification of fractures according to various criteria, methods of study of fracture surfaces and microfractographic analysis of specific samples. The laboratory exercises are dedicated to practicing the presented issues on specific technical materials with the aim to master the ways of description and interpretation of morphology of fracture surfaces.

The total time requirement of the subject is 130 hours per semester, of which 32 hours (8 weeks x 2 hours of lectures + 8 weeks x 2 hours of laboratory exercises) are direct teaching and 98 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the subject *Fractography*, the student will be able to describe fractures according to their macroscopic appearance, according to structural features and the way of stress, independently evaluate fracture surfaces and analyze the causes of failures.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject Fractography, students should have a general understanding of various materials, their structures, properties, and applications..

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	He/ she has extended and in-depth knowledge in the field of general knowledge, which is the basis for understanding complex relationships in the processes of designing, manufacturing, testing and application of engineering materials.
MS_O_02	He/ she can use information from literature, databases and other available sources. He/ she is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve complex innovative problems. He/ she can solve practical engineering tasks that require the use of engineering standards and norms.
MS_O_03	He/ she is aware and knows the possibilities of further training and improving professional, personal and social competences. He/ she 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.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	16	exam	MS_O_01 MS_O_02	Meth_01
FT_02	laboratory exercises	16	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature	independent work
a_02	Preparation for classes	Self-study, preparation for exercises, processing reports	independent work and cooperation
a_03	Preparation of reports	Preparation and processing reports	independent work and cooperation

Co-funded by the European Union

LEARNING OUTCOMES

By completing the subject *Fractography*, the student will be able to understand the importance of fractography in the evaluation of microstructure of metallic materials,describe fractures according to their macroscopic appearance, according to structural features and the way of stress, independently evaluate fracture surfaces and analyze the causes of failures, prepare, present and discuss a fractographic report.

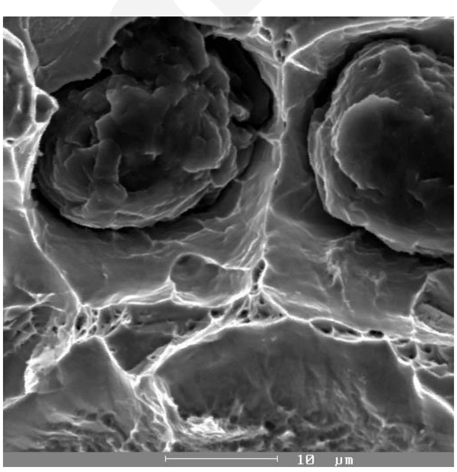
COMMENTS

LECTURER

prof. Ing. Radomila Konečná, PhD.

DO YOU KNOW

Fractographic analysis makes it possible to find out the causes of failure of material under different types of stress and to propose a way to prevent such accidents in the future.



Fracture of nodular cast iron

COURSE CONTENT – LECTURE

Topics 1

Basis and importance of fractography and microfractography; theory of fractures under overload (2 hours)

Topics 2

Classification of fractures according to macroscopic appearance; fractures according to structural features; fractures according to the way of stress (2 hours)

Topics 3

Transit behaviour of materials; methods of study of fracture surfaces; macrofractographic methods (2 hours)

Topics 4

Classification of fractures according to the morphology of fracture surfaces (2 hours)

Topics 5

Formation and propagation of cracks; micromechanisms of failure (2 hours)

Topics 6

Use of optical and electron microscopy in fractography (2 hours)

Topics 7

Microfractographic analysis; classification and morphological features (2 hours)

Topics 8

Microfractography of fractures in heterogeneous systems; ways of description and interpretation of morphology of fracture surface (2 hours)

Co-funded by the European Union

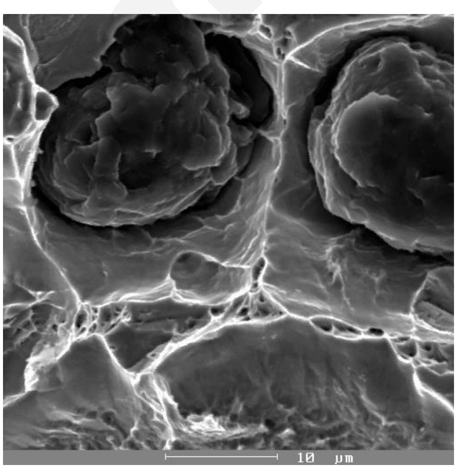
LEARNING OUTCOMES

By completing the subject *Fractography*, the student will be able to understand the importance of fractography in the evaluation of microstructure of metallic materials,describe fractures according to their macroscopic appearance, according to structural features and the way of stress, independently evaluate fracture surfaces and analyze the causes of failures, prepare, present and discuss a fractographic report.

COMMENTS

LECTURER
prof. Ing. Radomila Konečná, PhD.

DO YOU KNOW
Fractographic analysis makes it possible to find out the causes of failure of material under different types of stress and to propose a way to prevent such accidents in the future.



Fracture of nodular cast iron

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Introduction to the laboratory exercises of *Fractography* (2 hours)

Topics 2

Practical preparation of metallographic samples (2 hours)

Topics 3

Working with an optical and electron microscope (2 hours)

Topics 4

Structural analysis of material (2 hours)

Topics 5

Photo documentation of the analysed structure (2 hours)

Topics 6

Microfractographic analysis of material (2 hours)

Topics 7

Description and interpretation of micromechanisms of failure (2 hours)

Topics 8

Defense of the fractographic report (2 hours)

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Fractography*:

Hrivňák, I.: Fractography. STU Bratislava, 2009.

Optional recommended texts for a deeper understanding of the subject:

1. Wulpi, D. J.: Understanding how components fail, ASM International USA, 2001.

2. Brooks, C. R. – Choudhury, A.: Failure analysis of engineering materials, McGraw-Hill NY, 2002.

3. Hull, D.: Fractography: Observing, measuring and interpreting fracture surface topography, Cambridge University Press, 1999.

4. González-Velázquez, J. L.: Fractography and failure analysis, Springer International Publishing, 2018.

ASSESMENT

Semester paper (during the semester)**:** paper verifying knowledge of issues in the field of microfractographic analysis of metallic materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of microfractographic analysis.

GRADING POLICY

The subject *Fractography* is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + 1 semester paper (40 points) are evaluated. The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
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MATERIALS SCIENCE MASTERS

Co-funded by the European Union

DYNAMIC STRENGTH AND FATIGUE LIFE

Code: **DSFL**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

2

Language

English

Thematic block

Materials Testing Methods and Failure Analysis

Form of tuition and number of hours:

Lecture: 26h

Excersises: 26h

ECTS

6

COURSE DESCRIPTION

Dynamic Strength and Fatigue Life course is dedicated to the AIEMPS - Advances in Innovative Engineering Materials and Processes for Sustainability path. Most machine components operate under severe operating conditions and are subjected to complex, time-varying loads. This course addresses these components' strength, durability, and operational reliability from a material limit state perspective. It aims to explain the physical nature of the phenomena occurring in the material of dynamically and cyclically loaded components. The course deals with the problem of determining the operational reliability and service life of cyclically stressed machine components.

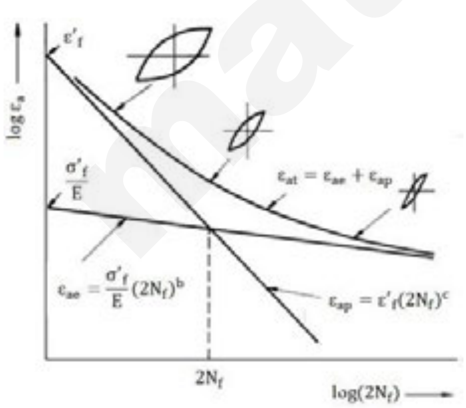
The course is divided into lectures and exercises. In the lectures, students will learn to understand the theoretical basis of the physical nature of phenomena occurring in the material and get a comprehensive view of the design of fatigue-loaded machinery, equipment, and structures and their operational reliability. During the exercises, students will become familiar with and learn methods of fatigue life assessment. They can describe the fatigue life curve for both low and high-cycle fatigue. They will learn how to apply the Smith fatigue diagram to determine the fatigue life of a material.

COURSE OBJECTIVES

At the end of the course, students can apply the problems of determining the operational reliability and service life of cyclically and dynamically stressed machine components, considering the criteria for selecting the most suitable material. Students will gain an understanding of the evaluation of fatigue testing and oscillatory loading processes. Students will be able to assess the reliability of components in service areas of limited and unlimited component life.

PREREQUISITES FOR TAKING THE COURSE

Before beginning the study of Dynamic Strength and Fatigue Life, the student should have a general knowledge of the different types of engineering materials, their structure, properties, heat treatment fundamentals, and applications.



Schematic life curve

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge of methods and processes for producing and processing engineering materials and of applying knowledge about advanced construction materials.
MS_O_02	He can use information from literature, integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental materials testing and its quality assurance problems.
MS_O_03	He can plan and carry out experiments, including measurements, interpret the results and draw conclusions related to the field of advanced construction materials.
MS_O_04	Can prepare a scientific study and present a presentation on implementing various materials testing methods for research tasks, containing a critical analysis and conclusions with an accent on materials quality and its influence on overall mechanical properties. Able to work individually and in a team and interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration, report, question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of Conducting Classes
FT_01	Lecture	13	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory Exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, and self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

At the end of the course, students will be able to apply the problems of determining the operational reliability and service life of cyclically and dynamically stressed machine components, taking into account the criteria for selecting the most suitable material. Students will gain an understanding of the evaluation of fatigue testing and oscillatory loading processes. Students will be able to assess the reliability of components in service areas of limited and unlimited component life.

