MATERIALS SCIENCE MA(S)TERS

developing a new master's degree

IO2

Syllabuses

Part 3

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

UNIVERSITY OF SILESIA IN KATOWICE

UNIVERSITY OF ŽILINA

REFRACTORY MATERIALS

Code: **RM**

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: 28h

Laboratory: 13h

ECTS

3

Ladle slag is transferred to carriers

Image Credit: ABCDstock/Shutterstock.com

COURSE DESCRIPTION

Refractories are the materials that line the furnaces, kilns, and reactors of industries such as steelmaking, ceramics and cement production. Without them, these industries would not be able to operate at the high temperatures needed to produce their products.

The subject deals with the introduction of refractory materials technology, understanding the properties of refractory materials and their applications in technological procedures and processing of metal and non-metal materials, e.g. iron, steel, ferroalloys, non-ferrous metals and alloys, cement and ceramics industry; appropriate selection of refractory materials for a particular production procedure with regard to required durability and stability at elevated or high temperatures; proper selection of refractory material caring the insulation efficiency and energy. The subject also deals with waste generation and secondary sources of raw materials usage at refractory production.

The lectures are intended for obtaining information about individual groups of refractory materials, understanding the Thermal, Mechanical and Chemical properties of the refractory materials, testing of refractory properties, and selection of refractories according to the industrial needs. Laboratory exercises are devoted to practicing the presented issues and specific experiments.

The total time requirement of the subject is 111 hours per semester, of which 41 hours (28 hours + 13 hours of laboratory exercises) are direct teaching and 70 hours are independent study and activity of the student.

COURSE OBJECTIVES

By completing the subject *Refractory Materials*, the student will be able to distinguish the different refractory material groups with their advantages and disadvantages. The student will be able to analyses the required refractory properties according to the industrial needs. The student will be able to make a proper selection of refractory materials for different furnace operations.

PREREQUISITES FOR TAKING THE COURSE

There are no prerequisites before starting the study of the subject of *Refractory Materials*. However, it is better to have basic knowledge of ceramic materials, and material science.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can distinguish the different refractory material groups with their advantages and disadvantages
MS_O_02	Can analyse the required refractory properties according to the industrial needs
MS_O_03	Can choose appropriate refractory materials for different furnace operations

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	**Lectures:** lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	S01, S03, S05
Meth_02	**Laboratory exercises**: experiment demonstrations; laboratory work; observation; problem learning; debate	S01, S03

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	28	Exam	MS_O_01 MS_O_02	Meth_01
FT_02	Laboratory exercise	13	Course work	MS_O_01 MS_O_02	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	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_02	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_03	Laboratory report	Preparation of the laboratory report; Consultation.	YES

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LEARNING OUTCOMES

The student will be able to distinguish the different refractory material groups with their advantages and disadvantages.
The student will be able to analyses the required refractory properties according to the industrial needs.
The student will be able to make proper selection of refractory materials for different furnace operations.

COMMENTS

LECTURER

DO YOU KNOW
.
A refractory material is a unique material system which are exposed the extreme temperatures and thermal shocks, high mechanical loading and chemical attack simultaneously and still working safely. Without them, not able to produce metals, ceramics and chemicals.

Rotary Cement Kiln.

https://sbcco-cement.com/wp-content/uploads/2021/02/Cement_rotary_kiln_01b.jpg

COURSE CONTENT - LECTURE

Topics 1

Introduction to refractory materials

At the beginning of the lecture Refractories will be introduced as an Industrial material which were used in high-temperature industrial processes. During the lecture students will learn basic definitions and terms of refractory materials, an overview of Refractory Industry, significance, and applications in various industries (metallurgy, glass, ceramics, etc.). Historical development and evolution of refractory materials.

Topics 2

Classification of refractories

Student will learn how to classify the refractories according to different classification approach. Types of Refractories according to different classification methods. DIN-EN-ISO. Based on chemical composition (acidic, basic, neutral), Based on method of formation (shaped, unshaped), High-temperature applications and suitability for different industries

Topics 3

Basics of thermal engineering

Refractories are materials produced to withstand extremely high temperatures while maintaining their strength, shape, and resistance to thermal shock and chemical degradation. Understanding their thermal properties is crucial in selecting the right materials for specific high-temperature applications. Students will learn Heat capacity, Thermal Conduction Theories, Theory of Thermal Insulation and basics of refractory wall design and calculations

Topics 4

Refractory manufacturing

Different manufacturing methods are used to produce refractory materials, each suited for different types of refractories and applications. Selection of the appropriate method based on the type of refractory material required, the desired properties, the intended application, and the economics of production. Each method has its advantages and limitations in terms of cost, complexity, precision, and the specific properties of the resulting refractory material. Students will learn various shaping methods (Dry pressing, Extrusion, Slip casting, Fused casting) and Firing (Sintering) Technology which is very important for refractories

LEARNING OUTCOMES

The student will be able to distinguish the different refractory material groups with their advantages and disadvantages.

The student will be able to analyses the required refractory properties according to the industrial needs.

The student will be able to make proper selection of refractory materials for different furnace operations.

COMMENTS

LECTURER

DO YOU KNOW

A refractory material is a unique material system which are exposed the extreme temperatures and thermal shocks, high mechanical loading and chemical attack simultaneously and still working safely. Without them, we are not able to produce metals, ceramics and some chemicals.

Basic Oxygen Converter

https://image.made-in-china.com/2f0j00PoSpQRctqzrF/4-88m-X-16-3m-Rotary-Refining-Furnace-and-Anode-Furnace.webp

Topics 5

Refractory testing.

Testing methods for refractory materials are crucial to ensure their performance and suitability for specific applications. These testing methods help determine the physical, thermal, mechanical, and chemical properties of refractory materials, ensuring their reliability and suitability for various high-temperature applications like furnaces, kilns, reactors, and other industrial settings. Students will learn RUL Test, HMOR Test, Creep Testing, Thermal Conductivity Test, Thermal Shock Test, Corrosion Test

Topics 6

Acidic refractory technology

Acidic refractories are those that exhibit excellent resistance to acidic environments and are used in industries where the materials come into contact with acidic compounds or gases at high temperatures. These materials are designed to withstand the corrosive effects of acids, such as acidic slag, acidic melts (silicate glass etc.) sulfuric acid, phosphoric acid, and other acidic substances. During the lecture student will learn different class of acidic refractories which are mainly based on Alumina-Silicate Refractories and learn their selection and properties with required phase diagram understanding

Topics 7

Basic refractory technology

The term "basic" in basic refractories refers to their ability to withstand basic environments, as opposed to acidic environments. Basic refractories primarily consist of basic compounds like oxides of magnesia (MgO), dolomite (calcium magnesium carbonate - CaO·MgO), chromite (chromium oxide and iron oxide - Cr_2O_3·FeO), and combinations thereof. Students will learn Magnesia and MA-Spinel Refractory Materials, their selection and properties with required phase diagram understanding.

LEARNING OUTCOMES

The student will be able to distinguish the different refractory material groups with their advantages and disadvantages.

The student will be able to analyses the required refractory properties according to the industrial needs.

The student will be able to make proper selection of refractory materials for different furnace operations.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Let's take the example of a car: it is made with steel, copper, glass, aluminum and plastics, among others. These materials are manufactured at very high temperatures. For example, iron is melted in an oven and transformed into steel by processes that reach 2,000 °C. In order that the walls of the furnace are not affected by these temperatures, they have a coating of refractory material. In the same way, these coatings are also used for the manufacture of glass, copper, aluminum and plastics.

Electric Arc Furnace Refractory lining section.

https://www.insertec.biz/wp-content/uploads/2020/01/DELTA.jpg

COURSE CONTENT – LABORATORY CLASSES

Topics 1

Grain Size and Particle Packing

The refractory grain size and particle packaging play crucial roles in determining the properties and performance of refractory materials used in various high-temperature applications like furnaces, kilns, and reactors. During the laboratory, students will have the opportunity to perform the Refractory grain size determination by a sieve analysis (1 hour) and also learn how to apply refractory raw material mixture preparation according to Andreasen Particle Packing theory

Topics 2

Refractory Shaping -Dry Pressing

Refractory materials are crucial for industries that require materials resistant to high temperatures and harsh environments, such as in furnaces, kilns, and reactors. Various manufacturing methods are used to produce refractory materials, each suited for different types of refractories and applications. Dry pressing which is the most used method involves pressing a dry mixture of refractory powders and binders into a mold using a hydraulic press. The resulting shape is then fired at high temperatures to achieve the desired properties. Students will able to apply shaping of the Low and High Alumina refractory samples with pressing technique

Topics 3

Refractory Shaping -Refractory Castable

Some of the refractories are shaped with casting technique. Refractory castables are also known as Monolithic Refractories. Production technique involves suitable binders (Calcium Aluminate Cement, sodium silicate etc), curing and final sintering. The particle size distribution of the aggregates influences the packing density, flowability, and mechanical properties of the castable. Careful control of particle sizes helps in achieving optimal properties. Students will able to apply castable technology of the Low and High Alumina refractory samples with pressing technique

Topics 4

Sintering of Refractories

The sintering process involves heating refractory raw materials at high temperatures but below their melting point to create a cohesive, solid structure. This process helps improve the strength, density, and other properties of the refractory material. Students will apply sintering technique to the previously shaped refractory pressed and cast refractory samples

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LEARNING OUTCOMES

The student will be able to distinguish the different refractory material groups with their advantages and disadvantages.

The student will be able to analyses the required refractory properties according to the industrial needs.

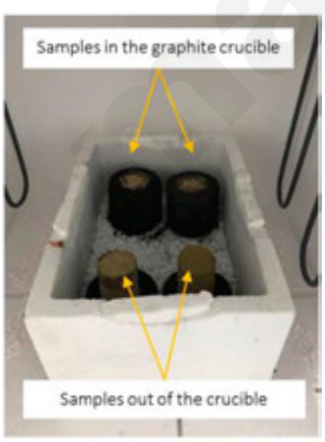
The student will be able to make proper selection of refractory materials for different furnace operations.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Let's take the example of a car: it is made with steel, copper, glass, aluminum and plastics, among others. These materials are manufactured at very high temperatures. For example, iron is melted in an oven and transformed into steel by processes that reach 2,000 °C. In order that the walls of the furnace are not affected by these temperatures, they have a coating of refractory material. In the same way, these coatings are also used for the manufacture of glass, copper, aluminum and plastics.



Crucible Corrosion Test against Steel Ladle Slag

doi.org/10.3390/ma15103425

Topics 5

Corrosion Testing

Corrosion testing of refractories involves evaluating their resistance to chemical attack, erosion, and degradation when exposed to harsh environments such as high temperatures, aggressive chemicals, or abrasive conditions. Several methods are used to assess the corrosion resistance of refractories. The crucible test, also called cup test, is most used corrosion test. Students will learn how to apply Corrosion testing of sintered refractory samples against different materials like, steel slag, cement, alkalis by using crucible method

Topics 6

Microstructure of Refractories

The microstructure of refractories refers to the arrangement, distribution, and composition of the constituent materials at a microscopic level. The microstructure of refractories typically consists of several key components; Refractory grains, pores and voids, binder matrix, secondary phases and additives (like fibers, graphite etc), The microstructure significantly impacts the properties and performance of refractories such as Thermal Properties, Mechanical Properties, Chemical stability. Students will observe the microstructure of the refractories at SEM and able to differentiate the stage grain and binder matrix interactions

Bottom Taping of Steel Ladle with High Tech. Refractory Silde Gates.

https://www.sevenrefractories.com/wp-content/uploads/2020/11/Schermata-2020-11-26-alle-16.47.25.png

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. G. Routschka, Refractory Materials (Basics-Structures-Properties) 2. Edition, Vulkan Verlag, Essen, 2004.ISBN 3-8027-3154-9

Assignment Weights	Percent
Reports	30%
Midterm Exam	20%
Final	30%
Total	100%

ASSESSMENT

Exam: There are two written exams. Midterm and Final.

Reports: Reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of Refractory Materials. The papers contain answers to each topic's theme and experimental results.

GRADING POLICY

During the laboratory exercises, students should submit 6 different laboratory reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 6 reports will be taken as a Report score. The maximum number of points achieved in the laboratory reports is 30. Students can get max 20 points for their presentations.

6 reports (average) – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

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POLYMERS AND LIGHT COMPOSITES

Code: **PLC**

Field of study
Materials Science and Engineering

Level of study
Master Study

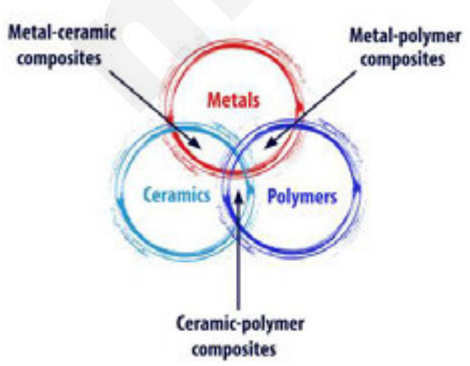
Semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours*:
Lecture: 18h
Laboratory: 18h

ECTS
4



https://www.vectorstock.com/royalty-free-vector/metal-ceramic-polymer-composites-diagram-vector-29056051

COURSE DESCRIPTION

The course will be about polymers, polymer composites, main matrix and reinforcement types used in their production, methods used in production and properties of final products. In addition to the application areas of the produced materials, the properties of polymer blends, production methods, nanocomposite synthesis and characterization and special composites will be mentioned.

Polymers and polymer composites are called the technology of the future thanks to their lightness and yet their properties. In particular, polymer composites are materials where the polymer is bonded by penetrating into the reinforcement bundles and as a result, superior properties are achieved. Polymer composite materials are mainly used in automotive and aerospace applications, and polyester and epoxy resins are the most common. These polymers can be reinforced with glass fiber, carbon fiber or many different nanoparticles and have much different mechanical, electrical, thermal, etc. properties than they have in pure form. Therefore, they have a very important place in today's and future technology.

The course aims to provide students with a full knowledge of the subject so that they have knowledge about polymers and their composites, know their production methods and can comment on how these methods affect the final properties. From time to time, it is aimed to consolidate the theoretical knowledge gained through the applications made in the laboratories. Students are expected to spend 18 hours of classroom teaching and learning, 18 hours of practice and 60 hours of independent study during the course of study.

COURSE OBJECTIVES

The aim of the course is to enable students to have a broad knowledge about polymers and polymer composites and to make an opinion about polymers and composites when they need to choose materials. At the end of the course, students will be able to answer questions such as which polymer composite material should be preferred in which situations, which method should be used to produce this preferred material, and what should be the expected properties of the final material as a result of this production method.

PREREQUISITES FOR TAKING THE COURSE

In order to complete this course, no prerequisite course Is required from the students. It is sufficient to know the materials groups and their basic properties.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain the properties and types of polymers materials. Thus, they know which property to expect from which matrix when designing polymer composite material.
MS_O_02	Can determine the components (matrix and reinforcement) and types of polymer composite materials. Thus, they can choose materials more easily when necessary.
MS_O_03	Can elaborate on the production methods of polymer composite materials and the effects of these methods on the material.
...	

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**: experiment demonstrations; laboratory work; observation; problem learning; debate	MS_O_03
...		....

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	18	Exam	MS_O_01	Meth_01
FT_02	Laboratory exercise	18	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	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
a_02	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_03	Laboratory report	Preparation of the laboratory report; Consultation.	YES

LEARNING OUTCOMES

Students who successfully pass this course gain knowledge, skills and competency in the following subjects;
Structure and production methods of polymeric composites.
Designing of polymeric composites according to applications
Properties, measurements and test methods for polymeric composites
Structure and production methods for polymer blends

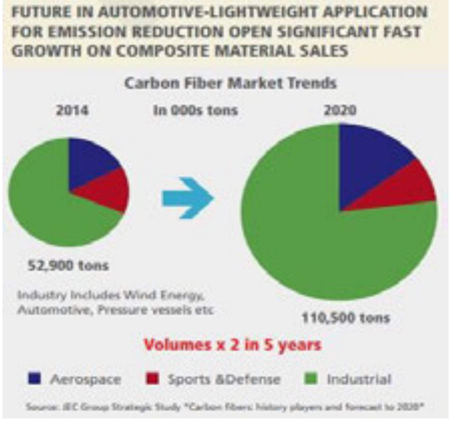
Students can explain the properties and types of polymers materials. Thus, they know which property to expect from which matrix when designing polymer composite material.
Students determine the components (matrix and reinforcement) and types of polymer composite materials. Thus, they can choose materials more easily when necessary.

COMMENTS

LECTURER

DO YOU KNOW

Although the composite dates back to ancient times in a range that has been used since adobe and extends to asphalt and reinforced concrete, it has made a rapid development after the invention of the "Condensation Reaction" in the 1930s. The first composite plastic samples, which were used for military purposes during World War II, were only commercialized all over the world after 1946. So, it is still a new material all over the world.



Expected future autmotive lightweight changes

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

Topics 1

Polymer History

Introduction to polymeric materials with relation to the theoretical basis including chemical bonding and its types: the history of polymeric materials and their use over the years, the history of the development of materials and technologies, chemical structure and properties

Topics 2

Classification and Properties of Polymers

Classification of polymer materials according to their different properties, learning in which areas these classifications are used, understanding the structure-property relationship, learning the mechanical, physical and thermal properties of polymers.

Topics 3

Polymer Composites

Introduction to composites in general and presentation of theoretical basis; introduction to composites made of polymers and their advantages, disadvantages, areas of use, the recognition of the components of polymer composite materials

Topics 4

Classification and Properties of Polymer Composites

Comprehending the classification of polymer composite materials according to their matrix and shape of reinforcing elements, properties of obtained composite materials and investigating the effect of matrix-reinforcement interface on these properties

Topics 5

Processing and Manufacturing Techniques of Polymer Composites.

The presentation of various methods of production of the processing and polymer composites; methods such as hand laying methods and machine assisted manufacturing will be presented; the effects of these manufacturing processes and their effect on composite properties.

Topics 6

Determination of Properties

The introduction to methods and methodologies of determining the mechanical, physical and thermal properties of the polymer based composites and application of these methods on the samples produced during the course of this study and analyze them with well known methods.

LEARNING OUTCOMES

Students who successfully pass this course gain knowledge, skills and competency in the following subjects;
Designing of polymer blends according to applications
Properties, measurements and test method for polymer blends
Recent and advanced applications of polymeric composites

Can elaborate on the production methods of polymer composite materials and the effects of these methods on the material.

COMMENTS

INSTRUCTOR

DO YOU KNOW
Weight is one of the most important design factors in the transportation industry. Especially being able to make airplanes lighter provides an incredible benefit in terms of both fuel and exhaust gases released into the environment. For this reason, manufacturers have started to produce light and durable aircraft by using carbon fiber reinforced polymer composites in new aircraft. If you can reduce the weight of an aircraft engine by 450 kg, you can save 1% on fuel.

Helmets made of polymeric composite materials

Source: Garanti Composite Co., Turkey

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

Topics 1

Introduction of polymer composite components (3 hours)

Introduction to polymeric materials with relation to the theoretical basis including chemical bonding and its types: the history of polymeric materials and their use over the years, the history of the development of materials and technologies, chemical structure and properties

Topics 2

Polymer composite production (6 hours)

In this class, composite materials will be produced with glass fiber fabric and epoxy resins by the hand lay-up method, which is explained theoretically in this laboratory class. During the class, how the production with the hand lay-up method may differ from person to person will be discussed

Topics 3

Polymer composite production: Vacuum bagging (6 hours)

In this laboratory class, composite materials will be produced with glass fiber fabric and epoxy resins hand with vacuum bagging method which is explained theoretically in this laboratory class. During the application, it will be discussed the advantages and disadvantages of the production with the vacuum bagging method

Topics 4

Polymer composite production: Hot Press (6 hours)

Glass fibre/epoxy plates prepared by the students using the hand lay-up method for hot press production will be kept in the press for curing

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TEXTBOOK/READINGS

Please list the mandatory reading for each form of tuition separately.

Polymer Composites: From Nano- To Macro-Scale: Klaus Friedrich, Stoyko Fakirov, Zhong Zhang, Springer,2005.

ASSESMENT

Reports: reports designed for experimental laboratory studies that serve to deepen theoretical knowledge about polymer composites.

Exam (end of semester): written exam confirming general knowledge in the field of polymer composites.

GRADING POLICY

The subject of polymers and lightweight composites is evaluated with points. The resulting scores are the sum of the student's scores during the semester (laboratory studies) and the scores obtained from the exam.

During laboratory classes, the following are evaluated continuously: theoretical preparation (An oral examination at the beginning of the laboratory study for understanding the topic) + prepared reports, ie each oral examination 1 point + 8 reports x 4 points = 32 points. The maximum score obtained from laboratory studies is 40.

The final assessment consists of the student's scores during the semester (from laboratory work) and the scores from the exam. The scores obtained in the lab work (up to 40) are added to the scores in the exam (up to 60), thus affecting the final assessment of the completed subject. The exam consists of a written (test) part.

Assignment Weights	**Percent**
8 reports	25%
oral examination	15%
Exam	60%
Total	100%

8 reports (max. 4 points each) – max. 32 points
oral examination – max. 8 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				

PROCESS, STRUCTURE AND PROPERTY RELATIONS IN NON-METALLIC MATERIALS

CODE: PSPRNM

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: 23 h
Laboratory: 19 h

ECTS
4

Ceramic inserts

COURSE DESCRIPTION

This lecture provides an overview of the process, structure, and property relationship of ceramic materials. Ceramics are widely used in diverse applications, ranging from traditional pottery to advanced technologies such as aerospace, electronics, and biomedicine. The unique properties of ceramics arise from their specific atomic and microstructural arrangements, which in turn are determined by the processing methods employed during their manufacture. In this lecture, we will explore the key aspects of ceramic processing, including powder synthesis, shaping, and sintering. We will also discuss the microstructural features of ceramics, such as grain size, porosity, and crystallographic texture, and how they affect mechanical, thermal, and electrical properties. Special attention will be given to the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions. Finally, we will discuss some recent advances in ceramic research and their potential impact on various fields of engineering and science. By the end of this lecture, students will gain a solid understanding of the fundamental principles that govern the processing, structure, and properties of ceramic materials and their applications in diverse technologies.

The total time requirement of the subject is 107 hours, of which 42 hours are direct teaching and 65 hours are independent study and independent creative activity of the student.

COURSE OBJECTIVES

Developing the ability to relate the structure and properties of non-metallic materials to their microstructure and interpret the information obtained about the microstructure to correlate with the process.

PREREQUISITES FOR TAKING THE COURSE

Before starting the course on processing, structure, and property relationships in non-metallic materials, students are expected to have a general knowledge of ceramic materials.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can elaborate on the structure and properties of ceramic materials and the production process of ceramic materials
MS_O_02	Can explain the relationships between process, structure, and properties i.e. to improve the properties of ceramics by controlling microstructure
MS_O_03	Can interpret the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions
MS_O_04	Can explain and analyse the effects of each stage by following a ceramic production process in practice.

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, MS_O_3
Meth_02	**Laboratory exercises**: experiment demonstrations; laboratory work; observation; problem learning; debate	MS_O_01, 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	23	Exam	MS_O_01, MS_O_02 MS_O_03	Meth_01
FT_02	Laboratory exercise	19	course work	MS_O_01, 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

- Can elaborate on the structure and properties of ceramic materials and the production process of ceramic materials

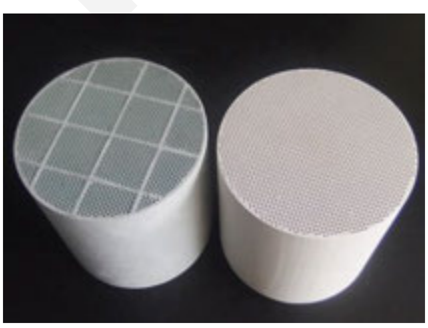
- Can explain the relationships between process, structure, and properties i.e. to improve the properties of ceramics by controlling microstructure.

- Can interpret the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions.

- Can explain and analyse the effects of each stage by following a ceramic production process in practice.

DO YOU KNOW

It is possible to produce a ceramic material that can conduct heat as well as metallic materials but not conduct electricity.



COURSE CONTENT – LECTURE

Topics 1

Introduction to Materials Science and Non metallic Materials

This lecture will introduce the fundamental concepts of materials science and engineering, which include the study of how the properties of materials are determined by their structure, as well as how processing affects the material structure and properties. The lecture will cover the relationships between process, structure, and properties of materials and their importance in the design and development of new materials for various applications.

Topics 2

Structure and properties of ceramics materials

This lecture will cover the structure and properties of ceramics materials. The lecture will introduce the basic concepts of ceramic materials and their atomic and crystal structure. The lecture will discuss the various properties of ceramics, including mechanical, thermal, electrical, and optical properties.

Topics 3

Ceramic production processes

This lecture will focus on the ceramic production processes, including the preparation, shaping, and sintering of ceramic materials. The lecture will cover the different techniques used for the preparation of ceramic powders, such as mixing and milling. The lecture will also discuss the various shaping methods used to form ceramics, such as pressing, extrusion, and injection molding. Finally, the lecture will cover the sintering process, which involves the heating of the ceramic material to a high temperature to densify and strengthen the material.

Topics 4

Advanced ceramics

This lecture will focus on advanced ceramics, which are a group of high-performance ceramics that exhibit superior mechanical, thermal, and electrical properties. The lecture will cover the different types of advanced ceramics, including oxide, non-oxide, and composite ceramics. The lecture will also discuss the applications of advanced ceramics in various fields, such as aerospace, electronics, and energy.

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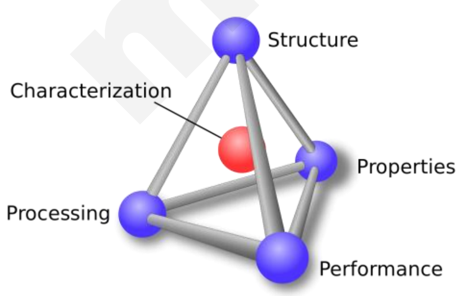
UNIVERSITY OF SILESIA IN KATOWICE
UNIVERSITY OF ŽILINA

LEARNING OUTCOMES

- Can elaborate on the structure and properties of ceramic materials and the production process of ceramic materials
- Can explain the relationships between process, structure, and properties i.e. to improve the properties of ceramics by controlling microstructure.
- Can interpret the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions.
-
- Can explain and analyse the effects of each stage by following a ceramic production process in practice.

DO YOU KNOW
Mostly ceramic materials have higher melting point than metals.



Topics 5

Microstructure and microstructure control of ceramics

This lecture will focus on the microstructure of ceramics and the control of microstructure for improved properties. The lecture will cover the basic concepts of microstructure, including grain size, porosity, and phase composition. The lecture will also discuss the various techniques used for microstructure control, such as doping, sintering additives, and grain growth inhibitors. Additionally, the lecture will cover the characterization techniques used to study microstructure, such as scanning electron microscopy and X-ray diffraction.

Topics 6

Mechanical properties of ceramics

This lecture will focus on the mechanical properties of ceramics, including the principles of elasticity and fracture. The lecture will also discuss the factors that affect the mechanical properties of ceramics, such as microstructure, defects, and processing conditions. Additionally, the lecture will cover the various testing techniques used to evaluate the mechanical properties of ceramics, such as bending and compression tests.

Topics 7

The relationship between structure, properties, process, and microstructure

This lecture will focus on establishing the relationship between structure, properties, process, and microstructure in ceramic materials. The lecture will cover the basic concepts of structure-property relationships in ceramics, including how processing conditions and microstructure affect material properties. The lecture will also discuss the different characterization techniques used to study structure and microstructure in ceramics, including microscopy, X-ray diffraction, and spectroscopy. Additionally, the lecture will cover the various processing techniques used to control microstructure and properties in ceramics, such as doping, sintering, and heat treatment.

LEARNING OUTCOMES

- Can elaborate on the structure and properties of ceramic materials and the production process of ceramic materials
- Can explain the relationships between process, structure, and properties i.e. to improve the properties of ceramics by controlling microstructure.
-
- Can interpret the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions.
- Can explain and analyse the effects of each stage by following a ceramic production process in practice.

COMMENTS

LECTURER

DO YOU KNOW

It is possible to produce transparent ceramics with a crystal structure.

Three thin disk specimens of aluminum oxide, (Specimen preparation, P. A. Lessing; photography by S. Tanner.)

COURSE CONTENT – LABORATORY EXERCISES

Topics 1

Preparation of ceramic powders

This laboratory class will focus on the determination of composition of ceramic powders using phase diagrams of the selected material. Additionally, the laboratory class will cover the characterization techniques used to evaluate the properties of ceramic powders, such as particle size analysis using sieves.

Topics 2

Mixing, milling and drying

This laboratory class will focus on the mixing and milling of ceramic powders, including the different methods and techniques used to prepare homogeneous ceramic powder mixtures with controlled composition and particle size distribution. The laboratory class will cover the basic principles of ceramic powder mixing and milling, including the effects of processing parameters on mixing and milling efficiency. The laboratory class will also discuss the various characterization techniques used to evaluate the properties of ceramic powder mixtures, such as particle size analysis.

Topics 3

Powder Pressing

This laboratory class will focus on the powder pressing of ceramic powders, including the different methods and techniques used to prepare green compacts with controlled shape and density. The laboratory class will cover the basic principles of powder pressing, including the effects of processing parameters on compactability and green density.

Topics 4

Sintering

This laboratory class will focus on the sintering of ceramic powders, including the different methods and techniques used to convert green compacts into dense, solid ceramic materials with controlled microstructure and properties. The laboratory class will cover the basic principles of sintering, including the effects of processing parameters on densification and microstructural development.

Co-funded by the European Union

LEARNING OUTCOMES

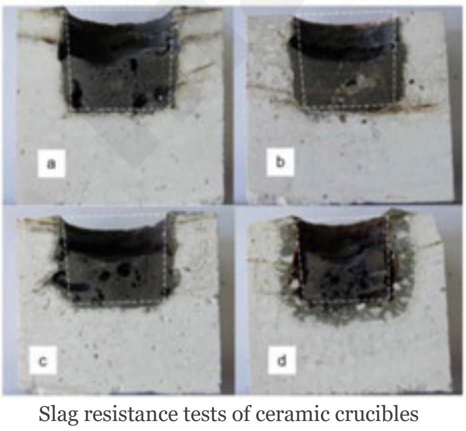
- Can elaborate on the structure and properties of ceramic materials and the production process of ceramic materials
- Can explain the relationships between process, structure, and properties i.e. to improve the properties of ceramics by controlling microstructure.
- Can interpret the role of defects, such as cracks and interfaces, and their influence on the behavior of ceramics under different loading conditions.
-
- Can explain and analyse the effects of each stage by following a ceramic production process in practice.

COMMENTS

LECTURER

DO YOU KNOW

Carbon nanotubes are very strong, with a tensile strength of up to 130 gigapascals, which is about 1000 times stronger than steel.



Slag resistance tests of ceramic crucibles

https://doi.org/10.3390/ceramics3010004

Topics 5

Mechanical testing of ceramics

This laboratory class will focus on the mechanical testing of sintered ceramics, including the different methods and techniques used to evaluate the mechanical properties of ceramics, such as strength, fracture toughness, and hardness. The laboratory class will cover the basic principles of mechanical testing, including the effects of microstructure and processing conditions on mechanical properties. The laboratory class will also discuss the various characterization techniques used to evaluate the mechanical properties of ceramics, such as compression testing, flexural testing, and indentation testing.

Topics 6

Microstructure investigation

This laboratory class will focus on the microstructure investigation of sintered ceramics, including the different techniques and equipment used to analyze the microstructure of ceramics, such as scanning electron microscopy (SEM) and X-ray diffraction (XRD). The laboratory class will cover the basic principles of microstructure investigation, including the effects of processing conditions on the microstructure of ceramics. The laboratory class will also discuss the various characterization techniques used to evaluate the microstructure of ceramics, such as grain size analysis and porosity measurement.

Alumina casting crucibles made of 98% purirty Alumina ceramic powder

https://gsac.com.bd/product/alumina-crucibles-25ml-100ml-up-to-1400c-india/

TEXTBOOK/READINGS

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

1. Reed, J. S. (1995). Principles of ceramics processing.
2. Rahaman, M. N. (2003). Ceramic processing and sintering. New York: M. Dekker, 567, 573.
3. Boch, P., & Ni, J. C. (Eds.). (2010). Ceramic materials: Processes, properties, and applications (Vol. 98). John Wiley & Sons.
4. Callister Jr, W. D. (2018). Materials science and engineering an introduction. 10th edition. Hoboken, NJ : Wiley.

ASSESMENT

Quiz: At the beginning of each laboratory course, a quiz will be held to test the students' knowledge of the subject and to see whether they have studied the subject or not, and to ensure that they are already familiar with the subject and that the students are ready to participate in laboratory courses.

Reports: Students are expected to prepare reports based on the data obtained during laboratory experiments.

Exam: Written exam verifying overall knowledge.

GRADING POLICY

The subject Process, Structure and Property Relations in 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.

The final evaluation consists of the scores the student received during the semester (from laboratory applications), quizzes and exam scores. The final grade is determined by adding the scores obtained from the quizzes before the laboratory applications (maximum 10), the scores obtained from the reports written as a result of the laboratory applications (maximum 50), and the score obtained in the final exam (maximum 40). The final exam is based on written knowledge and interpretation.