COMMENTS

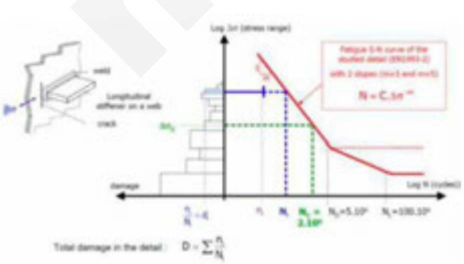
Lectures were conducted in a face-to-face format using presentation tools and commented on real problems from engineering practice.

LECTURER

Prof. Ing. František Nový, PhD.

DO YOU KNOW...

Material structure plays a key role in material properties and can be influenced by a variety of factors. One of the fascinating interests in the field of material structure changes is the so-called thermal processing. It is interesting to see how different temperature conditions and processing times can affect the organization of atoms and molecules in a material. For example, hardening can lead to the formation of martensite, which increases the hardness of the material. On the other hand, annealing can achieve a change in the crystalline structure and a reduction of stresses in the material.



Wohler's test

COURSE CONTENT - FORM OF TUITION (e.g. lecture)

Topics 1

Introduction. Systemisation of limit states of materials.

Topics 2

Energetic criteria of fracture formation. Dimensioning and basic fatigue properties of parts in fracture initiation and propagation.

Topics 3

Impact damage

Topics 4

Transition of material from a tough to a brittle state

Topics 5

Characteristics of variable loads.

Topics 6

Material fatigue under simple and complex stresses. The topics will be conducted for 2 weeks.

Topics 7

Changes in the structure and properties of materials caused by cyclic loading.

Topics 8

Fatigue life and criteria for its assessment. The topics will be conducted for 2 weeks.

Topics 9

Influence of factors on the fatigue resistance of materials

Topics 10

Calculations of reliability and fatigue life.

Topics 11

Recommendations for the design of cyclically and dynamically stressed components.

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COURSE CONTENT - FORM OF TUITION (e.g. laboratory classes)

Topics 1

Introduction to the laboratory exercise - instruction on laboratory order and workplace safety. Introduction to the concept of limit states of structures.

Topics 2

Low cycle fatigue - fatigue life curve under load in the controlled strain amplitude mode.

Topics 3

High cycle fatigue - fatigue life curves and Smith diagram under load in controlled stress amplitude mode.

Topics 4

Ultra-high cycle fatigue - fatigue life curve and Smith diagram under load in controlled voltage amplitude mode.

Topics 5

Fracture mechanics - determination of fracture toughness.

Topics 6

Fatigue crack propagation - fatigue crack propagation speed curve + determination of fatigue crack propagation speed based on fractographic analysis.

Topics 7

Excursion in production factories

LEARNING OUTCOMES

Knowledge of methods of control and prediction of dynamic strength and fatigue life of machine structures will familiarize the student with the fundamentals of this important engineering discipline, establish a set of necessary concepts and indicate the method of their application.
The desire to respect the effects of random oscillatory loads and the dispersion of material parameters has emphasized the need for a statistical approach to the evaluation of fatigue life and reliability indicators. The complexity of the mathematical procedures suggests that every designer, engineer and experienced technician should master the creation of algorithms adapted to the available computing technology. By completing the course, the student will have Expert knowledge, working with information, individual/team work, data processing and analysis, presentation skills, practical skills.

COMMENTS

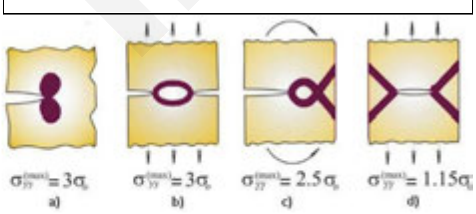
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

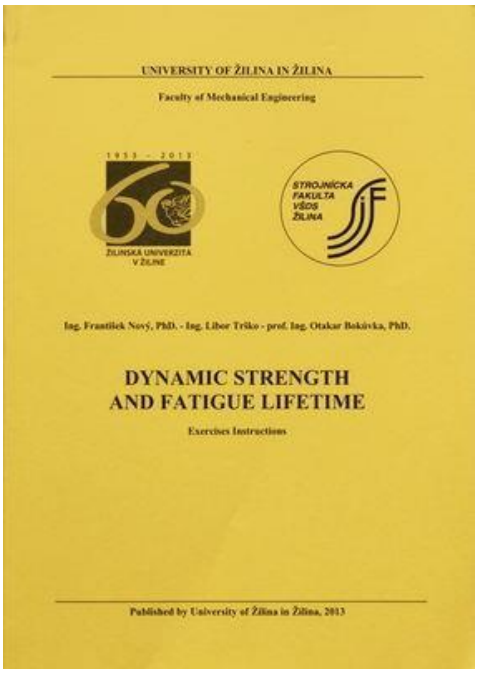
Ing. Martin Vicen, PhD.

DO YOU KNOW...

Fatigue cracks can form when the material is cyclically loaded (e.g. repeated loading and unloading). These cracks may grow progressively under the influence of repetitive loading until the material fractures. Interestingly, fatigue cracks can form even at relatively low loading levels.



Comparison of plasticity state



Dynamic strength and fatigue lifetime – Exercises instructions

TEXTBOOK/READINGS

The mandatory reading for completing the subject Dynamic Strength and Fatigue Life:

1. František Nový et al., Dynamic strength and fatigue lifetime – Exercises instructions", EDIS ŽU Žilina, 2023.

2. Otakar Bokuvka et al., "Fatigue of Materials at Low and High Frequency Loading. 2nd Edition", University of Žilina, Žilina 2015, 146 p. – ISBN 978-80-554-1056-2.

For a deeper understanding of the course subject matter, optional recommended texts include:

1. Anton Puškár et al., "Porušovanie a lomy súčastí." EDIS ŽU Žilina, 2000.

2. Otakar Bokuvka et al., "Degradation Processes and Lifetime Prediction – Fatigue of Materials: Lectures, 1st Edition", University of Žilina, Žilina 2020, 121 p. ISBN 978-80-554-1725-7.

3. František Nový et al., "Degradation Processes and Lifetime Prediction – Fatigue of Materials: exercises instructions, 1st Edition", the University of Žilina, Žilina 2019, 98 p. ISBN 978-80-554-1557-4.

ASSESSMENT

Reports: reports intended for experimental laboratory exercises, which deepen theoretical knowledge in Dynamic strength and fatigue life. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Exam (after the semester)**:** written and oral exam verifying overall knowledge about quality assurance of products (materials) in mechanical engineering.

Semester test (during the semester)**:** This test continuously verifies knowledge of issues in the field of Dynamic strength and fatigue life. The questions are related to exercises and laboratory exercises.

GRADING POLICY

The subject Dynamic strength and fatigue life is evaluated by points. The final points are the sum of the points the student earns during the semester in the exercises.

The following are continuously assessed in the exercises: theoretical preparation (professional discussion at the beginning of the exercises as an input for the preparation of the report) + submitted reports (max. 10 points), i.e., 10 reports x 10 points = 100 points. The maximum number of points achieved in the exercises is 100.

The course is assessed based on the student's work in the exercises. The course is graded based on the student's performance in the exercises, the submission of all papers, and a minimum of 65 points out of 100 during the semester.10 papers x 10 points. The final grade consists of the points the student earns during the semester in the exercises (max. 100).

Assignment Weights	**Percent**
10 reports	**60%**
Student portfolio	**40%**
Total	**100%**

10 reports (max. 10 points each) – max. 100 points

Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

MATERIALS TECHNOLOGIES

Code: **MT**

Field of study

Materials Science and Engineering

Level of study

Master Study

Year of study/semester

2

Language

English

Thematic block

Materials & Manufacturing

Form of tuition and number of hours:

Lecture: 26h

Excersises: 26h

ECTS

6

COURSE DESCRIPTION

The Materials Technologies is dedicated to the AIEMPS – *Advances in Innovative Engineering Materials and Processes for Sustainability* path.

The course aims to explain the essence of modern material technologies and teach the principles and applications of technologies in current practice. It also deals with thermal spraying, progressive welding methods, and composite materials.

Teaching is divided into lectures and exercises. In lectures, students learn to understand the theoretical basis of materials technology. During the practicals, students verify their theoretical knowledge acquired in lectures and visit companies working with advanced technologies. They also learn to distinguish between the different microstructures of new materials.

COURSE OBJECTIVES

By completing Materials Technologies, the student will be able to differentiate and describe various non-traditional technologies along with their applications in various areas of the stamping, aerospace, and automotive industries. The student will also be able to apply knowledge of coatings and coatings used on various types of materials and thermal spraying.

PREREQUISITES FOR TAKING THE COURSE

Before starting to study Materials Technologies, a student should have a general knowledge of the various types of engineering technologies and materials, their structure, properties, and applications.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	Students have extensive and deep factual knowledge of methods and processes for producing and processing engineering materials, which they apply to the field of quality control of materials.
MS_O_02	Students can use information from literature; they can integrate the obtained information, interpret, and critically evaluate it, draw conclusions and formulate and solve fundamental materials testing and its quality assurance problems.
MS_O_03	Students can plan and carry out experiments, including measurements, interpret the results, and draw conclusions related to material quality control.
MS_O_04	Can prepare a scientific study and present a presentation on implementing various materials testing methods for research tasks, containing a critical analysis and conclusions with an accent on materials quality and its influence on overall mechanical properties. Able to work individually and in a team and interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Exercises: motivational demonstration, report, question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of Conducting Classes
FT_01	Lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercise and self-study of recommended literature	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	Yes

Co-funded by the European Union

LEARNING OUTCOMES

By completing the Materials Technologies, the student will be able to distinguish and describe various non-traditional technologies along with their use in various areas of the scaffolding, aviation and automotive industries. The student will be able to apply concepts about layers and coatings used on different types of material, radiant sprays.