Assignment Weights	**Percent**
7 Reports	50%
7 Quizes	10%
Examination	40%
Total	100%

Total points – max. 100 points

Grading Scale

96 - 100 points = A
91 - 95 points = B+
86 - 90 points = B
80 - 85 points = C+
71 - 80 points = C
66 - 70 points = D+
61 - 65 points = D
0 - 60 points = F

COURSE SCHEDULE

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Co-funded by the European Union

CASTING AND CASTING TECHNOLOGY IN INDUSTRY

Code: **CCTI**

Field of study
Materials Science and Engineering

Level of study
Master Study

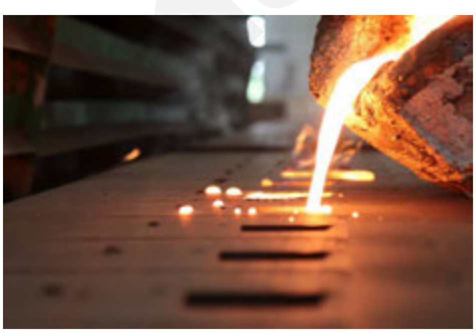
Year of study/semester
2

Language
English

Thematic block
Materials & Manufacturing

Form of tuition and number of hours*:
Lecture: 28h
Laboratory: 14h

ECTS
6



COURSE DESCRIPTION

The casting method is one the oldest shaping method for the industry. However, the required material performances from the industry (especially machine and automotive) are increasing every day, and defect-free cast materials, correct selection and application of casting methods are becoming crucial.

The subject deals with the introduction of casting technology, basic definitions, different melting and casting methods, core and sand mold-making technology, casting defects, and the selection of casting techniques for specific industrial needs. The course also deals with cast iron technology. Therefore, the subject has a close link to the Metallography and mechanical properties of materials.

The lectures are intended for obtaining information about individual groups of casting technology and cast iron materials, proper melting and casting method selection according to the required production capacity, and casting defect examination. Laboratory exercises are devoted to practicing the presented issues and specific experiments.

The total time requirement of the subject is 112 hours per semester, of which 42 hours (28hours of lectures + 14 hours of laboratory exercises) are direct teaching and 70 hours are independent study and activity of the student.

COURSE OBJECTIVES

By completing the subject *Casting and Casting Technology in Industry*, the student will be able to distinguish between individual types of melting and casting techniques; describe and compare the characteristic properties of individual types of cast iron, molding, and core-making methods. Analyze and solve the casting defects. Students will gain an understanding of the selection of proper casting methods for industrial requirements.

PREREQUISITES FOR TAKING THE COURSE

There are no prerequisites before starting the study of the subject of *Casting and Casting Technology in Industry*. However, it is better to have basic knowledge of metallic materials microstructures, and mechanical properties.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can distinguish the different casting techniques with their advantages and disadvantages
MS_O_02	Can distinguish the cast irons and select cast materials according to the industrial needs
MS_O_03	Can analyze the casting defects and proposes proper solutions to correct the casting process

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	**Lectures**: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01, MS_O_02, MS_O_03
Meth_02	**Laboratory exercises**: experiment demonstrations; laboratory work; observation; problem learning; debate	MS_O_02, MS_O_03

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	28	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Laboratory	14	course work	MS_O_01 MS_O_02 MS_O_03	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

- Can distinguish the different casting techniques with their advantages and disadvantages
- Can distinguish the cast irons and select cast materials according to the industrial needs
- Can analyze the casting defects and proposes proper solutions to correct the casting process

COMMENTS

LECTURER

DO YOU KNOW

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A foundry is a factory where metal is melted and cast into new shapes. Foundries are responsible for our current standard of living and industrial development, but most of us know next to nothing about them.

Sand mold and cores.

COURSE CONTENT - LECTURE

Topics 1

Introduction to the casting and casting technology

Introduction to the casting processes available in industry and casting technology presently used in the Industry. This section will also include the basic definitions and terms of casting process tools and apparatus etc..., the importance and the overview of casting methods as a manufacturing method.

Topics 2

Casting Techniques

Various casting methods will be explained in detail with real examples from industry; these will include gravity casting, pressure casting methods, sand casting, die casting, centrifugal casting, investment casting, and Thixocasting (Semi-solid casting methods). The methodology of these casting processes will also be shown in practice.

Topics 3

Basics of Solidification

The introduction to the solidification processes in casting and the shrinkage concept in casting processes. Solidification process with the difference in fast and standard casting conditions in addition to casting solidification in various casting methods as in centrifugal and pressure casting; basics of feeder and runner calculations will also be shown to students.

Topics 4

Sand Molding and Core Making

Introduction to the basics of foundry sands that are used in casting of hot molten metals; sand types that are used in gravity casting and selection criteria for different metals and processes. Mold making in foundries and properties of sand molds; sand molding additives (clay, coal, dextrin. etc.).

Topics 5

Cast Iron

The classification and types of the cast iron; these are gray cast iron, nodular cast iron, compacted graphite cast iron, white cast iron. The formation and mechanisms of intra-grain formations in cast iron will be explained in detail in addition to their microstructures and mechanical properties.

Topics 6

Melting and Casting

Principles and properties of induction furnaces used for melting metallic materials with inductive and non inductive properties; principles of charge preparation for cast iron and steel castings; thermal analysis of the melts; Inoculation concept (eutectic cell concept) in cast iron production and spheroidization method for nodular cast iron production.

LEARNING OUTCOMES

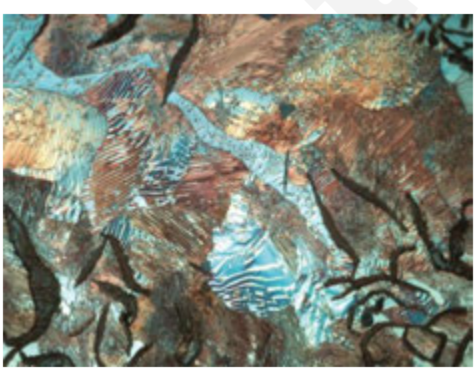
- Can distinguish the different casting techniques with their advantages and disadvantages
- Can distinguish the cast irons and select cast materials according to the industrial needs
- Can analyze the casting defects and proposes proper solutions to correct the casting process

COMMENTS

INSTRUCTOR

DO YOU KNOW

Foundries are one of the largest contributors to the manufacturing recycling movement, melting and recasting millions of tons of scrap metal every year to create new durable goods. Moreover, many foundries use sand in their molding process.



Lamellar graphite cast iron microstructure.

(https://www.leica-microsystems.com/)

Topics 7

Casting Defect

Classification and interpretation of the casting defects with respect to the casting processes; types of casting defects with respect to types of cast iron and steel castings; major sources of casting defects observed in gravity casting and centrifugal casting process; strategies for the remediation of defects in foundries and castings.

COURSE CONTENT – LABORATORY STUDIES

Topics 8

Foundry Sand and Sand Mold Preparation

Foundry sand classifications in industry and how they are used with respect to AFS number determination by a sieve analysis; sand mold preparation process with known dimensions using new grains of sand and used grains of sand with appropriate resin to observe the difference in surface quality and rigidity.

Topics 9

Melting and Casting

Operation of high-frequency induction furnace and melt preparation for the Al-12Si alloy casting, gravity sand mold casting demonstration

Topics 10

Core making

The process for the production of interior part of the casting to make holes and cooling parts i.e. core inner parts making processes using casting sands with CO_2 method (cold method for sand moulding); core making experimental with Novalac resin will also be shown with curing at high temperature (hot method).

Topics 11

Solidification

The cooling curve for pure metals and alloys and theoretical principles will be shown on the experimental material; the observation of shrinkage concept in casting and fast cooling conditions; solidification macrostructure observation at different cast sections.

Topics 12

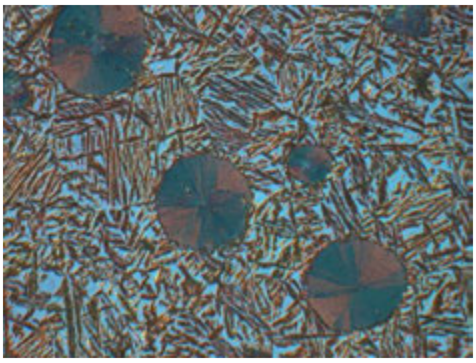
Metallography of Cast Iron

Slicing and mounting processes of cast iron and steel casting specimen obtained from MOTUS company will be used for this part; metallographic sample preparation on obtained specimen and analysis of their properties including mechanical properties of different cast iron and steel casting types.

Topics 13

Casting Defects

Various casting defects from different parts of the castings such as bottom, middle and top parts of the casting blooms and rolls and a general theory of defect formation in castings will be introduced to the students on parts obtained from industry; observations on casting defects will be made by students.



Austempered Nodular Cast Iron Microstructure (https://www.struers.com/)

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. John Campbell. Complete Casting Handbook Metal Casting Processes, Metallurgy, Techniques. Butterworth-Heinemann is an imprint of Elsevier ISBN–13: 978-1-85617-809-9

ASSESSMENT

Exam: There are two written exams. Midterm and Final.

Presentation: Students should present one term project on one of the casting topics.

Reports: Reports intended for experimental laboratory exercises, which serve to deepen theoretical knowledge in the field of Casting and Casting Technology in Industry. The papers contain answers to each topic's theme and experimental results.

GRADING POLICY

During the laboratory exercises, students should submit 6 different laboratory reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 6 reports will be taken as a Report score. The maximum number of points achieved in the laboratory reports is 30.. Students can get max 20 points for their presentations.

Assignment Weights	Percent
Reports	30%
Presentation	20%
Midterm Exam	20%
Final	30%
Total	100%

6 reports (average) – max. 30 points
1 presentation- max 20 points
1 Midterm Exam- max 20 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

COURSE SCHEDULE?

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Co-funded by the European Union

TESTING STANDARDS AND QUALITY ASSURANCE

Code: **TSQA**

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

Research & Development in Material Science and Engineering

Form of tuition and number of hours*:

Lecture: 39 h

ECTS

4

ISO is an international organization that arranges the standards in the world for most of the subjects of engineering

COURSE DESCRIPTION

What is Testing Standards? The purpose of Testing Standards is to promote good testing practices and to provide a common basis for evaluating the quality of these practices. In other words, it is the process of establishing and applying certain rules with the help and cooperation of all interested parties in order to obtain economic benefits in relation to any activity. This is also called standardization for short. What is Quality? Although it is extremely difficult to define quality, it can simply be stated as: "Fit for use or purpose." It's all about meeting people's needs and expectations regarding the functionality, design, reliability, durability and price of any product. What is Assurance? Assurance can be defined as a positive statement about a reliable product or service. It is the certainty that any product will work or serve well. In fact, it is to guarantee that the product will work smoothly in line with expectations or requirements. What is Quality Assurance? Quality assurance (QA) is the systematic process applied to determine whether a product or service meets the expected requirements. QA first identifies and maintains the requirements necessary to develop or produce reliable products. A quality assurance system aims to improve processes and efficiency, while increasing customer trust and a company's credibility, resulting in better competition. The concept of quality assurance as a formal practice began in the manufacturing industry and has since spread to most industries, including software development. This course aims to introduce ASTM standards to students and help them get the most realistic and standardized results when testing metallic and polymer materials in their business life.

COURSE OBJECTIVES

The aim of this course is to introduce ASTM standards to students and to help them get the most realistic and standardized results while testing metallic and polymer materials in their business life. Because the basic policy of businesses is to produce goods and services according to customer demands and expectations. The quality that can be obtained with 100% inspection in production enterprises; It is an undeniable fact that it will significantly affect competitiveness. Therefore, students' knowledge of test standards and quality control will put them ahead.

PREREQUISITES FOR TAKING THE COURSE

Students are not required to take any prerequisite courses to complete this course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can be acquainted with concepts such as quality control and standardization. By meeting ASTM standards, they will be familiar with the type of test that should be used with respect to circumstances and required outcome. So they will also be content with the source to refer to when they need to do any relevant test.
MS_O_02	Can comprehend how important testing and quality control are to produce a desired material. They learn how to set up the right test setup will make them stand out in today's competitive conditions.
MS_O_03	Can explain standardization and test methods of polymer and metallic materials and the effects of these methods on their properties. They will also be confident with the interpretation of results.
...	
...	

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	S01, S03, S05

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	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
...					

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 materials and review of activities necessary to participate in classes.	NO
a_02	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
a_03	Preparation for in class exercise study	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students will be acquainted with quality control and standardization. By meeting ASTM standards, they will be familiar with the type of test that should be used with respect to circumstances and required outcome. So they will also be content with the source to refer to when they need to do any relevant test.

Students will be able to comprehend how important testing and quality control are to produce a desired material. They learn how to set up the right test setup will make them stand out in today's competitive conditions.

Students will be familiar test standardization and test methods of polymer and metallic materials and the effects of these methods on their properties. They will also be confident with the interpretation of results.

COMMENTS

LECTURER

DO YOU KNOW

ASTM International is a global leader in the development of voluntary consensus standards used by individuals, companies, and other institutions around the world. ASTM consists of more than 30,000 volunteer members from more than 140 countries.

The organization meets the criteria of international standards developing organizations set by the World Trade Organization and is governed by a board of directors elected by all membership.

American Society for Testing and Materials

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

Topics 1

Definition of Quality Assurance and Standardization

Definition of quality and quality assurance in industry and its importance for the company and products; why standardisation is important for the company and its benefits to the company for the challenges in global economy; the product approval procedures and the role of testing standards during the manufacturing.

Topics 2

ASTM E8/E8M-21 Standard Test Methods for Tension Testing of Metallic Materials

Tensile testing procedures for the metallic and non metallic materials such as cast irons, soft materials i.e. aluminum and titanium alloys the standards for non specific materials, non specific standards for tensile test and the theory of testing; how to do analysis and what outcomes are expected from tensile tests.

Topics 3

ASTM D3039/D3039M-08 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials

Tensile testing procedures for the non metallic materials such as polymer matrix fiber reinforced composites and fiber reinforced third phase containing composites; the standards for non specific polymer metarix composites, non specific standards for tensile test and the theory of testing; how to do analysis and what outcomes are expected from tensile tests.

Topics 4

ASTM E9-19 Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature

Corrosion testing procedures with specimen preparation and possible outcomes regarding the types of test and respective material; theoretical approach to corrosion test equipments and interpretation of curves from tests; voltage and current relationship and tafel curves etc...; standard testing procedure for corrosions test; salt corrosion tests and testing on welds and joints.

Topics 5

ASTM D695-15 Standard Test Method for Compressive Properties of Rigid Metallic and Plastics

Compression test standards and theoretical background; compression test procedures for non specific and specific materials and preparation of test specimens; graphical analysis of compression test results and their interpretation; typical analysis of a compression test results.

MATERIALS SCIENCE MASTERS

Co-funded by the European Union

LEARNING OUTCOMES

Students will be acquainted with concepts such as quality control and standardization. By meeting ASTM standards, they will be familiar with the type of test that should be used with respect to circumstances and required outcome. So they will also be content with the source to refer to when they need to do any relevant test.

Students will be able to comprehend how important testing and quality control are to produce a desired material. They learn how to set up the right test setup will make them stand out in today's competitive conditions.

Students will be familiar test standardization and test methods of polymer and metallic materials and the effects of these methods on their properties. They will also be confident with the interpretation of results.

COMMENTS

LECTURER

DO YOU KNOW

There are more than 34 internationally well known companies producing tensile test machines with different capacity of loads and purposes.

The most important parts of the tensile testing machines are the load sensors and driving mechanisms for the specimen loading. There is always internal displacement sensors based on the number of turn of screws but not sensitive enough and hence external sensors- extensometers are used widely.

www. ZwickRoell.com

Topics 6:

ASTM E290-14 - Standard Test Methods for Bend Testing of Material for Ductility

Theory of bending tests and procedures; stress interpretation of bending test and types of bending tests such as three point and four point bending tests; special testing procedures for non specific and standard materials; graphical analysis of bending test results and their graphical interpretation.

Topics 7

ASTM D790-17 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

Theory of flexural bending tests and procedures for unreinforced and reinforced plastics and electrical insulating materials; interpretation of flexural bending test for plastics and plastic based materials including insulation materials; graphical analysis of typical bending test results and their interpretation.

Topics 8

ASTM E23-18 Standard Test Methods for Notched Bar Impact Testing of Metallic Materials

Theory of (Charpy) notched bar impact tests and relevant procedures for metallic materials; the composition dependent experimental outcomes and temperature effect of the environment; the analysis of impact test results and interpretation of results based on stress and microstructural point of view.

Topics 9

ASTM D6110-18 Standard Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics

Charpy impact testing for determining the impact resistance of notched plastic materials and plastic matrix composites; the preparation of specimens for the impact testing; the interpretation of impact testing results and their graphical analysis based on the stress and analysis of broken surfaces and their interpretation.

Topics 10

ASTM D3846-08 Standard Test Method for In-Plane Shear Strength of Reinforced Plastics

The theory of in-plane-shear testing and types of shearing in materials; in plane shear testing of metallic and plastic materials and standard procedures for shear testing and testing apparatus design for different material types; interpretation of test results; analysis of broken surfaces.

Topics 11

ASTM E10 – Standard Test Method for Determining Brinell Hardness of Metallic Materials

The theory of hardness tests, definition of standard and the strength-wear resistance versus hardness relationships; Brinell hardness test principles and application on different materials; the types of materials that Brinell hardness tests are applied; interpretation of Brinell hardness test results; the difference between Brinell and other hardness tests.

LEARNING OUTCOMES

Students will be acquainted with concepts such as quality control and standardization. By meeting ASTM standards, they will be familiar with the type of test that should be used with respect to circumstances and required outcome. So they will also be content with the source to refer to when they need to do any relevant test.

Students will be able to comprehend how important testing and quality control are to produce a desired material. They learn how to set up the right test setup will make them stand out in today's competitive conditions.

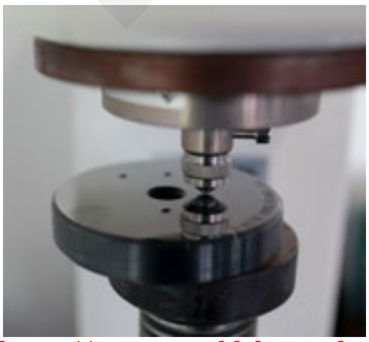
Students will be familiar test standardization and test methods of polymer and metallic materials and the effects of these methods on their properties. They will also be confident with the interpretation of results.

COMMENTS

INSTRUCTOR

DO YOU KNOW

A hardness test is typically performed by pressing a specifically dimensioned and loaded object (indenter) into the surface of the material you are testing. The hardness is determined by measuring the depth of indenter penetration or by measuring the size of the impression left by an indenter. But there are other types of hardness testers which do not leave any impression on the specimen but uses the elasticity of materials or the bouncing height such as bearing ball dropping and vibration effect.



https://www.rotechlabs.co.uk

Topics 12

ASTM E18 – Standard Test Method for Determining Rockwell Hardness of Metallic Materials

Rockwell hardness tests and definition of standard procedure; the scale comparison table between hardness results for steel and metallic materials; analysis of results based on different type of materials and differently treated steels; industrial applications and the use of Rockwell tests.

Topics 13

ASTM E92-17 Standard Test Methods For Vickers Hardness And Knoop Hardness Of Metallic Materials And ASTM D2240-15 Standard Test Method For Rubber

Knoop and Vickers hardness tests and scales for industrial and specific applications; theory behind the Knoop and Vickers tests and their standards; plastic/rubber materials and metallic materials hardness comparison and test procedures; microhardness or micro Vickers and micro Knoop tests on metallic and rubber/plastic based materials.

TEXTBOOK/READINGS

- Volume 3.01-3.07, Section 3: Metals Test Methods and Analytical Procedures, American Society For Testing And Materials (ASTM) Standards
- Handbook of Test Development, Ed: By Suzanne Lane, Mark R. Raymond, Thomas M. Haladyna, 2nd Edition, Taylor and Francis Group, 2016

ASSESMENT

Midterm exam: There are two written exams: midterm and final exams. Midterm exam will contribute 50% of the otal sum of marks as is final exam. Written exam confirming general knowledge in the field of standards.

Exam (end of semester): Written exam confirming general knowledge in the field of standards.

Assignment Weights	Percent
Midterm exam:	50%
Examination	50%
Total	100%

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 final assessment consists of the student's scores on written exams throughout the semester. 50% of the midterm grade and 50% of the final grade constitute the final assessment.

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.).

Co-funded by the European Union

NUMERICAL AND APPLIED METHODS IN MATERIALS CHARACTERIZATION

Code: **NAMMC**

Field of study

Materials Science and Engineering

Level of study

Master's Study

Semester

1

Language

English

Thematic block

Advanced Methods for Materials Characterisation

Form of tuition and number of hours:

Lecture: 41 h

ECTS

4

Working distance in high magnification is reduced dramatically

COURSE DESCRIPTION

The characterization of materials is the initial step for understanding of their behavior and capacity for the best application of use. For this, the first set of lectures will introduce the fundamental issues of image formation and its inherent attributes and proceed towards details about specific imaging techniques e.g. light/optical microscopy and electron microscopy. The course will also cover the basics of diffraction phenomena and related techniques using X-ray sources. It is frequently necessary to obtain quantitative measurements of microstructural features to compare experimental observations with theoretical predictions. These may relate to the kinetics of processes such as grain growth, phase transformations or particle coarsening, or to the development of mechanical properties such as strength and toughness. Quantitative metallography is concerned with the measurement of microstructural features such as grain size, and the size and spatial distribution of second phase particles from observations made on sections by optical or scanning electron microscopy, and on replicas or thin foils by transmission electron microscopy. In all cases only a small sample section or thin slice of material is observed in order to derive the microstructural characteristics in the bulk material. The lecture is intended to increase the awareness of students to relate the microstructural properties of materials with bulk and surface properties. The experimental section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 41 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different techniques available for structural characterization of various materials systems. By the end of the course, students will be able to differentiate between techniques by which materials are tested for the purpose of specific analysis. Students will gain an understanding of the background of the techniques that are commonly used for the characterization of surface, bulk properties and their quantitative relationships with microstructures.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can show how to prepare specimens and carry out image analysis on images from microscopes and analyze the images using their extensive experience in defining microstructural contents and prepare a report for analyzed images and their contents.
MS_O_02	Can define various qualitative and quantitative measurements on conventional materials and on microstructural constituents; students can use both an industrial processing software and ImageJ for the purpose of analyzing and reporting.
MS_O_03	Can describe the methods by which advanced calculations such as activation energy, diffusivity, and elemental distribution modes are calculated using layering, morphology and EDX measurements.
MS_O_04	Can perform statistical calculations and analysis of numerical data obtained from microstructures and images.

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, MS_O_03
Meth_02	**Team project**: critical analysis, synthesis and conclusions; individual and team work, communicate on specialist topics	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	Lecture	39	Exam	MS_O_01, MS_O_02 MS_O_03	Meth_01
FT_02	Essay reporting	2	Course work	MS_O_01, MS_O_02 MS_O_03	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	Query of materials and review of activities necessary to participate in classes. Preparation and development of reports.	NO
A_02	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
A_03	Preparation of report	Preparation of the subject report, Consultation.	YES

LEARNING OUTCOMES

Students are expected to learn how to prepare specimens and carry out image analysis on images from microscopes and gain extensive experience in defining microstructural contents and prepare a report for analyzed images and their contents; various qualitative and quantitative measurements and on microstructural constituents; use both an industrial processing software and ImageJ for the purpose. Students are expected to gain: their knowledge on methods by which advanced calculations such as activation energy, diffusivity, elemental distribution modes are calculated using layer thickness, morphology and EDX measurements; statistical calculations and analysis of numerical data obtained from microstructures and images.

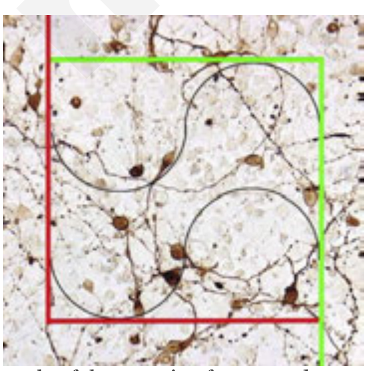
COMMENTS

LECTURER

Prof. Dr. Şükrü TALAŞ

DO YOU KNOW

Statistics, statistical geometry and topology have all played important role in quantitative stereology. By means of suitable two-dimensional measurements on the plane(s) of polish, statistically exact information can be obtained about the micro-structural features in the three-dimensional space occupied by the alloy.



Example of the counting frame used to count both neurites and neurons in cover-slip mounted cultures

COURSE CONTENT (e.g. lecture)

Topic 1

Introduction to Quantitative Analysis in Metallography

Systematic errors in general and principles of calculations of errors in statistical point of view; specimen preparation; depth of etching in chemical and electro-etching conditions; images and microstructural constituents; sampling principles from images and bulk; measurement errors and statistical theories .

Topic 2

Planes and Planar surfaces

Optical microscopy operational principles and types of image filters that are used in optical microscopes; the use of image corrections methods in lenses and microscope columns; planar surfaces and measurements of objects on surfaces; distance and shape measurements on optical microscopes.

Topic 3

Image preparation and its processing principles

An introduction on Image standards available in digital formats and their explanation and differences in format; equipments and operational principles of image processing software; the theory behind image processing and contrast mechanisms in images and other features that are available in place.

Topic 4

Experimental planning

Specimen slicing orientation effect on test results and preparation of specimens for analysis; point and one/two dimensional object counting on optical images; areal analysis and lineal analysis; linear intercept and grain area concepts and measurements; ASTM grain size; particle size measurements and methods.

Topic 5

Volume fraction from planar surfaces

Principles for point counting and related alternative methods to determine volume fraction in quantitative metallography: using graticule and mesh system ; using micrographs for point counting; lineal point counting analysis and quantitative methods; using micrographs for quantitative analysis.

Topic 6

Linear Intercept Size from Planar Surfaces

Definition and application of linear intercept measurement for grain size in metallic and ceramic materials; overall linear intercept principles alternatives and concepts that can be applied to other systems; directional and irregular linear intercept measurements; grain size aspect ratio concept and its effect; surface area per unit volume calculations.

Topic 7

Colony size and grain size from treated planar surfaces

Grain size and its importance in materials properties and types of grain size calculations; standards definition of grain size measurements in American Standards for Testing of Materials (ASTM) and grain size measurements; Grain size concept in single phase, in duplex structures and multiphase systems.

Topic 8

Size distribution of second phase particles and property relations

Definition of particles and recognizing the types and shapes of particles in metallic and ceramic systems; the principles of formation and distribution of second phase particles in metallic systems; the relation to solidification and solid

LEARNING OUTCOMES

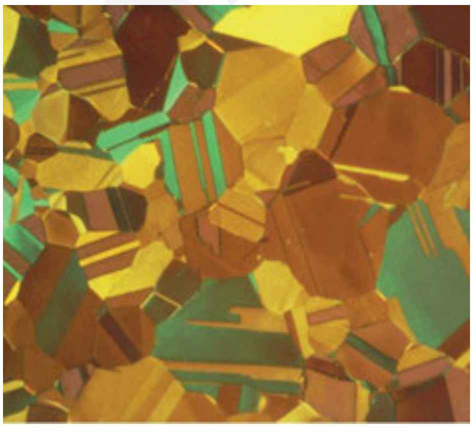
Students are expected to learn; how to prepare specimens and carry out image analysis on images from microscopes and gain extensive experience in defining microstructural contents and prepare a report for analyzed images and their contents; various qualitative and quantitative measurements and on microstructural constituents; use both an industrial processing software and ImageJ for the purpose. Students are expected to gain: their knowledge on methods by which advanced calculations such as activation energy, diffusivity, elemental distribution modes are calculated using layer thickness, morphology and EDX measurements; statistical calculations and analysis of numerical data obtained from microstructures and images.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Microstructural measurements are made on a two-dimensional plane-of-polish through a three-dimensional opaque metal. Stereology converts these 2-D measurements into 3-D estimates of microstructural parameters.



Twinning formations in alpha brass copper alloy

state reactions; measurement methods of size distribution in general; analysis of planar sections; analysis extraction replicas; analysis thin foils.

Topic 9

Interparticle spacing: size of particles

Spacing between objects and its relation to the volume fraction and other quantitative metallography quantities; inter-particle spacing importance in metallographic measurements and its effect on mechanical properties: spacing along a line; spacing in a plane; spacing in the volume.

Topic 10

Dislocation structures determination

Definition of dislocations in metallic materials; dislocation density concepts and its effect on mechanical and hardness properties; calculation of dislocation density; orientation and misorientation concepts in grains and atomic planes; definition of subgrain and determination of subgrain sizes with related microstructures.

Topic 11

Industrial applications: image processing for quality control

Principles of image processing of images obtained from technical instruments and general applications in software environment and the use of software (types) in industry; the industrial needs and requirements when using image processing software and standards for the production; steels and its microstructures and grain size determination examples.

Topic 12

Thermal analysis principles and analysis calculations

The principles and types of standard thermal analysis processes; the principles of thermal analysis calculations regarding the data analysis results and standard routes for scientific analysis for thermal processes; description of DSC and DTA methods and examples of DTA and DSC measurements; TG and DTG method description and examples.

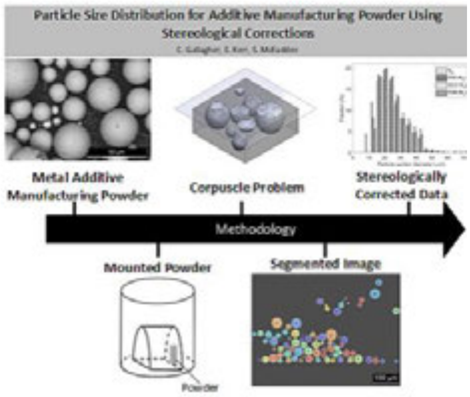
Topic 13

X-Ray diffractions and calculations of analysis results

Specimen preparation routines for X-Ray measurements and technical details regarding the use of equipments; the calculations of d spacings and lattice parameters based on real measurements and their interpretations; the relationship between microstructures and X-Ray analysis results; strain measurements of surfaces with the effect of microstructures and particles in various conventional and structural materials such as in some alloyed steels, low carbon steels, stainless steels.

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

None



Cross sectional projection distribution of additive powders

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. ASM International, Chapter: Quantitative Metallography. Materials Characterization (2019 Edition), Volume: 10, Publication date: 2019

ASSESMENT

Exam: There are two written exams. Midterm and Final.

Essay Reports: Case reports and review studies are expected in essay reports from the students for each classroom subject.

GRADING POLICY

During the in-classroom exercises, students should submit 13 different essay reports. Reports should include some answers to the questions about the topic. Reports should also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure images. Each report is 100 points. The standard average of 13 essay reports will be taken as an essay report score.

Assignment Weights	Percent
Essay Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

13 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

AVIATIC AND DEFENCE ALLOYS AND SCIENCE OF ARMOURS

Code: ADASA

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

3

Language

English

Thematic block

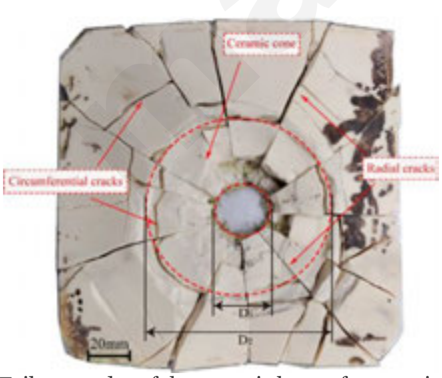
Applied Materials Science

Form of tuition and number of hours*:

Lecture: 42 h

ECTS

6



Failure modes of the ceramic layer of composite armor

COURSE DESCRIPTION

The aviation industry and aviatic materials classes are growing in an incredible extent in response to the need for lighter and stronger structural parts that are used for conventional and critical applications. Similar advances in ballistics materials can also be observed due to protection of vehicles as well as individuals, too. For this, the first set of lectures will introduce the basics of ballistics and alloys used for the aviation and ballistics industry. The course will also cover the basics of ballistic standards and human interactions that define the protection from projectiles and the effect of them on humans. The resistance to impact is mainly the issue of kinetics energy related to the velocity and the mass of projectile however, it is frequently necessary to obtain quantitative measurements of impact absorbing and projectile deflection features to compare experimental observations with theoretical predictions. Another important factor in aviatic and ballistically resistant materials is that functional protective and intrinsic properties which may relate to microstructural control that, in turn, affects the mechanical, physical and surface properties of all materials. This course is intended to increase the awareness of students to relate the various properties of alloys that are used in aerospace and defense industries with their place of use. The ballistics section is dedicated to provide knowledge regarding the background of dynamics and kinetics of particles built for the purpose of creating a physical impact on a target, as well as to present how to eliminate high impact energy using the specially designed targets. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different alloys available for structural and specific purpose that are used in aviatic and defense industry. By the end of the course, students will be able to suggest suitable alloys for aerospace and defense purposes in a compliance with well known standards Students will gain an understanding of the background of the selection and design techniques that are commonly employed for the ballistics purposes and their relationships with alloy microstructures.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

Co-funded by the European Union

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain the concept of ballistics and armor and their effect on the design of alloys and protective armors.
MS_O_02	Can elaborate on various alloy types that are employed in aerospace and defense purposes, their current and prospective applications and also properties to relate their properties to their place of use.
MS_O_03	Can elaborate on the effect of ballistics impact such as penetration and shock waves in interaction with human and static targets made of conventional and special materials.
MS_O_04	Can analyse the design of some armor systems and most aviation alloys and defense related standards.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** Activating methods: a case study; problem based lecture	MS_O_01, 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_0	Informative lecture, problem based lecture	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay reporting	3	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Reading literature	Query of materials and review of activities necessary to participate in classes.	NO
A_03	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students are expected to gain knowledge of concept of ballistics and armor and their effect on the design of alloys and protective armors.
Students are expected to gain knowledge of various alloy types that are employed in aerospace and defense purposes, their current and prospective applications and also properties to relate their properties to their place of use.
Students are expected to gain knowledge on the effect of ballistics impact such as penetration and shock waves in interaction with human and static targets made of conventional and special materials.
Students are expected to gain extensive knowledge on design of some armor systems and most aviation alloys and defense related standards.