COMMENTS

Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER
Prof. Ing. František Nový, PhD.

DO YOU KNOW
Thermal spraying is a method of mechanical plating in which fine particles of molten metal are thrown onto the surface of the object to be plated by means of a shot gun. The particles stick to the surface and form a continuous layer.

COURSE CONTENT - FORM OF TUITION (e.g. lecture)

Topics 1

Introduction. Material technologies - basic concepts, features, division.

Topics 2

Slow solidification - controlled crystallization, rapid solidification - non-crystalline materials, dispersion hardened materials.

The topics will be conducted for 2 weeks.

Topics 3

Production of composites, eutectic composites, polymer matrix composites.

Topics 4

Ceramic matrix composites, particle composites, fibre and whisker composites.

Topics 5

Intermetallic compounds. Intermediate phases.

Topics 6

Superconductor production technologies.

Topics 7

Modification of surface properties: preparation of thin films, chemical vapor deposition (CVD), and and physical vapor deposition (PVD) techniques.

Topics 8

Glow injections, modern electroplating.

The topics will be conducted for 2 weeks.

Topics 9

Unconventional technologies of processing and machining of materials. Laser and plasma technologies.

Topics 10

Electron beam technologies, ultrasonic technologies, electro spark and ion technologies.

The topics will be conducted for 2 weeks.

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LEARNING OUTCOMES

Based on the completed lectures, students should be able to apply the acquired knowledge when solving model examples aimed at data analyzes from research activities, evaluate results and process acceptance protocols (input/output) of individual methods to maintain the required quality of product material - individually and in a team; appropriately present the results of research activities etc.

COMMENTS

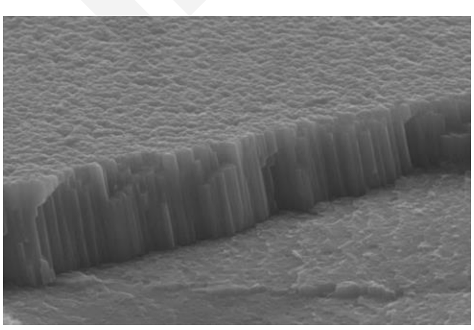
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

Ing. Martin Vicen, PhD.

DO YOU KNOW...

PVD (Physical Vapor Deposition) is the process of depositing thin layers of material on the surface of an object. It is a technique that is used in a variety of industries, including electronics, optics, medical and more. For example, it is in the field of nanoparticles and their applications. PVD allows the creation of very thin layers of material at the nanoscopic level. This is important in the development of new materials with unique properties that can be applied in the fields of sensors, electronics or medicine.



COURSE CONTENT - FORM OF TUITION (e.g. laboratory classes)

Topics 1

Introduction to the laboratory exercise - instruction on laboratory order and safety at work.ch plants.

Topics 2

Controlled and uncontrolled solidification.

Topics 3

Preparation of polymer matrix composites.

Topics 4

Evaluation of microstructural parameters and fillers of metal and ceramic matrix composites.

Topics 5

Evaluation of the quality and performance of PVD coatings, glow-in-the-dark coatings and electroplating.

Topics 6

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, electro spark and ion technologies).

Topics 7

Excursion in production factories.

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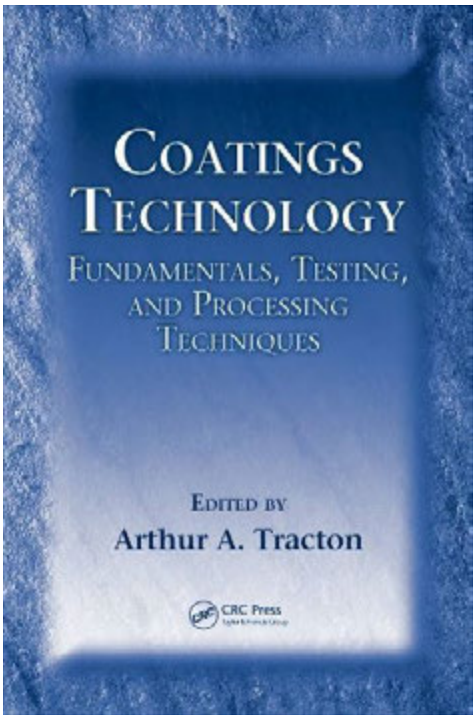

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Materials Technologies*:

TRACTION, A. A.: Coating Technology, fundamentals, testing and processing techniques. CRC New York 2007. 404p. ISBN 1-4200-4406-0

CANTOR, B. GIRINGE, M.J.: Metal and Ceramic Matrix Composites. London 2004. 442p. ISBN 978-075030824

For a deeper understanding of the course subject matter, optional recommended texts include:

GRPÁČ, P. JANOVEC, J. DOMÁNKOVÁ, M.: Nové materiály a technológie. STU Bratislava 2007. 207p. ISBN 978-80-227-2599-6

ASSESSMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of materials technologies. The papers contain the theoretical basis, assignments and introductions for processing experimental results.

Semester paper (during the semester): Paper and laboratory work continuously verify knowledge of issues in the quality control of materials.

Exam (after the semester): written and oral exam verifying overall knowledge in materials technologies.

GRADING POLICY

Points evaluated the subject *Materials Technologies*. The resulting points are the sum of the points the student gets during the semester (on exercises) and the points he gets on the exam. The exercises are continuously evaluated: theoretical preparation (professional discussion at the beginning of the exercises as an input for the processing of the assigned topics) + processing of the term paper (max. 10 points), i.e. 1 term paper x 10 points = 10 points is evaluated; 1 control test (1 x 10 points = 10 points). The maximum number of points achieved in the exercises is 20. The final grade consists of the points the student earns during the semester (in the exercises) and the points he/she earns in the exam. The points obtained in the exercises (max. 20) will be added to the points obtained in the examination (max. 80), thus affecting the final grade of the course. The examination consists of a written part (test) and an oral part (answers to individual questions).

Assignment Weights	Percent
10 semester work	10%
1 control test	10%
Final examination	80%
Total	100%

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
68 – 61 points = E
0 – 60 points = FX

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COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

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FATIGUE OF MATERIALS

Code: **FM**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

2

Language

English

Thematic block

Materials Testing Methods and Failure Analysis

Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

6

COURSE DESCRIPTION

The course is designed to implement the theoretical knowledge about the mechanical behaviour of the material, particularly focusing on fracture mechanics and fatigue characteristics to understand, assess and overcome failure. Both the linear-elastic and elastic-plastic fracture mechanisms will be discussed. This will be followed by a discussion of the characteristics and mechanisms of fatigue crack initiation and propagation. The importance of microstructure and environment in controlling the performance of materials will also be highlighted. Next, concepts on failure and methods for root cause analysis will be developed. The course will have necessary and appropriate schematic representation and case histories associated with the required lectures on fundamental concepts. Participants will acquire state-of-the-art knowledge on the broad field of fracture and fatigue and their implementation in the failure analysis of materials.

COURSE OBJECTIVES

Fatigue failure represents the largest driver of the failure of metallic materials; hence, it is an important area for the practicing engineer to understand. Upon completion of this course, students will be able to:

- Understand the fundamental principles of linear-elastic fracture mechanics;
- Determine the distribution of stresses & strains around a linear elastic crack and estimate the size of the plastically deforming zone around the crack tip;
- Understand the uncertainties and variability in fracture-related materials properties due to the stochastic nature of microstructure;
- Recognize there are differences in the definition of “fracture toughness” and be able to select the appropriate definition for a particular case;
- Understand stress-life (S-N) curves and how they are used in fatigue analysis;
- Understand the micro-mechanisms of fatigue damage initiation and propagation at various stages of fatigue (onset of cracking, during early and late stages of crack growth, and during final fracture;
- Identify various modes of fracture based on the appearance of the fracture surface.

PREREQUISITES FOR TAKING THE COURSE

Before beginning the study of Fatigue of Materials, the student should have a general knowledge of the different types of engineering materials, their structure, properties, heat treatment fundamentals, and applications.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Students will have extensive and deep factual knowledge of methods and processes for producing and processing engineering materials and applying knowledge in material quality control.
MS_O_02	Students can use information from literature, integrate the obtained information, interpret and critically evaluate it, draw conclusions, and formulate and solve fundamental materials testing and quality assurance problems.
MS_O_03	Students can plan and carry out experiments, including measurements, interpret the results, and draw conclusions about material quality control.
MS_O_04	Can prepare a scientific study and present a presentation on implementing various materials testing methods for research tasks, containing a critical analysis and conclusions with an accent on materials quality and its influence on overall mechanical properties. Able to work individually and in a team and interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration, report, question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of Conducting Classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises and self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

The aim of Fatigue of Materials is to provide students with a comprehensive understanding of fatigue behavior in materials, enabling them to apply theoretical knowledge to practical engineering scenarios, predict fatigue life, and implement strategies to mitigate fatigue-related failures in engineering design and maintenance. Adjustments can be made based on the specific focus and depth of the course curriculum.

COMMENTS

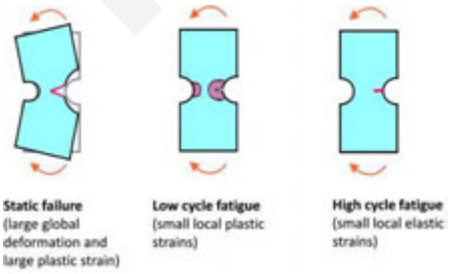
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURERS

Prof. Ing. Peter Palček, PhD.
Prof. Ing. František Nový, PhD.

DO YOU KNOW...