COMMENTS

LECTURER

DO YOU KNOW

Defense industries must be viewed as significant sue to having an economic and technological significance. In the UK, France and the US, defence equipment represents about 10 per cent of total manufacturing output. Equipment orders from home and abroad provide employment for around 500,000 people in the UK, at least 300,000 in France, and over two million in the US. The US Department of Defense, the Pentagon, employs 134,000 people just to procure equipment worth about $130 billion involving 15 million contracts a year.

Old Armors for army commanders

COURSE CONTENT (e.g. lecture)

Topic 1

Introduction to concept of ballistics and armor

Definition of Ballistics iin general and ballistic properties of high speed flying objects; concepts of kinetic energy and impact energy in impact on targets; basic principles of armours and their use in military and non military applications; shape and design issues with the projectiles; armor as a science.

Topic 2

Internal ballistics, terminal ballistics: terms and definitions

Definition of internal ballistics and its importance in ballistics science; the history of both internal and terminal ballistics; the types and classification of cartridge and projectile ammunitions and their place of use; the general and specific classification of ammunitions based on bodily harm conditions

Topic 3

Alloying and performance of special alloys

Definition of alloys in conventional systems and its types and alloying principles according to Hume Rothery and modern physical metallurgy; general alloy making processes, casting and standards that are specific to alloys in special industries, mechanical and high temperature performance of alloys: demands from alloys, welds and their ballistics performance.

Topic 4

Aluminium based alloys for aviatic and defense applications

Aluminium alloys and their classification for aviatic and ballistic purposes; technical specifications, mechanical properties of alloys, specific properties: high temperature applications, low temperature applications, heat treatment processing and final ballistic properties.

Topic 5

Titanium based alloys for aviation and defense applications

Titanium alloys and their classification for aviation and ballistic purposes; technical specifications, mechanical properties of alloys; specific properties: high temperature applications, low temperature applications, heat treatment processing and final ballistic properties.

Topic 6

Steel based alloys for aviatic and defense applications

Steel and iron based ferrous alloys and their classification in general and specifically for aviatic and ballistic purposes; technical specifications of steel and iron based ferrous alloys; high hardness in ferrous alloys; mechanical and specific properties; heat treatment processing and final ballistic properties.

Topic 7

Novel alloys for aviation and defense applications

New generation alloys and their classification for aviation and ballistic purposes, technical specifications, mechanical properties of alloys, specific properties: high temperature applications, low temperature applications, heat treatment processing and final ballistic properties.

Topic 8

Miscellaneous alloys for aviation and defense applications

Magnesium based and other alloys and their classification for aviation and ballistic purposes, technical specifications, mechanical properties of alloys,

LEARNING OUTCOMES

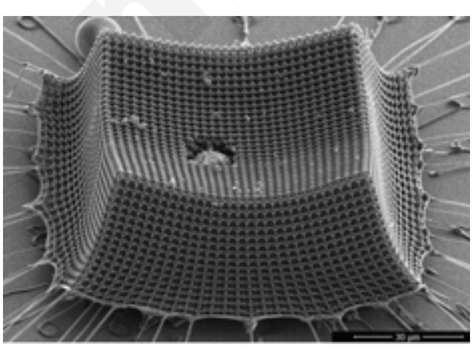
Students are expected to gain knowledge of concept of ballistics and armor and their effect on the design of alloys and protective armors.
Students are expected to gain knowledge of various alloy types that are employed in aerospace and defense purposes, their current and prospective applications and also properties to relate their properties to their place of use.
Students are expected to gain knowledge on the effect of ballistics impact such as penetration and shock waves in interaction with human and static targets made of conventional and special materials.
Students are expected to gain extensive knowledge on design of some armor systems and most aviation alloys and defense related standards.

COMMENTS

INSTRUCTOR

DO YOU KNOW

The CO_2 emissions of all flights departing from EU27+EFTA airports reached 147 million tonnes in 2019, which was 34% more than in 2005. The average grams CO_2 emitted per passenger kilometre went down by an average 2.3% per annum to reach 89 grams in 2019, equivalent to 3.5 litres of fuel per 100 passenger kilometres. Long-haul flights (above 4,000 km) represented approximately 6% of departures during 2019 and half of all CO_2 and NOx emissions.



New Nanomaterial Resists Projectile Impact Better Than Kevlar

specific properties: high temperature applications, low temperature applications, heat treatment processing and final ballistic properties .

Topic 9

Composites applications

Metal matrix composites and ceramic based composites and their classification for aviation and ballistic purposes, sandwich structures, technical specifications, mechanical properties of alloys, specific properties: high temperature applications, low temperature applications, heat treatment processing and final ballistic properties.

Topic 10

Penetration mechanics and failure modes

Introduction to the repelling and deflecting by armours and threats from free flying objects at high speeds; failure mechanisms at impact; high speed object penetration analysis into thick plate; penetration into finite thick plates; penetration of rods into thick plates; hydrodynamic penetration.

Topic 11

Human vulnerability

The production of Shock waves through low level and high level blasting and gun/pistol firing muzzle; ballistics loading and body-projectile interactions; blast loading and survivability of humans under free flying debris and behind armour; vapour effect from the high speed impact of projectile.

Topic 12

Design of armour systems via materials properties

Modeling of materials under impact: elastic behavior, elastic-plastic behavior; strain hardening; Johnson cook models, Johnson-Halmquist model, Cowper-Sydmons model; modeling failure models, Cockroft-Latham failure model, stress triaxiality.

Topic 13

Ballistics standards

Ballistic testing techniques used for the standard procedures including short and long distance shooting; impact blast, high energy blasting and fragmentation of projectile and their analysis with simple techniques; target perforation tests on metallic and non metallic targets; NIJ standards, STANAG standards.

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

None

A composite body armour plate made of B_4C and Al_2O_3 with a layer of fiber reinforced composite: Garanti Kompozit

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. S. Gialanella, A. Malandruccolo, Aerospace alloys, springer international publications, 2020

2. D. E. Carlucci, S. S. Jacobson, Ballistics: Theory and Design of Guns and Ammunition, CRC press, 2013

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exam will contribute to 20% of total marks and final exam contributes to 50% of total marks.

Essay reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics.

GRADING POLICY

During case study and end class activity, students will be given a topic to prepare an essay and they should submit 7 different essay reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points but contributes to 30% of total sum of marks. The average of 7 reports will be taken as a Report score.

Assignment Weights	Percent
Essay Reports	30%
Midterm Exam	20%
Final	50%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 20 points
1 Final exam – max. 50 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Co-funded by the European Union

FAILURE ANALYSIS AND ITS PREVENTION

Code: **FAP**

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: 39 h

ECTS
6

Fatigue failures occur in the tooth root fillet

COURSE DESCRIPTION

Failure analysis is the science of determining the mechanism of failure in many industries. Collecting and analyzing data to determine the cause of a failure comes often with the goal of determining corrective actions or liability. Failure analysis can eventually save money, lives, and resources in an ample time. It is an important discipline in many branches of manufacturing industry, such as the metallurgical and mechanical engineering industry, where prevention and restoring is vital tool used in the processing of new products and for the improvement of existing products. The failure analysis process relies on collecting failed components for subsequent examination of the cause or causes of failure using a wide array of methods, especially microscopy and spectroscopy.

Failure analysis is also concerned with the prevention and suggestions that are within reasonable limits of materials. Feasible mechanisms can be life saving and the performance of a machine part or materials that are working under abnormal conditions or extended period of working service time may positively affected. The lecture is intended to increase the awareness of students to relate the most observed failure types and mechanisms with regard to service properties of materials with technical background information. The experimental section is dedicated to strengthen the knowledge gained during the course topic and aimed to give a reasonable insight real experimental data and images. Students are expected to spend 35 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different failures types that have been appeared over the years in metallic and non metallic materials that are used in structural applications in industry. The causes and prevention of failures are of prime importance in industry due to tremendous cost of operation. By the end of the course, students will be able to differentiate between types of failures and root causes and also will be able to suggest a feasible prevention method or route for a specific application. Students will gain an understanding of the background of the mechanisms that are commonly active for each failure types be it on the surface and inside a bulk material and methodologically relate them with microstructures and physical properties.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can demonstrate competence in approaching failed components and analysing them in terms of mechanics, material properties and external factors.
MS_O_02	Can acquire knowledge of failure modes of materials and systems based on operating conditions and to correlate them to conclude on the main cause of failure and to suggest a prevention route.
MS_O_03	Can acquire knowledge of methods of analysis using known characterization methods and apply them to find the root cause.
MS_O_04	Can show the obtained knowledge of the types of failure based on the type of industry and production methods; also the significance of the failure and the prevention mechanism.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_01, 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	Lecture	36	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay Preparation	3	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Reading literature	Preparation for class	NO

Co-funded by the European Union

LEARNING OUTCOMES

Students are expected to demonstrate competence in approaching failed components and analysing them in terms of mechanics, material properties and external factors.
Students are expected to acquire knowledge of failure modes of materials and systems based on operating conditions and to correlate them to conclude on the main cause of failure and to suggest a prevention route.
Students are expected to acquire knowledge of methods of analysis using known characterisation methods and apply them to find the root cause.
Students are expected to gain knowledge of the types of failure based on the type of industry and production methods; also the significance of the failure and the prevention mechanism.

COMMENTS

LECTURER

Prof. Dr. Şükrü TALAŞ

DO YOU KNOW

Resolving the source of metallurgical failures can be of financial interest to companies. The annual cost of corrosion (a common cause of metallurgical failures) in the United States was estimated by NACE International in 2012 to be $450 billion a year, a 67% increase compared to estimates for 2001.

Collapse of the Tacoma Narrows Bridge, 1940.

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

Topic 1

Introduction to failure and causes

Definitions of failure in materials and metallic systems from metallurgical point of view at macro and micro levels; the mechanical metallurgy of failures and generalized failure concept with the help of relevant theories; strength and stress requirements for failure of materials; types of failures and brief definitions

Topic 2

Failure in castings and melting related processes

Definition and types of casting operations in industry and fabrication routes for re-melting of pure metals and scraps; various casting defects and prevention of such defects with remedies from industry; typical problems of solidification during the casting; proposed design problems and the role of inclusions; examples of defects and solutions

Topic 3

Hydrogen cracking

The theory of crack formation and relevant stress-strain relationships in process; the entrapment of hydrogen in lattice and effects of free hydrogen in metals on their mechanical properties especially impact energy and tensile tests; mechanism of hydrogen cracking; how to determine hydrogen presence and the amount; prevention of hydrogen cracking and examples

Topic 4

Liquid metal cracking/solidification cracking

Solidification and definition of solid/liquid ratio; phase diagrams and their interpretation for solidification; undercooling and supercooling in solidification processes; defects during the cooling of liquid metal and alloys; contraction stress and effect on the cooling liquid; prevention of liquid metal cracking

Topic 5

Plastic deformation processes and defects

Mass shape forming ability of metals and materials; the effect of temperature and material property; defects during and after plastically deformed sheet metals; limit diagrams for shaping of sheet metals with respect to bending; surface porosity of shaping dies; forging and defect mechanisms; precautions for defect formation

Topic 6

Corrosion defects

Introduction to corrosion in materials and definitions of corrosion and its types; corrosion defect types and classifications according to applications; analysis of corrosion defects and consequences; parameters per type of corrosion, prevention suggestions with respect to type of corrosion

Topic 7

Welding and weld defects

Weldability of metals and alloys with respect to welding methods; carbon equivalency concept in steel welds; weld metal solidification and zones as a result of thermal cycles; stress distribution during welding; weld defects; internal and external factors in defect formation; prevention of weld defects

Topic 8

Heat treatment of metals and related defects:

LEARNING OUTCOMES

Students are expected to demonstrate competence in approaching failed components and analysing them in terms of mechanics, material properties and external factors.
Students are expected to acquire knowledge of failure modes of materials and systems based on operating conditions and to correlate them to conclude on the main cause of failure and to suggest a prevention route.
Students are expected to acquire knowledge of methods of analysis using known characterisation methods and apply them to find the root cause.
Students are expected to gain knowledge of the types of failure based on the type of industry and production methods; also the significance of the failure and the prevention mechanism.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Failures can be caused by excess temperature, excess current or voltage, ionizing radiation, mechanical shock, stress or impact, and many other causes. In semiconductor devices, problems in the device package may cause failures due to contamination, mechanical stress of the device, or open or short circuits.

Items containing pressurized gas may be too dangerous

Heat treatment processes and classifications in steels; definitions and the use of diagrams such as CCT and TTT diagrams and their use; heat treatment types; Fe-C phase diagram; heat treatment cycle effect on properties; defect mechanisms in heat treatment and fast cooling; prevention and suggestions

Topic 9

Wear

Introduction to wear and its effects in industrial applications; definitions of wear processes and mechanisms of wear and tear on the surface of metallic and non-metallic materials; adhesive and abrasive wear processes; pitting and spalling wear types on metals and suggestions for prevention; fretting wear and prevention measures

Topic 10

Milling and machining defects of metals and alloys

A short introduction to machining processes for removal of excessive metal volume from a bar or slabs of metals; the cutting tools used in the machining of metals and alloys; stresses and forces during machining of metals; poor surface finish and crack formation; burning of metals; tool parameters

Topic 11

Defects in rollers and extrusion processes

Short definition of rolling processes and its applications in metal shaping industry; mechanical property changes during and after rolling processes; temperature-stress relationship during rolling; causes for cracking: design or material; extrusion processes and defects; prevention and suggestions.

Topic 12

Shaping and forging limit diagrams

A detailed elaboration of limit diagrams for sheet metal forming processes with respect to thickness and types of metals; yield strength, impact energy and deformation capacity relationships; Kooler Goodwin diagrams; heat treatment applications during forming and defects formation mechanisms therein

Topic 13

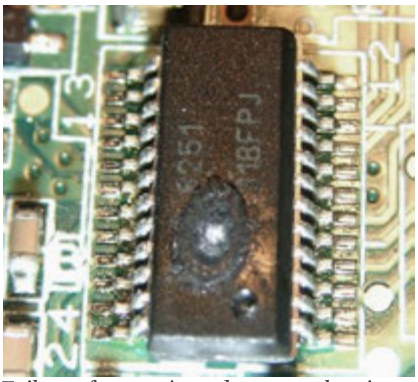
Defects formation during metal pouring

Introduction to casting process in industry; casting furnaces and working temperatures; handling of liquid metal during casting and alloying processes during or before pouring; effects of ambient moisture and slag residues; slag extraction and waste management; precautions during liquid pouring

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

None

Co-funded by the European Union


Failure of a transistor due to overheating

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. ASM International, Chapter: Quantitative Metallography. Materials Characterization (2019 Edition), Volume: 10, Publication date: 2019

Assignment Weights	Percent
Midterm Exam	40%
Final	60%
Total	100%

1 Midterm Exam- max 40 points
1 Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

ASSESEMENT

Exam: There are two written exams: Midterm and Final.

GRADING POLICY

The maximum number of points achieved in the midterm exam is 40 and 60 for the final exam.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				

UNIVERSITY OF SILESIA IN KATOWICE
UNIVERSITY OF ŽILINA

Co-funded by the European Union

MATERIALS SELECTION AND PRINCIPLES

Code: MSP

Field of study

Materials Science and Engineering

Level of study

Master study

Semester

1

Language

English

Thematic block

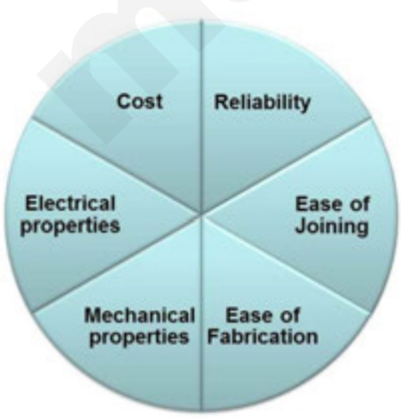
Fundamental aspects of materials science

Form of tuition and number of hours*:

Lecture: 41 h

ECTS

4



Selection parameters for the materials selection

COURSE DESCRIPTION

The materials selection is one of prime subjects in applied and manufacturing related industry due to its dominant effect on the quality and longevity of products. In the first set of lectures, a definition of material selection and related criteria for selection process are given and the fundamental issues in manufacturing and the background information are provided in addition to types of materials for selection and solutions to the problems related to the materials selection. The last set of lectures present materials selection diagrams and their interpretation.

With the developing technology, the need for materials used / can be used in various industrial areas is also increasing. In terms of engineering, economical selection and design of materials suitable for service conditions is important. The aim of this course is to provide engineering candidates with a vision regarding the determination, design and selection of material properties, taking into account the costs.