Fatigue is a failure mechanism that involves the cracking of materials and structural components due to cyclic stress. While applied stresses may be tensile, compressive or torsional, crack initiation and propagation are due to the tensile component. One of the intriguing factors about fatigue development is that fatigue cracks can be initiated and propagated at stresses well below the yield strength of the material of construction (these stresses are usually thought to be related to elastic deformation, not plastic deformation).



Mechanical fatigue

COURSE CONTENT - FORM OF TUITION (e.g. lecture)

Topics 1

Introduction to fatigue of materials

Topics 2

Cyclic deformation in ductile single crystals and in polycrystalline ductile solids

Topics 3

Fatigue crack initiation in ductile solids

Topics 4

Cyclic deformation and crack initiation in brittle solids and in noncrystalline solids

Topics 5

Stress–life approach

Topics 6

Strain–life approach

Topics 7

Fracture mechanics and its implications for fatigue

Topics 8

Fatigue crack growth in ductile solids and in brittle solids

Topics 9

Fatigue crack growth in noncrystalline solids

Topics 10

Contact fatigue: sliding, rolling and fretting

Topics 11

Retardation and transients in fatigue crack growth

Topics 12

Small fatigue cracks

Topics 13

Environmental interactions: corrosion-fatigue and creep-fatigue

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LEARNING OUTCOMES

Based on the completed lectures, students should be able to apply the acquired knowledge when solving model examples aimed at data analyzes from research activities, evaluate results and process acceptance protocols (input/output) of individual methods to maintain the required quality of product material - individually and in a team; appropriately present the results of research activities etc.

COMMENTS

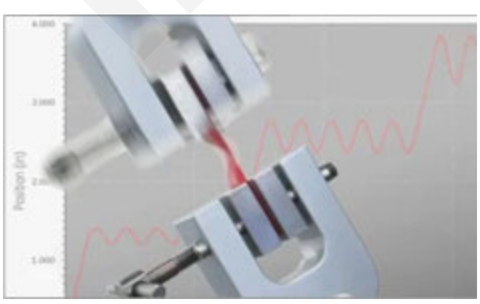
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

Prof. Ing. František Nový, PhD.
Ing. Milan Uhríčik, PhD.

DO YOU KNOW...

Fatigue testing is defined as the process of progressive localized permanent structural change occurring in a material subjected to conditions that produce fluctuating stresses and strains at some point or points and that may culminate in cracks or complete fracture after a sufficient number of fluctuations.



Fatigue testing

COURSE CONTENT - FORM OF TUITION (e.g. laboratory classes)

Topics 1

Introduction to limit states. Basic classification

Topics 2

Limit states in elastic and plastic region

Topics 3

Body fracture initiators. Structural notches

Topics 4

Linear fracture mechanics

Topics 5

Nonlinear fracture mechanics

Topics 6

Material fatigue - introduction, basic knowledge. Experimental approaches

Topics 7

Material fatigue - High cycle uniaxial fatigue

Topics 8

Material fatigue - High cycle multiaxial fatigue

Topics 9

Material fatigue - High cycle fatigue - experimental approaches

Topics 10

Material fatigue - Low cycle uniaxial fatigue

Topics 11

Material fatigue - Low cycle multiaxial fatigue

Topics 12

Material fatigue - Low cycle fatigue - experimental approaches

Topics 13

Numerical procedures for material fatigue

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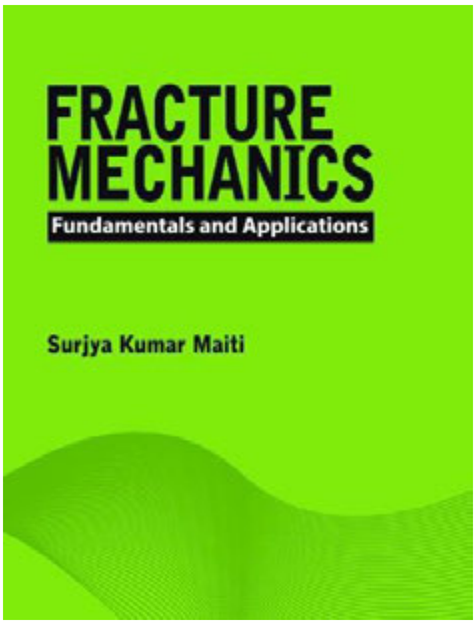


TEXTBOOK/READINGS

- 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

- 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.

ASSESSMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of fatigue. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester): Paper and laboratory work continuously verify knowledge of issues in the field of fatigue of materials.

Exam (after the semester): written and oral exam verifying overall knowledge about the fatigue of materials in mechanical engineering.

Assignment Weights	Percent
10 reports	30%
Semester paper	10%
Examination	60%
Total	100%

GRADING POLICY

Points evaluate the subject Fatigue of Materials. The resulting points are the sum of the points the student gets during the semester (on exercises) and the points he gets on the exam.

During the exercises, the following are continuously evaluated: theoretical preparation + submitted reports (max. 3 points), i.e., 10 reports x 3 points = 30 points; and a one-semester paper (10 points). The maximum number of points achieved in the exercises is 40.

The final assessment consists of points that the student gets during the semester (on exercises) and points that he gets on the exam. The points obtained in the exercises (max. 40) are added to the points obtained in the exam (max. 60) and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

10 reports (max. 3 points each) – max. 30 points
Semester paper – max. 10 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

FUELS AND LUBRICANTS IN AUTOMOTIVE INDUSTRY

Code: **FLAI**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Applied Materials Science

Form of tuition and number of hours*:

Lecture: 26h

Laboratory: 26h

ECTS

3

Four-Cylinder Engine

COURSE DESCRIPTION

The *Fuels and lubricants in automotive industry* course is dedicated to the *AIEMPS - Advances in Innovative Engineering Materials and Processes for Sustainability* path. This course explores the science, technology, and practical applications of fuels and lubricants in the automotive industry. The course covers the properties, production, distribution, and utilization of fuels, as well as the composition, functions, and selection of lubricants. The course also deals with the characteristics and properties of hydraulic fluids (damper oils, brake fluids) and cooling fluids. As part of the evaluation of the ecological aspects of fuels and lubricants, the harmful components of exhaust gases are listed and evaluated, as well as the influence of design, engine settings and operating conditions on the composition of exhaust gases. A description of ways to reduce the content of harmful emissions (secondary air systems, catalytic converters, exhaust gas recirculation, particulate filters, selective catalytic reduction) is also part of this course.

Teaching is divided into lectures and laboratory exercises. In the lectures, students will gain a comprehensive understanding of the role fuels and lubricants play in vehicle performance, efficiency, and environmental impact. During laboratory exercises focused on testing important properties of fuels and lubricants, students will summarize and apple theoretical knowledge obtained during lectures. The course aims to prepare students for roles in automotive engineering, maintenance, and environmental sustainability within the industry.

After finishing *Fuels and lubricants in automotive industry* course a student will be able to describe traditional and alternative fuels, their origin, composition, processing, properties, compare their advantages and disadvantages, explain the functions of lubricants and their properties with regard to friction arising during vehicle operation, distinguish between the typical composition of fuels, their combustion properties, economic and ecological engine parameters, identify harmful components in exhaust gases, determine and compare the physical-chemical properties of oils and plastic lubricants, individually/in a team present the results of a research report and propose the application of lubricants in practical use.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Fuels and lubricants in automotive industry* course, a student should have a basic knowledge of general and organic chemistry and a basic knowledge of various types of combustion engines.

Co-funded by the European Union

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Has extensive and in-depth substantive knowledge and comprehensive understanding the composition and the properties of automotive fuels and lubricants. Identifies and analyzes the impact of fuel and lubricant choices on vehicle performance, efficiency, and emissions.
MS_O_02	Can use information from literature and other available sources in the field of fuels and lubricants, interpret and critically evaluate them.
MS_O_03	Can plan and carry out experiments, interpret the results and draw conclusions regarding the composition and properties of fuels and lubricants
MS_O_04	Can prepare and present results of performed experimental measurements, including critical analysis, synthesis and conclusions. Able to work individually and in a team, and lead a debate.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Lectures:** lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	**Laboratory classes:** experiment demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	Lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_02	Preparation for classes	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_03	Preparation of reports	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

COURSE CONTENT - LECTURE

LEARNING OUTCOMES

After finishing *Fuels and lubricants in automotive industry* course a student will be able to describe traditional and alternative fuels, their origin, composition, processing, properties, compare their advantages and disadvantages, explain the functions of lubricants and their properties with regard to friction arising during vehicle operation, distinguish between the typical composition of fuels, their combustion properties, economic and ecological engine parameters, identify harmful components in exhaust gases, determine and compare the physical-chemical properties of oils and plastic lubricants, individually/in a team present the results of a research report and propose the application of lubricants in practical use.

DO YOU KNOW

Algae are rich in lipids, and can be converted into biofuel. Researchers are exploring the potential of cultivating algae on a large scale to produce a sustainable and environmentally friendly alternative to conventional fossil fuels. Algae-based biofuels have the advantage of rapid growth and can be cultivated in areas unsuitable for traditional agriculture.

Algae could be a future source of biofuel

Topics 1

Fuels and lubricants: Introduction, crude oil characterization
The lecture is focused on introduction to the issue of fuels and lubricants in automotive industry, basic characteristics and classification; crude oil - characteristics, origin, composition, undesirable substances; crude oil processing - treatment before distillation, fractional distillation at atmospheric pressure and under vacuum, processing of fractions from vacuum distillation (4 hours).

Topics 2

Conventional automotive fuels
Students will organize their knowledge about automotive gasolines - composition 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 number, anti-knock additives, other quality indicators of automotive gasolines and diesel fuel - composition and basic characteristics, mixture formation in diesel engines; ignition delay, cetane number; physical-chemical properties of diesel (distillation range, flash point, properties at low temperatures); other indicators of diesel quality (5 hours).