This course aims to increase the student's awareness on how to select a material for a machine part or a structure that is produced to operate whether in a challenging or well preserved conditions with a view of manufacturing conditions, cost, bulk and surface properties. This course also presents actual case studies to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 41 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of this course is to provide a broad overview about materials selection process and help suggest selection parameters and threshold values from diagrams available for structural, surface and bulk properties of various materials systems. By the end of the course, students will be able to put forward selection criteria for a specific case and methodology by which different industrial materials are also considered. Students will gain an understanding of the background of the industrial problems that are commonly and rarely encountered during the service.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can elaborate on a specific and general material selection criteria for industrial manufacturing, structural and specific applications.
MS_O_02	Can analyse and review and suggest a selection routine suitable for service conditions of the parts or structure in question with the knowledge of background information.
MS_O_03	Can apply obtained knowledge on design methods by which advanced and reliable selection of materials for which the specific cases are encountered.
MS_O_04	Can explain the procedures for selection of materials and use on various materials selection diagrams which are documented as tabulated data and also obtain and analyze numerical outcome using these diagrams.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_01, 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	Lecture	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	2	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Reading literature	Preparation for essay report	NO

LEARNING OUTCOMES

Students are expected to gain knowledge on a specific and general material selection criteria for industrial manufacturing, structural and specific applications.
Students are expected to review and suggest a selection routine suitable for service conditions of the parts or structure in question with the knowledge of background information.
Students are expected to gain knowledge on design methods by which advanced and reliable selection of materials for which the specific cases are encountered.
Students are expected to gain knowledge on various materials selection diagrams which are documented as tabulated data and also obtain and analyze numerical outcome using these diagrams.

COMMENTS

LECTURER

DO YOU KNOW

The number of materials types increased tremendously between 1940 and 1980 by the introduction of polymers and their improved means of manufacturing made this possible. However, the need for stronger and high temperature applications increased the use of composites and new generation of alloys from 1990s.

Computer Aided Materials Selection Route

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

Topic 1

Materials and classification based on the use in industry

General classification of materials for the purpose of different areas of application, steps for the selection and the factors (mechanical properties, design, availability, manufacturability and the cost of materials and production), accountability of the selection processes and selection principles of materials

Topic 2

Materials selection criteria and tabulated data

Introduction and brief explanation of concepts pf vailability and economics, manufacturability, joinability, corrosion and wear capacities of materials available for industrial applications; some important tabulated data available in literature; case study: the selection of alloys for coins and production of coins

Topic 3

Materials selection for strength purpose

Determination of strength and evaluation process; classification of low strength, medium and high strength materials and alloys; definition of ultrahigh strength steels and materials; strength of thermoplastics, fiber reinforced materials, hybrid composites, materials selection for static and dynamic strength

Topic 4

Materials selection for toughness purpose

The definition of toughness concept in materials and metallic systems in particular, and calculation of toughness through experimental route in steels; principles of fracture mechanics and failure examples; materials selection principles for toughness; tabulated data of toughness for some materials and systems

Topic 5

Materials selection for fatigue purpose

Theory behind the fatigue; and historical problems associated with Fatigue in materials and its effect on metallic materials, how to evaluate the fatigue, factors for fatigue in metals and other material systems; the calculation of fatigue life and experimental procedures; materials selection for fatigue strength

Topic 6

Materials selection for creep purpose

Creeping in materials and metallic systems; the parameters for creeping in metals in selecting the best material; the evaluation procedure for creeping and experimental setup; factors of creeping in other material systems; calculation of creeping and predicting the creep life; materials selection for creeping systems

Topic 7

Corrosion and prevention

Introduction to corrosion and its types available; atmospheric corrosion, high temperature corrosion, soil and corrosion factors, fluid related corrosion, polymeric materials and corrosion, materials selection procedures and suggestion for all corrosion types, material selection for a chemical factory

Topic 8

Wear and materials behaviour

Tribology and historical background on wear and wear behavior of materials; the economics of wear and tear in components in a machine; extensive definitions of

LEARNING OUTCOMES

Students are expected to gain knowledge on a specific and general material selection criteria for industrial manufacturing, structural and specific applications.
Students are expected to review and suggest a selection routine suitable for service conditions of the parts or structure in question with the knowledge of background information.
Students are expected to gain knowledge on design methods by which advanced and reliable selection of materials for which the specific cases are encountered.
Students are expected to gain knowledge on various materials selection diagrams which are documented as tabulated data and also obtain and analyze numerical outcome using these diagrams.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Transistors are built from materials such as Silicon and Germanium which can either behave as an electrical insulator or conductor.
The first general purpose electronic computer contained 17468 thermionic valves and 70,000 resistors covering 167 square metres of floor space and weighed 30 tonnes, consumed 160 kW of electricity. Now, your computer could handle 3 billion instructions with a few million transistors packed into a few mm² of tiny silicon chip.


Failed blades due to over loading

types of wear; wear measuring devices and principles, wear resistance and improvement methods, oils and lubrication, materials selection for wear

Topic 9

Material selection diagrams

Materials selection diagrams for common properties and specific collection of materials selection diagrams: elasticity modulus, tensile and yield strength diagrams, density comparison diagrams, fracture toughness, rigidity, thermal conductivity, thermal expansion, thermal diffusivity diagrams and their interpretation

Topic 10

Design issues and materials selection

The relationship between design of parts to be used and its material selection process, materials selection improvement route for new design and existing design, performance and design, materials production and selection issues, cost and materials selection and demands from industry, design limits for materials

Topic 11

Materials selection in automotive industry

The general problems in automotive industry and related materials solutions: fuel economy and materials selection; historical past of automotive materials, several automotive parts and their prospective and standard materials; chassis, bumper, piston, crankshaft, connecting rod examples

Topic 12

Materials selection in aviation industry

The materials selection specifications for aviation related structures with respect to lightness and durability; materials selection procedures in specific aviation industry; the needs from materials and its selection, materials for high speed air vehicle applications, iron based aviation materials, non ferrous aviation materials

Topic 13

Materials selection in gear and shipping industry

Materials used for ship building: steels, alloyed cast iron, non ferrous alloys for specific applications: walls and exteriors, beams and columns, vibration issues; gear making process and related materials selection, surface hardening of gears and moulds; possible defects and prevention

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

None


Improper selection of barrel material

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. M. FARAG, "Selection of Materials and Manufacturing Processes for Engineering Design", Prentice Hall, New York, 1990.

2. D. WILLIAM, JR. CALLISTER, "Fundamentals of materials science and engineering", John and Willey, New York, 2000.

ASSESMENT

Exam: There are two written exams: Midterm and Final.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics.

GRADING POLICY

During the classroom discussion session at the end of the lecture, students should submit 7 different essays. Reports should include some answers to the questions about the topic. Each report is 100 points. The average of 7 reports will be taken as a Report score. The maximum number of marks achieved in the discussion essay reports is 30. Students will get 30% marks from midterm exam and 40% from final exams.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				

SINTERING TECHNOLOGIES

CODE: ST

Field of study

Materials Science and Engineering

Level of study

Master Study

Year of study/semester

2

Language

English

Thematic block

Materials and Manufacturing

Form of tuition and number of hours*:

Lecture: 42 h

ECTS

4

COURSE DESCRIPTION

Sintering of materials is a forming process technology which has an extensive field of application without many limits of types of materials. Starting with ancient civilizations for several thousand years in the form of pottery, bricks, and art and continuation with near-perfect quality and high performance of modern sintered technical products are demanded more with the competitive edges. In this course, the sintering process will be explained in detail by introducing the thermodynamical bases of sintering and atomistic shuffling and densification during the sintering and continue with types of sintering processes and applications in industry. Most industrial applications are regularly concerned with the intrinsic parts manufacturing that are frequently used in automotive industry. The heat and pressure are employed without melting the metallic and non-metallic powdered materials that are pressed prior to sintering. The quality of sintered products is dominantly dependent of diffusional processes which may relate to the kinetics of processes such as grain growth, or particle coarsening, or the development of mechanical properties such as strength and toughness. The fundamentals of sintering (densification and grain growth) will be explained. Major challenges in grain growth in the solid state and also the microstructure development will be covered. This course is intended to relate the sintering processes with mechanical and surface properties and the related metallurgical process. The experimental section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different sintering techniques for powder metallurgy and their effect on the various properties. By the end of the course, students will be able to differentiate between sintering techniques and their extensive use for different areas of industry. Students will also gain an understanding of the background of the mechanisms and parameters that are effective in strong bonding and their relationships with microstructures.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain types and principles of sintering and the mechanisms by which joining of powders are achieved.
MS_O_02	Can explain and show porosity and densification of powders and their effect on the mechanical properties of sintered products.
MS_O_03	Can elaborate on methods of manufacturing of powders and compaction principles in order to achieve optimum results.
MS_O_04	Can explain typical industrial applications of sintered products and possible ways of which they can be modified for the purpose of specific use.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** critical analysis, synthesis and conclusions; individual and team work	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	40	Exam	MS_O_01 MS_O_02 MS_O_03 MS_O_04	Meth_01
FT_02	Essay preparation	2	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
A_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students are expected to gain knowledge of types and principles of sintering and the mechanisms by which joining of powders are achieved.

Students are expected to gain knowledge of porosity and densification of powders and their effect on the mechanical properties of sintered products.

Students are expected to gain knowledge on methods of manufacturing of powders and compaction principles in order to achieve optimum results.

Students are expected to gain knowledge on typical industrial applications of sintered products and possible ways of which they can be modified for the purpose of specific use.

COMMENTS

LECTURER

DO YOU KNOW

Why is Sintering done and Why is it Important? Sintering is done to impart strength and integrity to a material as well as reducing porosity and enhancing electrical conductivity, translucency and thermal conductivity.
Sintering is generally considered successful when the process reduces porosity and enhances properties such as strength, electrical conductivity, translucency and thermal conductivity.

Powders are starting material for PM parts

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

Topics 1

Sintering processes, thermodynamics of the interface

This lecture will focus on the sintering processes and thermodynamics of interfaces in materials science, with a particular emphasis on powders and their transformation into engineered shapes, including the mechanisms involved in powder consolidation, and the behavior of interfaces between powder particles, analyzing sintering behavior and the properties of sintered materials and factors affecting powder-to-powder interfaces during the sintering process

Topics 2

Powder production and characterization

This class will focus on powder production and characterization, encompassing various methods of producing powders, as well as techniques to analyze and classify powders based on their properties, and the fundamental principles of powder production, including traditional and modern methods.

Topics 3

Pre sintering processes

This class will focus on the pre-sintering processes involved in powder metallurgy and ceramics manufacturing, specifically covering the compaction and shaping of powders, the pre-sintering densification process, and related considerations. The class will explore the techniques and methods used for working with ceramic and metallic powders, the role of lubricants and binders in powder compacts, and the overall process of achieving desired densification prior to final sintering

Topics 4

Sintering processes and polycrystalline microstructures

This class will explore the sintering processes, solid-state sintering models. The focus will extend to modern techniques such as microwave sintering, with the resulting microstructures in sintered materials, the differences between liquid and solid-state sintering, the advantages and challenges of microwave sintering, and the significance of microstructural characteristics in sintered materials

Topic 5

Initial, intermediate and final stages of sintering

This class will provide an in-depth exploration of the various stages of sintering, including initial, intermediate, and final stages. The focus will encompass the mechanisms and phenomena associated with each stage, including grain growth, interface formation, diffusion kinetics, void growth, and closure mechanisms.

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LEARNING OUTCOMES

Students are expected to gain knowledge of types and principles of sintering and the mechanisms by which joining of powders are achieved.

Students are expected to gain knowledge of porosity and densification of powders and their effect on the mechanical properties of sintered products.

Students are expected to gain knowledge on methods of manufacturing of powders and compaction principles in order to achieve optimum results.

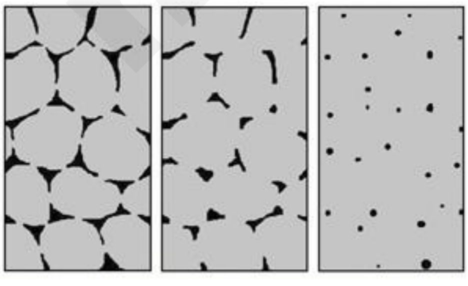
Students are expected to gain knowledge on typical industrial applications of sintered products and possible ways of which they can be modified for the purpose of specific use.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Sintering is thermal behavior of materials where particles bond together via mass transport mechanisms. The bonds reduce free particle surface to minimize the surface energy. Most materials sinter at temperatures exceeding approximately one-half of the melting temperature.



Three stages in sintering

Additionally, the class will examine the transition from curved to straight boundaries in the context of interface evolution. The lecture will cover the intricacies of sintering kinetics and microstructural changes at different stages of the process.

Topics 6

Normal grain growth & second phase particles

This class will focus on the phenomena of normal grain growth and the influence of second-phase particles in sintered materials. The class will discuss the mechanisms of normal grain growth in the context of adjacent powder particles

Topics 7

Grain boundary segregation & grain boundary migration

This class will explore the phenomena of grain boundary segregation and grain boundary migration in sintered materials. The focus will encompass the process of grain boundary segregation that occurs during sintering, including the kinetics of formation for metallic and non-metallic segregates

Topics 8

Solid state sintering: SPS and HIP assisted sintering

This class will focus on solid-state sintering processes with a specific emphasis on spark plasma sintering (SPS), hot isostatic pressing (HIP), extrusion sintering, and pulsed electric current sintering. The class will cover the principles, mechanisms, and applications of these advanced sintering techniques

Topic 9

Solid state sintering: mechanical alloying

This class will focus on the solid-state sintering process known as mechanical alloying, specifically involving the use of powders to create alloyed materials. The class will cover the principles of mechanical alloying, including its production and synthesis methods. It will discuss the effects of powder size, shape, and density on the mechanical alloying process

Topics 10

Alloying in powder metallurgy: diffusion alloying

This class will focus on alloying in powder metallurgy, specifically exploring diffusion alloying as a mechanism for achieving desired material compositions. The class will explain the principles of mass transfer through diffusion and its application to sintering processes. It will cover the mechanisms of elemental transport through surface and volume diffusion for alloying purposes

LEARNING OUTCOMES

Students are expected to gain knowledge of types and principles of sintering and the mechanisms by which joining of powders are achieved.

Students are expected to gain knowledge of porosity and densification of powders and their effect on the mechanical properties of sintered products.

Students are expected to gain knowledge on methods of manufacturing of powders and compaction principles in order to achieve optimum results.

Students are expected to gain knowledge on typical industrial applications of sintered products and possible ways of which they can be modified for the purpose of specific use.

COMMENTS

INSTRUCTOR

Asst. Mahmud YALÇIN

DO YOU KNOW

Simulate constrained sintering with the accompanying shape distortion
– Variations in density
– Multi-layered materials
– Functionally graded materials
– Powder packing defects
At the continuum, component scale.

Furnace sintering of the gears produced P/M process

Topics 11

Liquid phase sintering

This class will focus on the phenomenon of liquid phase sintering, exploring various aspects of this process and its applications. The class will delve into topics such as transient liquid phase sintering, eutectic assisted sintering, third body melting sintering, and reactive liquid formation. It will cover the principles, mechanisms, and field of application for each type of liquid phase sintering

Topics 12

Reactive sintering process and hardening of sinters

This class will focus on the reactive sintering process and the subsequent hardening of sintered materials. The class will explore the principles and applications of reactive sintering, covering the mechanisms of reactions during sintering and their influence on material properties

Topics 13

Machining and testing of sintered products

This class will focus on the processes of machining and testing of sintered products, encompassing practical examples and case studies. The class will delve into the techniques and methods used to machine sintered products, including cutting, grinding, and finishing. It will also cover the various testing procedures and characterization techniques employed to evaluate the mechanical, physical, and functional properties of sintered products

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

None

Casting filters and parts produced by sintering

TEXTBOOK/READINGS

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

1. S-K. L. Kang, Sintering: densification, grain growth and microstructure, Elsevier, Publication year: 2005

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports/Essays: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics.

GRADING POLICY

During the laboratory exercises, students should submit 7 different essay reports. Reports should include some answers to the questions raised during the discussion session of the classroom lectures. Reports also have some discussion of the experimental findings in literature and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 reports will be taken as essay report score. The maximum number of points achieved in the case study (essay) reports is 30.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Co-funded by the European Union

THEORY OF ALLOYS AND PHASE EQUILIBRIA IN MATERIALS

Code: TAPEM

Field of study

Materials Science and Engineering

Level of study

master study

Semester

1

Language

English

Thematic block

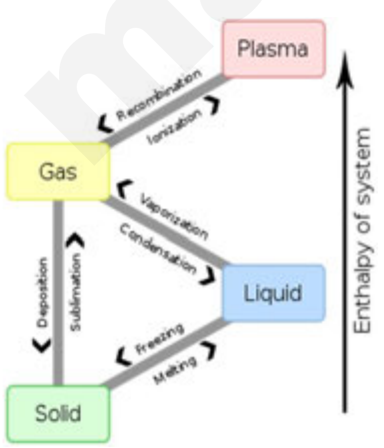
Advanced Engineering Materials

Form of tuition and number of hours*:

Lecture: 42 h

ECTS

4



States of the matter, transformations and the relation of enthalpy

COURSE DESCRIPTION

The phase systems in alloys and their prediction are becoming a indispensible tool for material scientists as it provides valuable information as to which temperature and corresponding phase is stable for the process in question. For this, the first set of lectures will introduce the fundamental issues of thermodynamics and alloy formation in binary alloy systems in detail with respect to types of systems. The course will also cover the basics of intermediate phases with which recent alloys are dominated extensively such as intermetallics and high entropy alloy systems. A proper knowledge of a phase diagram and interpretation of microstructure is important in analyzing problems in physical and process metallurgy and materials science. Alloy phase equilibria in material systems provide an extensive instrument by which a quantitative treatment of binary and ternary phase diagrams are evaluated. It is also a great tool for the evaluation of microstructural features resulting due to both solidification of liquid and solid to solid transformation reaction. The lecture is intended to increase the awareness of students to relate the microstructural and structural properties of metallic materials with phases and phase diagrams. The course is also dedicated to strengthen the background knowledge of phase transformations in mostly metallic systems and non metallic systems during the course and aimed to give the students clear view of reading phase diagrams correctly. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different types of phase diagrams available for most alloy and hybrid systems of metals and ceramics, too. By the end of the course, students will be able to differentiate between types of phase diagrams and their basic calculations with regards to solid solution and solubility by analyzing the curvature of phase diagrams. Students will also gain an understanding of the background of ternary and quasi ternary phase diagrams calculations that are commonly used for the complex systems of metallic and non metallic nature.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can elaborate on basics of phase diagrams of most metallic systems and phase rules regarding the free energy, single component and equilibrium in thermodynamics systems.
MS_O_02	Can analyse binary phase diagrams with microscopic and phase separation features of tectic and tectoid systems dominating binary systems.
MS_O_03	Can interpret binary phase calculations that are governing the appearance of microstructures with equilibrium and non equilibrium transformations
MS_O_04	Can explain intermediate phases that are of importance to complex alloying systems and differentiate them within the phase diagrams.

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, MS_O_03, MS_O_04
Meth_02	**Team project**: critical analysis, synthesis and conclusions; individual and team work, communicate on specialist topics	MS_O_01, 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	38	Exam	MS_O_01 MS_O_02 MS_O_03 MS_O_04	Meth_01
FT_02	Essay reporting	4	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	Preparation for classes	Preparation for the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students are expected to gain knowledge of basics of phase diagrams of most metallic systems and phase rules regarding the free energy, single component and equilibrium in thermodynamics systems.
Students are expected to gain knowledge of binary phase diagrams with microscopic and phase separation features of tectic and tectoid systems dominating binary systems.
Students are expected to gain knowledge on binary phase calculations that are governing the appearance of microstructures with equilibrium and non equilibrium transformations
Students are expected to gain knowledge on intermediate phases that are of importance to complex alloying systems and differentiate them within the phase diagrams.

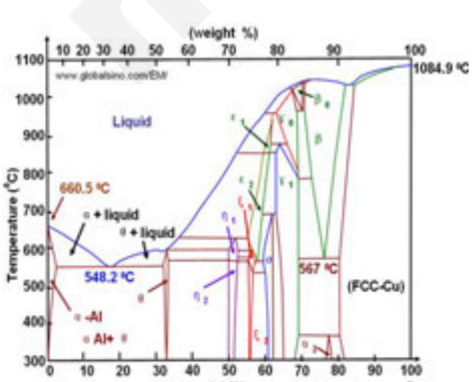
COMMENTS

LECTURER

Prof. Dr. Şükrü TALAŞ

DO YOU KNOW

The early history of the phase diagram in physics is connected to Gibbs, Maxwell and van der Waals: the van der Waals equation (1873) implies that there are coexisting liquid and gas phases below the critical temperature in real gases. Van der Waals received the 1910 Nobel Prize in physics for this work. The term `phase' appears to have been coined by J. Willard Gibbs



Al-Cu phase diagram

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

Topic 1

Basic thermodynamics and its application

Laws of thermodynamics, enthalpy and entropy, free energy concept, heterogeneous equilibrium and phase rule, free energy of mixtures, the free energy of solutions-quasi chemical model, single component system: pressure temperature diagrams, effect of curvature on the melting point

Topic 2

Alloy making from melt and atomic interactions in crystalline matter

Alloy making rules for metallic systems and their practical application, alloy making mechanisms in liquid state and their theoretical background using thermodynamics and thermochemical principles, the random alloys, order and disorder rules and theory behind order disorder reactions, one dimensional and multi dimensional alloy models, rigid bond models and virtual crystal approximations

Topic 3

Solid state reactions and alloying mechanisms

Hume Rothery principles of alloy making; diffusion processes and the effect of diffusion solid state reactions with respect to operational temperature; atomic layering and atomic displacement in lattice; phase diagram rules relating alloy making rules; substitutional alloys and interstitial alloys and their

Topic 4

Isomorphous systems-Binary systems

Application of phase rule, the lever rule, equilibrium solidification and microstructure, non equilibrium solidification and coring, conditions for phase equilibrium, free energy curves, solute redistribution during solidification, zone refining, constitutional supercooling, dendrites formation

Topic 5

Binary eutectic, peritectic and metatectic systems

Binary eutectic systems and application of phase rule, the eutectic reaction, microstructure of eutectic reactions, hypo and hyper eutectic structures, modification of eutectic structures, isothermal diffusion and growth of eutectics, equilibrium solidification of peritectic systems, hypo and hyper peritectic structures, metatectic systems

Topic 6

Binary monotectic and syntectic systems

Monotectic and syntactic reactions in metallic alloy systems, equilibrium and equilibrium solidification of monotectic systems as hypo and hyper monotectic, free energy composition diagrams, equilibrium solidification of syntectic systems, gravity segregation on natural cooling of syntectic alloy

Topic 7

Intermediate phases

Classification of intermediate phases in alloy systems, origin of formation of intermediate alloy systems, crystal structure of intermediate phases and its principles, structural classification of intermediate phases, non stoichiometric compounds, congruent transformations in solids

LEARNING OUTCOMES

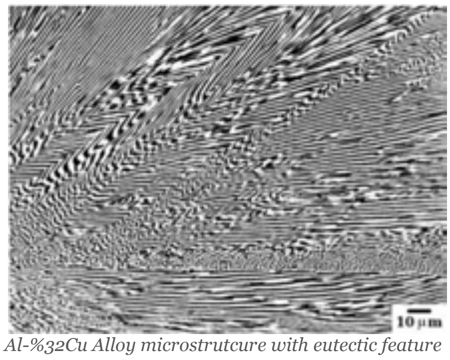
Students are expected to gain knowledge of basics of phase diagrams of most metallic systems and phase rules regarding the free energy, single component and equilibrium in thermodynamics systems.
Students are expected to gain knowledge of binary phase diagrams with microscopic and phase separation features of tectic and tectoid systems dominating binary systems.
Students are expected to gain knowledge on binary phase calculations that are governing the appearance of microstructures with equilibrium and non equilibrium transformations
Students are expected to gain knowledge on intermediate phases that are of importance to complex alloying systems and differentiate them within the phase diagrams.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Some 40 years ago, Larry Kaufman and Himo Ansara provided the stimulus to bring together a small number of scientists who were working on the calculation of alloy phase diagrams using as basis the required consistency of experimental thermodynamic and phase boundary data. This group represented the origins of CALPHAD and of subsequent developments concerned with computer coupling of phase diagrams and thermochemistry. From those origins, the "CALPHAD Method" has become a successful and widely applied tool in all areas of materials development.



Al-%32Cu Alloy microstrutcure with eutectic feature

Topic 8

Binary eutectic and eutectoid systems: Fe-C phase transformation systems (Carbon steels)

Eutectic alloy systems and the role of equilibrium concept in binary eutectic systems, eutectic transformations in Fe-C alloys and F-C phase diagram explanation, structural and microstructural transformation from austenite to pearlite, ferrite, bainite and martensite, tempering of martensite

Topic 9

Binary eutectic systems: cast iron systems

Eutectic and eutectoid reaction in cast irons and high carbon ferrous alloy systems; definitions and microstructural and structural characteristics of white cast iron, grey cast iron, ductile cast iron, malleable cast iron, alloy cast iron, binary peritectoid systems, binary monotectoid alloy systems

Topic 10

Binary phase diagrams calculations

Binary isomorphous alloy systems, definitions of maximum and minimum in the solidus and liquidus curves, binary eutectic/peritectic/monotectic and syntectic alloy systems, description of numerical methods for phase diagram calculations, calculation of slopes of phase boundaries in binary alloy systems

Topic 11

Ternary system: general

Ternary alloy systems and their definitions and examples of ternary phase diagrams, the application of phase definition and separation rule in ternary alloy systems, the representation of ternary alloy system, and application of the lever rule-tie lines and tie-triangles in ternary alloy systems

Topic 12

Exemplary studies in phase diagrams

Binary fully soluble, binary eutectic, binary peritectic, binary monotectic and basic and complex ternary systems in mostly metallic systems and application rules of phase calculations in some industrially important applications including graphical representation of alloy systems in well known commercial and literature studied ternaries

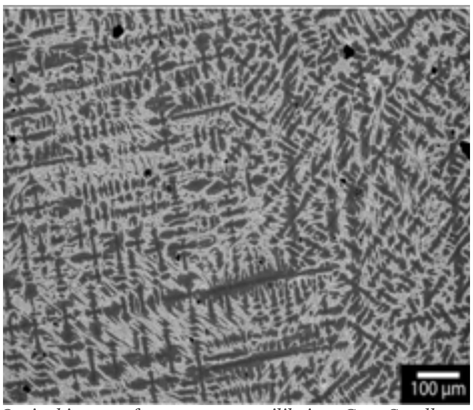
Topic 13

Non equilibrium reactions: martensitic, bainitic and precipitation hardening

Non equilibrium reactions and phase relations; equilibrium phase diagrams and practical understanding of non equilibrium phase diagrams; martensitic reactions and atomistic explanation; bainitic reaction and formation mechanisms of lower and upper bainite; introduction to precipitation and well known precipitation reaction systems and short introduction to precipitates

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

None


Optical image of as cast non equilibrium Cu20Sn alloy

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. ASM International, Chapter: Quantitative Metallography. Materials Characterization (2019 Edition), Volume: 10, Publication date: 2019

ASSESEMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding phase transformations and alloy systems.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

GRADING POLICY

During the class, students should submit 7 different topic reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 reports will be taken as a Report score. The maximum number of points achieved in the essay reports is 30.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

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MECHANICS OF COMPOSITE MATERIALS

Code: MCM

Field of study
Materials Science and Engineering

Level of study
Master Study

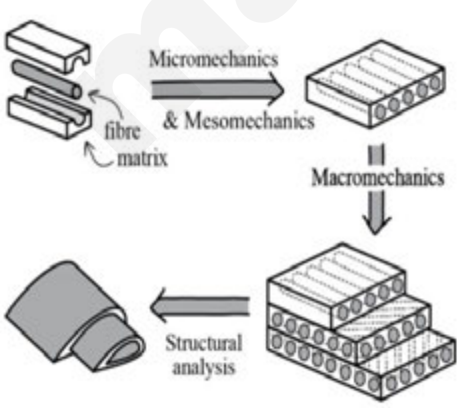
Semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours*:
Lecture: 30 h
Laboratory: 13 h

ECTS
4



Classification and analysis of light composites

COURSE DESCRIPTION

Although synthetic composites have existed for thousands of years, the high technology of advanced composites has been used in the aerospace industry only for the last fifty years. The applications are becoming diverse – from aircraft structures and missile canisters to tennis racquets and fishing rods. The objective of this course is to analyze and design structures made of fiber reinforced composite materials.

Composites are becoming an essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue strength, and faster assembly. Composites are used as materials in making aircraft structures to golf clubs, electronic packaging to medical equipment, and space vehicles to home building. Composites are generating incredible interest in students all over the world. They are seeing everyday applications of composite materials in the commercial market, and job opportunities are increasing in this field. The technology transfer initiative of the US federal government has opened new and large scale opportunities for use of advanced composite materials.

The lecture is intended to increase the awareness of students to relate the microstructural properties of materials with bulk and surface properties. The experimental section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 40 hrs of in class training and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide an introduction to advanced composite materials and their applications; develop fundamental relationships for predicting the mechanical and hygrothermal response of multi layered materials and structures and micromechanical and macromechanical relationships for lamina and laminated materials with emphasis on continuous filament; introduce material, structural, and strength optimization to design laminated composite materials using user friendly software.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, mechanics and strength of materials prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can apply their knowledge about principles of stress-strain relations and failure criteria based on the properties of composites.
MS_O_02	Can elaborate on metal and ceramics matrix composites and their production and prepare a report for analyzed images and their contents.
MS_O_03	Can explain manufacturing, mechanical properties, factors affecting mechanical properties of different types of composite materials.
MS_O_04	Can show how to produce laminated composites, explain the production methods and stress-strain relationships in addition to recycling of most of composites produced for general use.

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, MS_O_03
Meth_02	**Team project**: critical analysis, synthesis and conclusions; individual and team work, communicate on specialist topics	MS_O_01, MS_O_02, 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	36	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	4	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students are expected to gain knowledge about principles of stress-strain relations and failure criteria based on the properties of composites.
Students are expected to gain knowledge of metal and ceramics matrix composites and their production and prepare a report for analyzed images and their contents.
Students are expected to gain knowledge on manufacturing, mechanical properties, factors affecting mechanical properties of different types of composite materials.
Students are expected to gain knowledge on laminated composites, their production methods and stress-strain relationships in addition to recycling of most of composites produced for general use.

COMMENTS

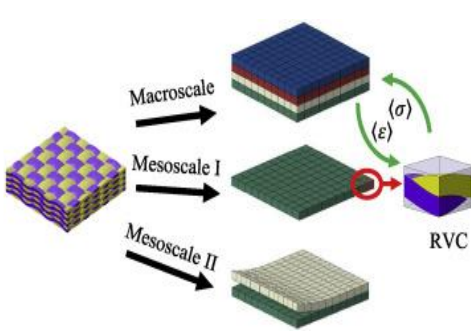
LECTURER

DO YOU KNOW

Composites are new type of materials that has been utilized in large amounts in a short time than that of steel or any other materials.

Concrete is also a well-known composite having cement to bind and hold together mortars and steel reinforcements. About 10 billion tons are made every year – more than one cubic meter for every person on Earth.

There are many natural composites including bone, wood and rock.



COURSE CONTENT - FORM OF TUITION: LECTURE

Topic 1

Introduction to composite materials

A comprehensive understanding of the principles, applications, and inherent advantages and disadvantages associated with composite materials; the fundamental concepts underpinning composite materials, exploring their composition, manufacturing processes, and the science behind their enhanced properties

Topic 2

Fiber reinforced plastic processing

Introduction to the working with fiber reinforced plastics (FRP); the classification of composites, diverse fiber and matrix types, various production methods, and the mechanical properties crucial for successful FRP applications; insights into the distinctions between particle-reinforced, fiber-reinforced, and structural composites, choosing fiber-reinforced plastics for specific applications, considering factors such as strength, weight, and durability

Topic 3

Basic principles of mechanics of materials

Key concepts such as stress, strain, elastic moduli, and strain energy; stress, the internal force experienced by a material, and strain, the resulting deformation; fundamental parameters that govern the mechanical behavior of materials; the in-depth analysis of stress-strain relationships for various materials. how different materials, including metals, polymers, and ceramics, exhibit distinct behaviors under different loading conditions

Topic 4

Lamina structures

Uni/bi-directional lamina in terms of the stiffness and compliance parameters of the lamina; stress-strain relationships, strengths, thermal and moisture expansion; effects of uni/bidirectional lamina and the angle of the ply; emphasizing their stiffness and compliance parameters; parameters influence the overall mechanical response of lamina; the design and analysis of composite materials (3 hours).

Topic 5

Types of Composites in design

The utilization of various types of composites, each tailored to specific applications and structural requirements; fibrous composites and reinforcement through the integration of fibers within a matrix; diverse applications of fibrous composites in planes and plates; thin plates and thick plates, and their mechanical behaviors and design considerations

Topic 6

Laminated composites

General terminology for laminated composites including terms such as lamina, ply, stacking sequence, and interlaminar stresses; applications of laminated composites; automobile, aircrafts, missiles; electrical and electronics, Marine, recreational and sports equipment, future potential of composites

Topic 7

Metal matrix composites fabrication process

Metal Matrix Composites; reinforcement materials, types, characteristics and selection base metals; fabrication of MMC's: powder metallurgy and liquid metallurgy technique and secondary processing, special techniques; various reinforcement materials are employed, including ceramics, carbides, and fibers

LEARNING OUTCOMES

Students are expected to gain knowledge about principles of stress-strain relations and failure criteria based on the properties of composites.