Topics 3

Alternative automotive fuels
This lecture brings overview of alternative automotive fuels: gaseous fuels (CNG, LNG, LPG) - basic characteristics, properties, comparison, advantages - disadvantages. Alcohols, ethers, biodiesel, emulsion diesel - basic characteristics, 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. (4 hours).

Topics 4

Friction and lubricants properties
In this lecture the basic aspects of friction as types of friction in general and during lubrication and wear are defined and explained. Students will learn about basic functions of lubricants, properties of lubricants - characteristics, methods of measurement; classification of lubricants according to the physical state; gas lubricants - basic characteristics and properties; liquid lubricants - their classification according to the chemical composition, additives improving their properties (5 hours).

Topics 5

Automotive lubricants and fluids
This lecture deals with most important facts about engine and transmission oils (basic functions, properties, classifications, testing), plastic lubricants (characteristics, properties, advantages - disadvantages, overview of thickener types, testing of lubricating grease), solid lubricants (characteristics, properties, overview, sliding varnishes) and hydraulic fluids (characteristics, properties) (5 hours).

Topics 6

Ecological aspects of fuels and lubricants
This lecture is focused on ecological aspects of fuels and lubricants. It summarizes harmful components of exhaust gases, describes influence of design, engine settings and operating conditions on the composition of exhaust gases. Methods of reducing the content of harmful emissions are also presented (3 hours).

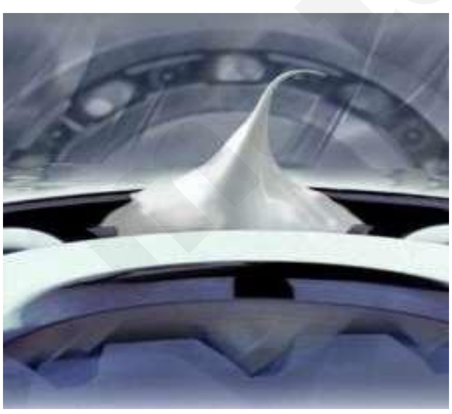
Co-funded by the European Union

LEARNING OUTCOMES

After finishing *Fuels and lubricants in automotive industry* laboratory classes a student will be able to understand and apply methods for assessing the properties of different fuels (measure and compare viscosity, density, flash point of various fuels and prepare biodiesel in laboratory conditions), determine and compare the physical-chemical properties of oils (dynamic and kinematic viscosity, density, pH of the aqueous extract of motor oils), individually/in a team present the results of a research report and propose the application of lubricants in practical use.

DO YOU KNOW

The slipperiest substance in the world is a lubricant called "perfluoropolyether" (PFPE). PFPE is a synthetic lubricant known for its extremely low coefficient of friction. With remarkable stability and resistance to extreme temperatures, PFPE ensures smooth and efficient operation in harsh environments where traditional lubricants may fail.



PFPE - the slipperiest substance in the world

COURSE CONTENT – LABORATORY CLASSES

Topics 1

Introduction and Flashpoint determination
Introduction will be focused on instruction related to laboratory order and safety at work. Students will perform flashpoint determination by the Cleveland method on specimens of the same type automotive gasoline and on specimens of the same type of diesel (4 hours).

Topics 2

Laboratory preparation of biodiesel
Students will carry out laboratory preparation of biodiesel by transesterification of rapeseed oil with methanol - rapeseed oil specimen will be heated with sodium methanolate solution (4 hours).

Topics 3

Determination of dynamic viscosity
Students will carry out measurements of dynamic viscosity of new and used engine oils (the same type of oil) using the Physica MCR 301 Oscillatory/Rotational Rheometer . The dynamic viscosity measurements of both oils will be performed at the temperatures of 20, 40 and 100 °C. (4 hours).

Topics 4

Determination of kinematic viscosity
Students will carry out measurements of kinematic viscosity 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 (4 hours).

Topics 5

Determination of the density
Students will carry out density measurements of new and used engine oils with a hydrometer. Using the determined density values students will calculate the kinematic viscosity (the ratio of dynamic viscosity to density) and compare the obtained results with the values obtained using a capillary viscometer (4 hours).

Topics 6

Assessment of protective properties of used engine oil
Students will assess protective properties of used engine oil by determining the pH of the aqueous extract (pH test is an important criterion for assessing the degree of degradation of used oils in terms of their corrosiveness) and by indicative determination of the water content (4 hours).

Topics 7

Data analysis and reporting
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 (2 hours).

Biodiesel life cycle

TEXTBOOK/READINGS

The mandatory reading for completing *Fuels and lubricants in automotive industry* course.

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.

FANCHI, J.R. – CHRISTIANSEN, R.L. 2016. Introduction to Petroleum Engineering. Wiley, USA, ISBN 978-1119193449.

BHATIA, F.C. 2023. Automotive Fuels and Lubricants. Laxmi Publications, India, ISBN ISBN 978-935767073

For a deeper understanding of the course subject matter, optional recommended texts include:

DENTON, T. 2018. Alternative Fuel Vehicles. Routledge, UK, ISBN 978-1138503700.

ASSESMENT

Reports: Each report is related to the particular laboratory exercise. It contains an explanation of the theoretical bases of experiment, procedure, summarization of results and conclusion. A brief oral presentation of the obtained result is also included in the scoring of the report.

Summarizing report (described in Topics 7) focused on comparison of new and used engine oils properties and behavior on the basis of results obtained in Topics 3 – 6.

Exam (after the semester)**:** Written and oral exam verifying overall knowledge obtained in *Fuels and lubricants in automotive industry* course.

GRADING POLICY

The *Fuels and lubricants in automotive industry* course is evaluated by points.

Laboratory exercises: Submitted reports (max. 6 points for each report) and semester paper are evaluated. The maximum number of points achieved in the laboratory exercises is 40.
The resulting points are the sum of the points that the student obtained during the semester (laboratory exercises, max. 40 points) and the points he/she achieved on the exam (max. 60 points).

Assignment Weights	Percent
6 reports	30%
Summarizing report	10%
Examination	60%
Total	100%

6 reports (max. 5 points each) – max. 30 points
Summarizing report – max. 10 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

Co-funded by the European Union

PROPERTIES AND USE OF MATERIALS

Code: **PUM**

Field of study
Materials Science and Engineering

Level of study
Master Study

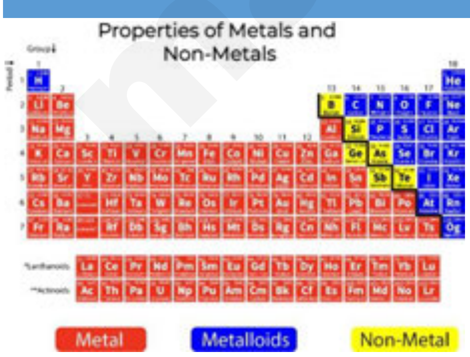
Year of study/semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours:
Lecture: 26h
Laboratory: 26h

ECTS
6



COURSE DESCRIPTION

The subject deals with the properties of metal materials and their specific applications in technical practice, focusing primarily on mechanical tests and the use of material standards and material databases for the optimal choice of metals for technical purposes.

The subject Properties and Use of Materials follows on from earlier material-related subjects from the bachelor's study. It deals with the physical nature of technical materials, general knowledge about their structure and properties, and ways of influencing them (e.g., by heat treatment). It also includes specific information about various material groups, primarily metals but also plastics, ceramics, and composites, their structure, properties, and applications. This subject further expands the knowledge in these areas, with a focus on metals, their properties, and their use.

The lectures are aimed at obtaining information about the properties and use of various types of metal materials and the mechanical testing of these materials. Laboratory exercises are dedicated to practicing the presented issues and specific experiments.

The total time requirement of the subject is 140 hours per semester, of which 52 hours (13 weeks x 2 hours of lectures + 13 weeks x 2 hours of laboratory exercises) are direct teaching and 88 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

By completing the subject *Properties and use of materials*, the student will be able to describe and compare the characteristic properties of various types of metal materials, their use in practice and solve the issue of the appropriateness of using a particular metal based on its specific properties.

PREREQUISITES FOR TAKING THE COURSE

Before beginning the study of Properties and Use of Materials, students are expected to have a general understanding of various types of metal materials, their structure, properties, and applications. This foundational knowledge is essential for successfully engaging with the subject matter.

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LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	He/ she has extended and in-depth knowledge in the field of general knowledge, which is the basis for understanding complex relationships in the processes of designing, manufacturing, testing and application of engineering materials.
MS_O_02	He/ she can use information from literature, databases and other available sources. He/ she is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve complex innovative problems. He/ she can solve practical engineering tasks that require the use of engineering standards and norms.
MS_O_03	He/ she is aware and knows the possibilities of further training and improving professional, personal and social competences. He/ she 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.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; laboratory work; observation; problem teaching	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature	independent work
a_02	Preparation for classes	Self-study, preparation for exercises, processing reports	independent work and cooperation
a_03	Preparation of reports	Preparation and processing reports	independent work and cooperation

LEARNING OUTCOMES

By completing the subject *Properties and use of materials*, the student will be able to describe and compare the characteristic properties of various types of metal materials, their use in practice and solve the issue of the appropriateness of using a particular metal based on its specific properties.

COMMENTS

LECTURER
Ing. Alan Vaško, PhD.

DO YOU KNOW
Metal materials are used not only in mechanical engineering, but in all industries including automotive, aviation, aerospace or medicine.

Different types of metal materials

COURSE CONTENT – LECTURE

Topics 1

Properties of metal materials – distribution of properties; physical, physico-chemical, mechanical and technological properties (2 hours)

Topics 2

Mechanical tests – division of mechanical tests, basic principles in mechanical tests, preparation of test bars (2 hours)

Topics 3

Tensile test – principle of the tensile test; test bars; pull diagram; evaluation of the test; test machines (2 hours)

Topics 4

Impact bending test – principle of the impact bending test; test bars; evaluation of the test; test machines (2 hours)

Topics 5

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)

Topics 6

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)

Topics 7

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)

Topics 8

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)

Topics 9

Material databases – use of material databases (2 hours)

Topics 10

Principles of material choice – division of metal materials; considerations for the choice of material; methodology of material design (2 hours)

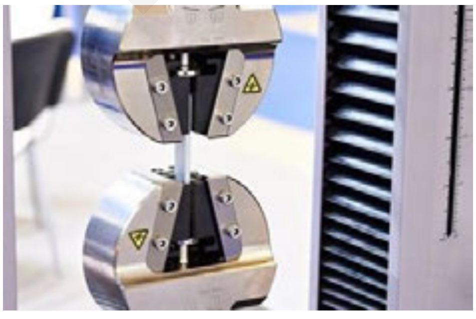
LEARNING OUTCOMES

By completing the subject *Properties and use of materials*, the student will be able to describe and compare the characteristic properties of various types of metal materials, their use in practice and solve the issue of the appropriateness of using a particular metal based on its specific properties.

COMMENTS

INSTRUCTOR
Ing. Alan Vaško, PhD.

DO YOU KNOW
Mechanical testing provides crucial information about the mechanical properties of materials. Some key parameters that can be determined through mechanical testing include: tensile strength, yield strength, elongation, modulus of elasticity, impact resistance, hardness, fatigue strength, creep resistance etc. These mechanical properties are vital for engineers and material scientists in selecting appropriate materials for specific applications and ensuring the safety, reliability, and performance of engineered components.



Tensile test

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Introduction to the laboratory exercises of *Properties and use of materials* (2 hours)

Topics 2

Properties of metal materials (2 hours)

Topics 3

Tensile test (2 hours)

Topics 4

Impact bending test (2 hours)

Topics 5

Hardness tests – static methods (Brinell, Vickers, Rockwell) (2 hours)

Topics 6

Hardness tests – dynamic methods (Poldi hammer, Leeb) (2 hours)

Topics 7

Fatigue tests (2 hours)

Topics 8

Creep tests (2 hours)

Topics 9

Material standards – marking of steels and cast irons (2 hours)

Topics 10

Material standards – marking of non-ferrous metals and alloys (2 hours)

Topics 11

Material database – Lexicon of metals (2 hours)

Topics 12

Principles of material choice (2 hours)

Topics 13

Semester thesis presentations (2 hours)

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Properties and use of materials*:

Vaško, A. – Skočovský, P.: *Properties and use of metal materials*. EDIS, Žilina 2014.

Optional recommended texts for a deeper understanding of the subject:

1. Skočovský, P. – Bokůvka, O. – Konečná, R. – Tillová, E.: *Materials science*, EDIS, Žilina, 2014.

2. Skočovský, P. – Palček, P. – Konečná, R. – Várkoly, L.: *Construction materials*, EDIS, Žilina, 2000.

3. Veles, P.: *Mechanical properties and testing of metals*. ALFA, Bratislava, 1989.

...

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of mechanical testing and applications of metal materials. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper (during the semester)**:** paper continuously verifying knowledge in the field of mechanical properties and applications of materials.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of mechanical properties and applications of materials.

GRADING POLICY

The subject *Properties and use of materials* is evaluated by points. The resulting points are the sum of the points the student gets during the semester (laboratory exercises) and the points he/she gets on the exam.

During the laboratory exercises, the following are continuously evaluated: theoretical preparation (discussion at the beginning of the laboratory exercises as an input for processing the report) + submitted reports (max. 3 points), i.e. j. 10 reports x 3 points = 30 points are evaluated; 1 semester paper (1 x 10 points = 10 points). The maximum number of points achieved in the exercises is 40.

The final evaluation consists of the points the student gets during the semester (on laboratory exercises) and the points he/she gets on the exam. The points obtained in the laboratory exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
10 reports	25%
Semester paper	10%
Student portfolio	5%
Examination	60%
Total	100%

10 reports (max. 2 or 3 points each) – max. 25 points
Semester paper – max. 10 points
Independent work of student – max. 5 points
Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points = A
85 – 92 points = B
77 – 84 points = C
69 – 76 points = D
61 – 68 points = E
0 – 60 points = FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

MATERIALS ENGINEERING

Code: **ME**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

1

Language

English

Thematic block

Fundamental Aspects of Materials Science

Form of tuition and number of hours:

Lecture: 26h

Laboratory: 26h

ECTS

3

Different types of materials: steels, alloys, plastic materials, composites, non-metalic materials etc.

COURSE DESCRIPTION

Materials Engineering offers a comprehensive exploration of the properties, behaviours, and applications of various materials essential in engineering contexts. Integrating content from multiple disciplines, this course provides a unified understanding of fundamental principles and advanced topics in materials science and engineering.

Students delve into the crystalline structure of metals and alloys, equilibrium diagrams, and phase transformations in solid-state materials, with a particular emphasis on the iron-carbon system. They also study heat treatment procedures, mechanical properties, failure mechanisms, corrosion resistance, and non-destructive testing methods.

In addition, the course covers non-ferrous metals and alloys, light metals, refractory alloys, powder metallurgy techniques, and macromolecular chemistry, focusing on the properties of plastics and their applications. Practical laboratory exercises offer hands-on experience in material testing, microstructural analysis, and evaluation, preparing students to tackle real-world engineering challenges effectively.

By the course's conclusion, students will have acquired a comprehensive understanding of materials engineering principles and practical skills necessary for analysing, designing, and selecting materials to meet specific engineering requirements.

COURSE OBJECTIVES

By the conclusion of the course *Materials Engineering*, students will have developed a comprehensive understanding of materials engineering principles and practical skills necessary for addressing real-world challenges in various engineering applications. They will be equipped to analyse, design, and select materials effectively to meet specific engineering requirements.

PREREQUISITES FOR TAKING THE COURSE

Prerequisites: Students should have completed introductory courses in chemistry, physics, and engineering, with a strong foundation in material properties and structures. Basic understanding of crystallography and thermodynamics is advantageous.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge in the field of methods, processes of production and processing of engineering materials (ferrous and non-ferrous alloys) in connection with the application of knowledge in the field of materials engineering (atomic bonding fundamentals, Miller-Bravais crystal lattices, fundamental binary diagrams of alloys, Fe-Fe3C diagram, classification of steels, cast irons, aluminium, copper, titanium, cobalt, and nickel alloys; fundamentals of heat-treatment processes).
MS_O_02	Can use information from literature, He is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental material related problems.
MS_O_03	**He can plan and carry out experiments, including measurements, interpret the results and draw conclusions related to field of materials engineering.**
MS_O_04	Can prepare a scientific study (laboratory work) and deliver a presentation on the implementation of various materials engineering techniques (metallography evaluation, microstructures of steels and cast irons, microstructures after heat-treatment as well), for a research task. This includes critical analysis, drawing conclusions, emphasizing the optimization and impact on overall mechanical properties. Proficient in individual and teamwork, adept at collaboration and communication within team settings.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; report; question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

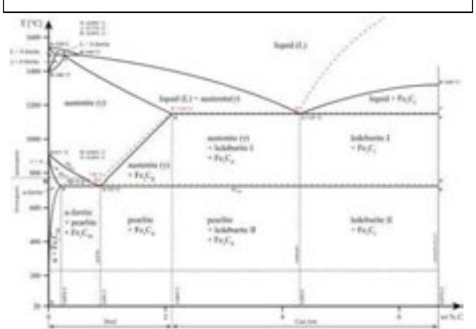
Upon completion of the lectures, students will exhibit mastery in topics ranging from crystalline structures and phase transformations to mechanical properties, heat treatment procedures, and material selection criteria. They will adeptly apply this broad understanding to analyze materials for engineering applications and employ various laboratory techniques for comprehensive material evaluation and testing

COMMENTS
Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER
assoc. prof. Ing. Lenka Kuchariková PhD.
prof. Ing. Otakar Bokůvka, PhD.

DO YOU KNOW

In a materials engineering course, you might learn ***about shape memory alloys****, which have the remarkable ability* ***to return*** *to their original shape after being deformed, making them ideal for applications like medical stents,* ***aerospace components****, and robotics.*



Iron-Carbon Phase Diagram

COURSE CONTENT - LECTURE

Topics 1

Focus is on fundamental concepts underlying materials structure and properties, including crystalline structures of metals and alloys, crystal disorders, diffusion mechanisms, crystal labelling, and the crystallization process. Gain insights into equilibrium diagrams and their role in understanding material behaviour.

Topics 2

Examine the dynamic processes of phase transformations in solid-state materials, particularly within iron-carbon systems and alloy structures. Investigate the methodologies and implications of heat treatment procedures, including chemical-heat treatments, on altering material properties and characteristics.

Topics 3

Characteristics of mechanical behaviours of materials, scrutinizing their physical properties and resistance to corrosion. Explore deformation mechanisms and crystallization processes while dissecting failure mechanisms such as fracture mechanics, fatigue, and creep behaviour.

Topics 4

Examine the properties, heat treatment, and applications of advanced materials such as technical iron alloys and carbon and low-alloy structural steels. Investigate the development trends in structural steels and explore the diverse range of alloys including non-ferrous metals, light metals, refractory alloys, and alloys of refractory metals. Gain insights into powder metallurgy techniques and the structure of high molecular weight substances.

Topics 5

Explore the realm of polymer and composite materials, delving into macromolecular chemistry and its influence on material properties. Investigate the structure and properties of plastics, including thermoplastics, reactoplastics, and elastomers. Gain an understanding of the production methods and structural variations within these versatile materials.

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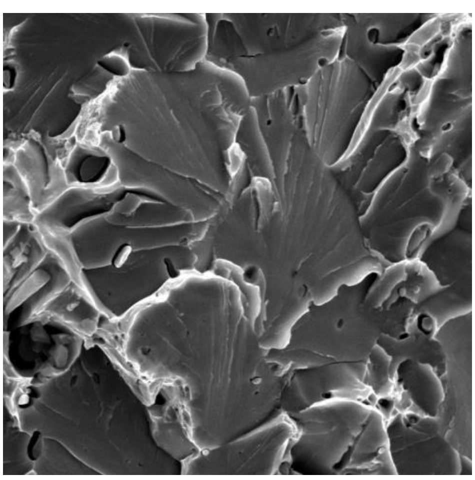
LEARNING OUTCOMES

Upon completion of exercises, students will adeptly conduct crystallography, interpret equilibrium diagrams, and analyze systems of iron with carbon. Additionally, they will perform laboratory tests including tensile, bending impact, hardness, and fatigue tests, gaining hands-on experience in material characterization and evaluation. Furthermore, students will acquire competence in microscopy techniques, microstructure analysis, and non-destructive testing methodologies, essential for understanding material behavior and performance in real-world applications.

COMMENTS
Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR
Ing. Denisa Medvecká, PhD.
Ing. Alan Vaško, PhD.
Ing. Milan Uhríčik, PhD.

DO YOU KNOW
In a materials engineering course, you might explore the fascinating world of ***composite materials****, which are engineered by combining two or more distinct materials to create a new material with enhanced properties. Examples include* ***carbon fiber composites*** *used in aerospace and automotive industries, offering* ***high strength-to-weight ratios*** *and excellent corrosion resistance.*



Fracture surface of steel 1.0715 after immersion hydrogen saturation; a change in fracture character from ductile to cleavage has occurred; facets with river morphology can be observed here.

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Explore the principles of crystallography, mastering the interpretation of equilibrium diagrams, and analysing iron-carbon systems. Gain insights into the structural complexities of materials and their behaviour under varying conditions, essential for material characterization and engineering applications.

Topics 2

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.

Topics 3

Master the fundamentals of light microscopy to analyse 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 behaviour.

Topics 4

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.

Topics 5

Explore advanced material applications, including the application of metastable $Fe-Fe_3C$ 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.

Topics 6

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.

The three-point bending test assesses a material's flexural strength and stiffness. A sample is supported at two ends while a force is applied at the centre, inducing bending. This test measures properties like modulus of elasticity and ultimate strength, crucial for material analysis and design.

TEXTBOOK/READINGS

The mandatory reading for completing the subject Materials Engineering:

1. Lynch, Ch.T.: Handbook of Materials Science, Taylor & Francis Ltd, 2021, 448 p.
2. Callister, W.D.: Materials Science and Engineering, John Wiley & Sons, 2014, 936 p.

For a deeper understanding of the course subject matter, optional recommended texts include:

1. ASM Handbook, Volume 10: Materials Characterization ASM International, 2019, 807 p.
2. Moran, M.: Materials Science and Metallurgy, Larsen and Keller Education, 2017, 260 p.
3. Vander Voort, G.F.: ASM Handbook Volume 9: Metallography and Microstructures, ASM International, 2004, 1184 p.

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of materials engineering. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper and laboratory work (during the semester)**:** paper and laboratory work continuously verifying knowledge of issues in the field of materials engineering.

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of theory of phase transformation.

GRADING POLICY

The subject Materials Engineering is evaluated by points. The final points are the sum of the points the student earns during the semester in the exercises.

In the theoretical preparation (short tests at the beginning of the exercises and laboratory exercises as an input for the processing of the report) + submitted reports (max. 2 points), i.e. 10 reports x 2 points = 20 points are evaluated; 2 continuous control written work (2 x 10 points = 20 points).

The final grade consists of the points the student earns during the semester (in practical's and laboratory exercises) and the points he/she earns on the exam. The points earned in the practical's (max. 40) will be added to the points earned in the examination (max. 60) and will thus affect the final grade for the course. The examination consists of a written part (test) and an oral part (answers to individual questions).

Assignment Weights Percent

Assignment	Percent
10 reports	20%
2-semester work	20%
Final examination	60%
Total	100%

10 reports (max. 2 points each) – max. 20 points
2-semester paper – max. 20 points

Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

Points	Grade
93 – 100 points	A
85 – 92 points	B
77 – 84 points	C
69 – 76 points	D
61 – 68 points	E
0 – 60 points	FX

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

SURFACE TREATMENT OF ADVANCED ENGINEERING MATERIALS

Code: **STAEM**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Applied Materials Science

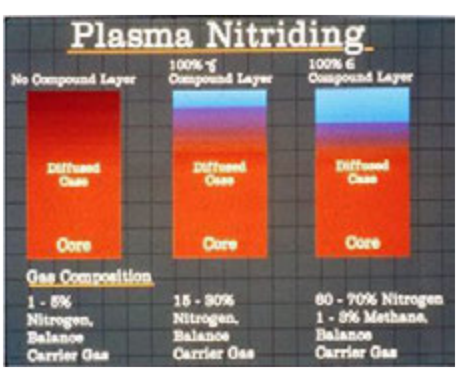
Form of tuition and number of hours:

Lecture: 26h

Laboratory: 26h

ECTS

3



COURSE DESCRIPTION

This advanced course is designed to provide an in-depth understanding of surface engineering principles, focusing on diffusion mechanisms and thermo-chemical processing techniques. The course aims to equip students with the knowledge and skills necessary to comprehend, analyse, and optimize surface treatment procedures for enhancing the mechanical and chemical properties of materials. The course begins with an exploration of diffusion principles, emphasizing dissociation, adsorption, absorption, and the behaviour of atomic elements. Students will delve into the intricacies of substitutional and interstitial atoms, understanding how these diffusion mechanisms contribute to changes in material properties. The core of the course is dedicated to thermo-chemical processing techniques, covering fundamental procedures such as carburizing, nitro-cementing, nitriding, carbonitriding, alitizing, nitro-oxidation, and more. The course extends its scope to progressive PVD and CVD technologies, exploring how thin film deposition can enhance the functional properties of surfaces. Students will learn the principles behind physical vapor deposition and chemical vapor deposition, understanding how these techniques can be employed to apply coatings with specific properties to meet industry requirements. Key areas of focus include diffusion principles, thermo-chemical processing methods, and the application of advanced physical vapour deposition (PVD) and chemical vapour deposition (CVD) techniques for extending the service life of structural components.

COURSE OBJECTIVES

By completing the subject *Surface Treatment of Advanced Engineering Materials*, the student will be able to understand diffusion principles (dissociations, adsorption, absorption, etc. of atomic elements – substitutional or interstitial atoms) and calculate basic equations from the area of diffusion in metals; distinguish individual procedures in the area of chemical-thermal processing (basic procedures, carburizing, nitro cementing, nitriding, carbonitriding, alitizing, nitro-oxidation, etc.), to compile and optimize the application procedures of progressive PVD and CVD layers to increase the service life of structural components used not only in the automotive industry; draw up a proposal for a chemical-thermal treatment procedure; and present the obtained results individually/in a team.

PREREQUISITES FOR TAKING THE COURSE

Before starting the study of the subject *Surface Treatment of Advanced Engineering Materials*, a student should have a general knowledge of the various types of engineering materials, their structure, properties, heat-treatment fundamentals and applications.

LEARNING OUTCOMES OF THE MODULE

Code module	Description
MS_O_01	He has extensive and deep factual knowledge in the field of methods, processes of production and processing of engineering materials (with special accent on low carbon steels for carburizing and medium carbon content steels for nitridation and PVD and CVD layers application on cutting tools in life time improvement relation) in connection with the application of knowledge in the field of thermo-chemical surface treatment (carburizing and nitro-carburizing processes; advanced processes of nitridation – ion and plasme nitriding, alitize, chromium and boron rich layers; CVD and PVD processes applied on cutting tools with life time improvent).
MS_O_02	Can use information from literature, He is able to integrate the obtained information, interpret and critically evaluate it, draw conclusions and formulate and solve fundamental diffusion (application of Ficks laws at carburizing and nitriding processes) and thermo-chemical treatment problems (CVD and PVD layer thicknes measurement, Mercedes test for layer adhesion evaluation).
MS_O_03	**He can plan and carry out experiments, including measurements, interpret the results and draw conclusions related to field of surface treatment of engineering materials.**
MS_O_04	Can prepare a scientific study (semester work with accent on technological procedures for carburizing and nitriding of low and medioum carbon content steels) and present a presentation on the implementation of various thermo-chemical treatment techniques for research task, containing a critical analysis, conclusions with accent to optimization of treatment processes and its influence on overall mechanical properties. Able to work individually and in a team as well as interact with others in teamwork.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	Lectures: lectures with problem interpretation, interactive lectures with discussion, and lectures with multimedia support.	MS_O_01 MS_O_02
Meth_02	Laboratory exercises: motivational demonstration; report; question and answer method.	MS_O_03 MS_O_04

FORM OF TEACHING

Code	Name	Number of hours	Assessment of the learning outcomes of the module	Learning outcomes of the module	Methods of conducting classes
FT_01	lecture	26	exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercises	26	course work	MS_O_03 MS_O_04	Meth_02

THE STUDENT'S WORK, APART FROM PARTICIPATION IN CLASSES, INCLUDES IN PARTICULAR

Code	Category	Name	Work with teacher
a_01	Reading literature	Preparation for exercises, self-study of recommended literature.	NO
a_02	Preparation for classes	Self-study, preparation for exercises and processing of reports.	As needed
a_03	Preparation of reports	Preparation and processing of reports. Consultation.	YES

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LEARNING OUTCOMES

Upon successful completion of the "Surface Treatment of Advanced Engineering Materials" course, students will achieve the following learning outcomes:

- Comprehensive understanding of diffusion mechanisms and application of Fick's laws to calculate diffusion profiles in metals and analyse how diffusion influences material properties.
- Mastery of thermo-chemical processing techniques such as carburizing, nitro-cementing, nitriding, carbonitriding, alitizing, and analyse the impact of thermo-chemical treatments on material surfaces, including improvements in hardness, wear resistance, and corrosion resistance.
- Application of progressive physical vapour deposition (PVD) and chemical vapour deposition (CVD) techniques and evaluate the applications of PVD and CVD in the automotive industry and other structural components for extending service life and improving performance.
- Formulate a comprehensive proposal for a thermo-chemical treatment procedure, considering material requirements, process optimization, and expected outcomes. Integrate theoretical knowledge to propose surface treatment solutions for real-world engineering applications.

COMMENTS

Lectures conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

LECTURER

Prof. Ing. Branislav Hadzima, PhD.
Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW

Thermo-chemical treatments, such as carburizing and nitriding, are widely used for case hardening of materials like steel. These processes enhance the surface hardness of the material, improving wear resistance and durability. Thermo-chemical surface treatments find extensive applications in the aerospace and automotive industries, where components require high strength, wear resistance, and durability.

COURSE CONTENT - LECTURE

Topics 1

Introduction to thermo-chemical surface treatment and application of metastable system Fe – Fe3C; T-T-T and C-C-T Diagrams:

- Overview of thermo-chemical surface treatment processes.
- Importance of surface treatment in enhancing material properties.
- Understanding the Fe – Fe3C phase diagram.
- Introduction to T-T-T (Time-Temperature-Transformation) and C-C-T (Continuous-Cooling-Transformation) diagrams and applications of these diagrams in predicting microstructural transformations during heat treatment.

Topics 2

Diffusion in metals and alloys: Fick's Law:

- Fundamentals of diffusion in metals and alloys.
- Explanation of Fick's laws of diffusion.
- Importance of diffusion in thermo-chemical surface treatment processes.

Topics 3

Austenitization in hypo- and hyper-eutectoid steels:

- Definition and significance of austenitization.
- Differences between hypo- and hyper-eutectoid steels in terms of austenitization behaviour.
- Effects of austenitization on microstructure and mechanical properties of steels.
- Overview of pearlitic, bainitic, and martensitic transformations.
- Factors influencing the formation of these microstructures during cooling.
- Relationship between cooling rate and microstructure in steels.

Topics 4

Thermo-chemical processing and methods of surface enhancement and steels for thermo-chemical treatment:

- Introduction to thermo-chemical processing techniques.
- Methods for increasing mechanical, physical, and chemical properties of material surfaces.
- Focus on carburising, nitro-cementing, nitriding, carbonitriding, boriding, diffused alitizing, etc.
- Selection criteria for steels suitable for thermo-chemical treatment, influence of alloy composition on heat treatment response, examples of steels commonly used in thermo-chemical surface treatment processes.

Topics 5

Thermophysical PVD and Thermochemical CVD Coatings:

- Explanation of Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) techniques.
- Overview of thermophysical PVD and thermochemical CVD coatings.
- Discussion of thermophysical Physical Vapour Deposition (PVD) and thermochemical Chemical Vapour Deposition (CVD) coatings for surface enhancement.

LEARNING OUTCOMES

These exercises aim to provide hands-on experience that complements the theoretical knowledge gained in lectures on Surface Treatment of Advanced Engineering Materials subject. Students learn the practical aspects such as the construction and interpretation of T-T-T and C-C-T diagrams based on experimental data, acquire the ability to calculate diffusion coefficients and verify Fick's laws, understand the effects of temperature and concentration gradients on diffusion, and apply knowledge to propose a technological procedure for steel treatment. By completing laboratory exercises, students understand the principles and applications of thermo-chemical surface treatment.

COMMENTS

Laboratory exercises conducted in a face-to-face format using presentation tools and commented real problems from engineering practice.

INSTRUCTOR

Assoc. prof. Ing. Juraj Belan, PhD.

DO YOU KNOW

Thermo-chemical treatments can be performed in various atmospheres, including gas-based methods like gas carburizing and plasma-based techniques like plasma nitriding. Plasma processes offer precise control over treatment parameters and can be more environmentally friendly compared to traditional methods. Through thermo-chemical treatments, materials can exhibit improved fatigue resistance due to the creation of a hardened surface layer. This is crucial for components subjected to cyclic loading, such as gears and bearings.

High performance 4340 steel crankshafts during plasma/ion nitriding.

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Introduction to thermo-chemical surface treatment. Safety protocols in a laboratory setting. Familiarization with basic equipment used in thermo-chemical surface treatment.

Topics 2

Application of metastable system Fe – Fe3C: T-T-T and C-C-T diagrams. Microscopic examination of metallurgical samples to identify phases. Construction of T-T-T and C-C-T diagrams based on experimental data. Interpretation of diagrams to predict microstructural transformations.

Topics 3

Diffusion in metals and alloys: Fick's Law – calculation of diffusion coefficients for selected alloy systems. Verification of Fick's first and second laws through diffusion experiments. Analysis of the effects of temperature and concentration gradients on diffusion.

Topics 4

Thermo-chemical processing and methods of surface enhancement - performance of common thermo-chemical surface treatments (carburizing, nitriding, boriding, etc.). Measurement of surface hardness, wear resistance, and other properties. Analysis of treated samples to observe microstructural changes.

Topics 5

Proposal of the thermo-chemical procedure – a semester work (project) with consultations with the teacher. Based on the knowledge gained, propose a technological procedure for the thermo-chemical treatment of steel. For this purpose, calculate tetrahedral and octahedral spaces in crystallographic lattices, diffusion coefficients and diffusion conditions as a function of temperature and time.

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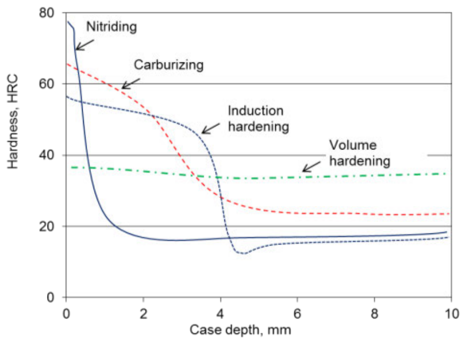

Hardness depth profiles for selected thermal and thermo-chemical treatments, emphasizing differences in the maximum hardness and penetration depth

TEXTBOOK/READINGS

The mandatory reading for completing the subject *Selected chapters from Phase Transformation*:

1. Askeland, Donald, R., et al.: *The Science and Engineering of Materials – 6th – Edition*. Cengage Learning, USA, 2011. ISBN-13: 987-0-495-29602-7.
2. Chandler, H. et al.: *Heat Treater's Guide - Practices and Procedures for Nonferrous Alloys*, ASM International, ISBN 0-87170-565-6, 2006.
3. Mittemeijer, Eric, J., Somers, Marcel, A., J.: *Thermochemical Surface Engineering of Steels*, Woodhead Publishing, Oxford, 2015, ISBN 978-0-85709-592-3.

For a deeper understanding of the course subject matter, optional recommended texts include:

1. Kvaśny, W. *Prediction properties of PVD and CVD coatings based on fractal quantities describing their surface*. 2006. [online].
2. ASM Metals Handbook *Volume 04 - Heat Treating*, ASM International 2002.
3. Dossett, Jon, L., Boyer, Howard, E.: *Practical Heat Treating – Second Edition*, ASM International 2006.

ASSESMENT

Reports: reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of surface treatment of advanced engineering materials. The papers contain the theoretical basis, assignments and instructions for processing experimental results.

Semester paper and laboratory work (during the semester)**:** paper and laboratory work continuously verifying knowledge of issues in the field of increasing the surface mechanical and physical properties (carburizing, nitridation, PVD and CVD layers, etc.).

Exam (after the semester)**:** written and oral exam verifying overall knowledge in the field of related subject.

GRADING POLICY

Points evaluate the subject *Surface Treatment of Advanced Engineering Materials*. The resulting points are the sum of the points that the student gets during the semester (on exercises) and the points that he gets on the exam.

During the exercises, the following are continuously evaluated: theoretical preparation + submitted reports (max. 2b), i.e. 5 reports x 2b = 10 points; 1-semester paper (1 x 30 points = 30 points). The maximum number of points achieved in the exercises is 40.

The final assessment consists of points that the student gets during the semester (on exercises) and points that he gets on the exam. The points obtained in the exercises (max. 40) are added to the points obtained in the exam (max. 60), and thus affect the final assessment of the completed subject. The exam consists of a written (test) and an oral part (answers to individual questions).

Assignment Weights	**Percent**
5 reports	10%
1-semester work	25%
Student portfolio	5%
Final examination	60%
Total	100%

5 reports (max. 2 points each) – max. 10 points
1-semester paper – max. 30 points

Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

93 – 100 points	= A
85 – 92 points	= B
77 – 84 points	= C
69 – 76 points	= D
61 – 68 points	= E
0 – 60 points	= FX

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COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

* In this field, provide information in what didactic form the course is implemented (e.g. lecture, seminar classes, laboratory, field activities, etc.). If the subject is implemented in several didactic forms (consists of e.g. lecture and laboratory, etc.), all forms of the subject implementation should be indicated. In this field, you should also specify the number of hours organized for a given form of classes (separately for lectures, separately for laboratory classes, etc.).

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