Students are expected to gain knowledge of metal and ceramics matrix composites and their production and prepare a report for analyzed images and their contents. Students are expected to gain knowledge on manufacturing, mechanical properties, factors affecting mechanical properties of different types of composite materials.

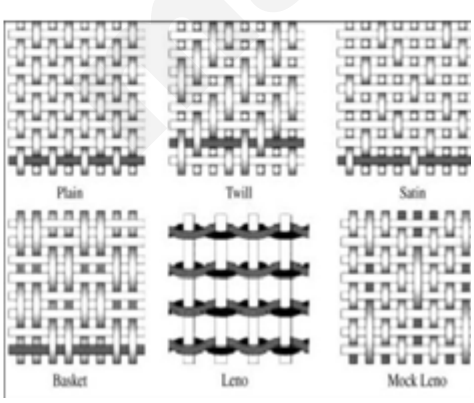
Students are expected to gain knowledge on laminated composites, their production methods and stress-strain relationships in addition to recycling of most of composites produced for general use.

COMMENTS

INSTRUCTOR

DO YOU KNOW

The earliest man-made composite materials were bricks made of straw and mud. The ancient Egyptians recorded these being made in tomb paintings. Concrete is the most commonly used composite.



Some typical woven styles used as reinforcements in making composites

Topic 8

Ceramic matrix composites fabrication process

Ceramics Matrix Composites: Reinforcement materials for ceramic based composite materials; types, characteristics and selection of matrix phase and material, production CMC's and its application; fabrication Process For MMC's; powder metallurgy and special fabrication techniques

Topic 9

General properties of MMC'S

Physical such as density and thermal conductivity and Mechanical properties of Metal Matrix Composites; wear, machinability and other important properties; the intricate relationship between the properties of MMCs and the size, shape, and distribution of the reinforcing particulate

Topic 10

General properties of CMC'S

The exploration of Ceramic Matrix Composites (CMCs) with their physical, mechanical, wear, machinability, and other properties, with a particular emphasis on understanding the influence of particulate size, shape, and distribution; relationship between these properties and the intricate characteristics of the reinforcing particulate

Topic 11

Recycling of composites and its effect on properties

The composite industry challenges related to waste management; the production and processing of composite materials and their by-products and end-of-life components; effective waste management strategies to minimize environmental impact; developing sustainable practices for useful products and applications for composite waste

Topic 12

Failure of composites and Analysis

Destructive test for composites and evaluating the mechanical properties of composite materials; insights into their performance and structural integrity; analysis and standards; impact testing and measurement of mechanical properties of composites; different types of impact tests, such as Charpy and Izod tests, and gain proficiency in interpreting impact test results

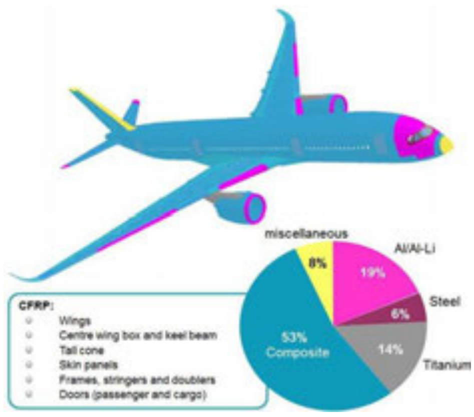
Topic 13

Examples of industrial applications

Exemplary studies related to the processing and production of composites; students will observe case studies about problems encountered in the industry and speculate about their solutions in the light of the information they have learned throughout the course

COURSE CONTENT - FORM OF TUITION : LABORATORY CLASSES

None



Around half of the materials used to make an airplane are composites

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1 D. Gay, Composite Materials: Design and Applications, 3rd ed., CRC Press, 2014

ASSESMENT

Exam: There are two written exams. Midterm and Final.

Essays: Case reports and review studies are expected as reports from the students for each classes.

GRADING POLICY

During the in class exercises, students should submit 7 different in class discussion essays. Essays should include some answers to the questions about the topic. Each report is 100 points. The average of 7 reports will be taken as a Report score to represent 30 % of final mark. The maximum number of points achieved in the essay reports is 30. There is one midterm (30%) and one final exam (40%).

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

SOLIDIFICATION AND HEAT TREATMENT PROCESSES

Code: SHTP

Field of study
Materials Science and Engineering
Level of study
Master Study
Semester
2
Language
English
Thematic block
Materials and Manufacturing
Form of tuition and number of hours*:
Lecture: 42 h

ECTS
4


Open heart heat treatment furnace

COURSE DESCRIPTION

Solidification is a process in which atoms are converted into an ordered solid state from a liquid disordered state. The conversion rate for the process of solidification can be achieved by following the kinetic laws. The movement of atoms for the conversion of liquid can be observed by these laws.

Heat treating (or heat treatment) is a group of industrial, thermal and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve the desired result such as hardening or softening of a material. Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering, carburizing, normalizing and quenching. Although the heat treatments are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

The lecture is intended to increase the awareness of students to relate the solidification and heat treatment processes and final properties of materials with bulk and surface/coating properties. The experimental section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using practical applications in heat treatment and solidification processes. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide extensive definitions and background information of solidification and heat treatment processes and later present different applications available for industry and academic research and manufacturing. By the end of the course, students will be able to define the uses of both techniques with the purpose of specific applications and also will gain an understanding of the physical properties obtained through these two processes and relate their surface, bulk properties including microstructures.

PREREQUISITES FOR TAKING THE COURSE

Students are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain solidification processes and how to define the mechanisms involving diffusional and non diffusional transformations leading to different microstructures with respect to parameters such as cooling rate, alloying additions and temperature.
MS_O_02	Can analyse various heat treatment regimes and analyze and describe respective microstructural constituents after any heat treatment process.
MS_O_03	Can show how to use TTT and CCT and various diagrams used in heat treatment predictions in places where a semi quantitative outcomes are expected.
MS_O_04	Can explain industrial applications of both solidification and heat treatment processes and suggests a feasible regime from which a desired outcome is expected in a specific case.

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the programme
Meth_01	**Lecture**: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01, MS_O_02, MS_O_03
Meth_02	**Lecture:** Problem methods; Activating methods: a case study	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	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	3	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

LEARNING OUTCOMES

Students are expected to gain knowledge on solidification processes and how to define the mechanisms involving diffusional and non diffusional transformations leading to different microstructures with respect to parameters such as cooling rate, alloying additions and temperature.
Students are expected to gain knowledge of various heat treatment regimes and analyze and describe respective microstructural constituents after any heat treatment process.
Students are expected to gain knowledge on how to use TTT and CCT and various diagrams used in heat treatment predictions in places where a semi quantitative outcomes are expected.
Students are expected to gain knowledge on industrial applications of both solidification and heat treatment processes and suggests a feasible regime from which a desired outcome is expected in a specific case.

COMMENTS

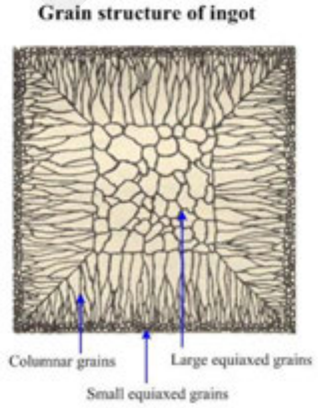
LECTURER

Prof. Dr. Şükrü TALAŞ

DO YOU KNOW

Heat treatment processes are becoming more local by heating the targeted parts of the moulds using various new techniques which are usually in hybrid form. These include laser pulsed heating to produce finely hardened regions and electron beam and coolant assisted surface hardening for a desired hardness levels.

Grain structure of ingot



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

Topic 1

Introduction to Solidification

Importance of solidification; heat extraction from liquid; capillary effects and wetting on surfaces; solidification microstructures; thermodynamics basics: free energy of formation and heat of melting; practical importance of solidification in casting and manufacturing industry

Topic 2

Atom transfer and diffusion at liquid solid interface

The introduction to solid liquid interface and the formation of liquid solid interface for pure substances and alloys; solute pile up the interface; matano interface; overheating and undercooling and interface instability; thermodynamic treatment of solidification with respect to heat transfer

Topic 3

Solidification microstructures I

The definition of equilibrium concept in solidification processes and its importance in nucleation and growth process; thermodynamics of equilibrium processes in general with relation to freezing and the formation of cells and dendrites; eutectic and peritectic transformations; diffusion coupled growth

Topic 4

Solidification microstructures II

The analysis of interface and its formation in detail and stability issue with interfaces in mechanistic way; the diffusion at tip of dendrites; transient concept in solute diffusion process; mass balance equations; morphology and crystallography of dendrites; dendrite spacing and dendrite shape; directional growth

Topic 5

Non equilibrium solidification

Solidification processes at high cooling rates and the definition of non equilibrium conditions; non equilibrium thermodynamics during solidification; application of rapid solidification and resulting microstructures; Macrosegregation and Microsegregation; Zone melting solidification model, Coring

Topic 6

Applications utilising solidification

Zone refinement in the production of solidified metallic materials and some non metallic materials such as Silicon; bulk metallic structures and production methods; powder production; casting; continuous casting; single crystal formation processes, processing microstructure maps

Topic 7

Heat treatment and basic principles

Heat treatments in various metallic systems; heat treatment needs for industry and end results analysis; fundamental concepts in heat treatment processes and their classification; phase transformations related to heating and cooling during property modifications; classifications and mechanisms of transformations in steels

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LEARNING OUTCOMES

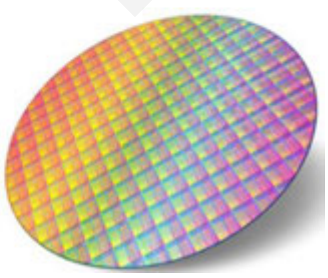
Students are expected to gain knowledge on solidification processes and how to define the mechanisms involving diffusional and non diffusional transformations leading to different microstructures with respect to parameters such as cooling rate, alloying additions and temperature.
Students are expected to gain knowledge of various heat treatment regimes and analyze and describe respective microstructural constituents after any heat treatment process.
Students are expected to gain knowledge on how to use TTT and CCT and various diagrams used in heat treatment predictions in places where a semi quantitative outcomes are expected.
Students are expected to gain knowledge on industrial applications of both solidification and heat treatment processes and suggests a feasible regime from which a desired outcome is expected in a specific case.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Manufacturing silicon wafers begin by growing a silicon ingot which can take one week to one month. More than 75% of all single crystal silicon wafers are grown by the Czochralski (CZ) method. Silicon ingots are grown by placing chunks of polycrystalline silicon into a quartz crucible along with small quantities of dopants.



Silicon wafers are produced by zone refining

Topic 8

Effect of alloying elements on alloy properties of heat treated metals

Alloying elements in steels and some other alloys and their interactions within the matrix; the limits of alloying additions in steels; alloying elements in structural alloys; effect of alloying elements in steels and their relationship to mechanical and microstructural properties; case study: weld composition and property

Topic 9

Property diagrams and their usage in industry

Time-transformation-temperature diagrams and their use in industry, Continuous Cooling Time diagrams, Time Transformation / Time Property diagrams, ITh diagrams and their use in practice; heat treatment types and cooling medium diagrams and their interpretations based on these predetermined diagrams

Topic 10

Hardenability

Definition of hardenability in steels and other metallic materials with a reference to deformation capacity; principles of hardening processes; jominy effect, effect of carbon and mechanism of martensite formation in carbon steels and alloyed steels; distortion; hardness—cooling medium-tempering relationship

Topic 11

Case studies and problems in heat treatment

Various case study examples from industry, especially from metal processing industry i.e. screw and gear making processes; heat treatment type and alloy relationship analysis in case studies; thermal stresses; stress transformation relations; residual stresses; overheating; burning and decarburization; preventive measures

Topic 12

Heat treatment of welded structures

Weld thermal cycle and its effect base metal; heat input concept and its effect on base metal; the heat affected zone and base material; dimensional changes and stress distribution during welding operation; stress measurement and destructive testing for property prediction; heat treatment processes in welded structures and their effect on final properties

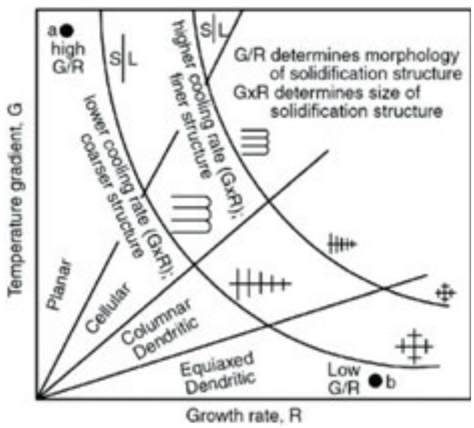
Topic 13

Heat treatment with gaseous atmospheres

Surface modification processes using heat treatment as a tool for improved diffusion and non diffusive medium; Carburizing or pack cementation; boriding; nitriding techniques, pack boriding and chromising, ferritic nitrocarburizing, and austenitic nitrocarburizing techniques and methods

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

None



TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. ASM International, Chapter: Quantitative Metallography. Materials Characterization (2019 Edition), Volume: 10, Publication date: 2019

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding solidification and heat treatment.

GRADING POLICY

During the in-class exercises, students should submit 7 different essay reports. Essay reports should include some answers to the questions about the discussion topic. Reports also have some discussion of the experimental findings from literature and evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 essay reports will be taken as Essay/Report score. The maximum number of points achieved in the essay reports is 30.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 essay/reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

NOVEL ALLOYS: HEAs, SUPERALLOYS AND INTERMETALLICS

Code: NAHSI

Field of study
Materials Science and Engineering

Level of study
Master Study

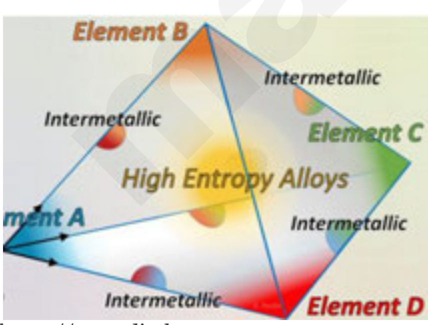
Semester
1

Language
English

Thematic block
Advanced Engineering Materials

Form of tuition and number of hours*:
Lecture: 42 h

ECTS
4



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COURSE DESCRIPTION

The new alloy systems are challenging in terms of defining their exact properties. Multiple alloying design approaches (density functional theory (VASP), molecular dynamics (LAMMPS), self-consistent field method (SCF), phase field dislocation dynamics, and CALPHAD calculations) can provide novel alloys with unique properties, including high strength with sufficient ductility and fracture toughness and excellent corrosion and wear resistance for a wide range of temperatures due to the concentrated alloying that cannot be obtained by traditional microalloying based on a single principal element. In addition, the alloy design approach provides new alloy systems in astronomical numbers with variety of microstructural attributes that can yield different properties. Intermetallics and superalloys are the first one to emerge the alloy systems as groundbreaking systems since their high temperature applications are crucial to the engine technology and corrosion resistant applications. BMGs and HEAs have newly emerged alloys system that changed the design approach and made this approach dependent on computing power and database. However, there is a lot to learn from an old theories and metallurgical kinetics approach. Various new applications such as resistant to sulfidation, dimensional stability at ambient and high temperatures are all in demand and need alloys which can offer such a material.

This course is intended to increase the awareness of students to relate the structural properties of novel alloys with industrially and academically relevant needs. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different novel alloys such as HEAs, BMGs, superalloys and intermetallics available for both structural and specific applications. By the end of the course, students will be able to define the alloying systems and relevant alloys with a purpose of possible usage where a specific need is defined. Students will also gain an understanding of the background of the techniques that are commonly used for alloy design and the mechanisms for high class outputs such as high temperature strength and dimensional stability.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisites in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain types of high entropy alloys, superalloys, intermetallics and bulk metallic glasses and alloying design principles about novel alloys.
MS_O_02	Can classify various properties of novel alloys and suggest feasible alloying systems that are specific and unique to certain applications.
MS_O_03	Can elaborate on methods and mechanisms by which novel alloys are strengthened and calculations that are useful to simulate the properties such as free energy, diffusivity, strength of bulk materials.
MS_O_04	Can explain on how to modify the alloys based on the effect of each alloying additions with respect to alloy system and differentiate their properties based on their alloying additions and analyze microstructures.

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, MS_O_03
Meth_02	**Lecture:** Problem methods; Activating methods: a case study	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	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	3	Course work	MS_O_01 MS_O_02 MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

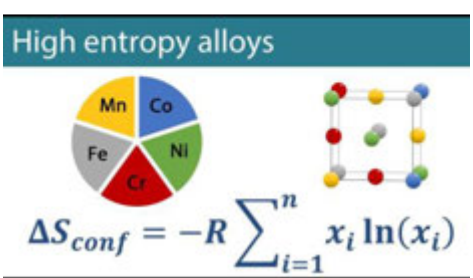
Students are expected to gain knowledge of types of high entropy alloys, superalloys, intermetallics and bulk metallic glasses and alloying design principles about novel alloys.
Students are expected to gain knowledge of various properties of novel alloys and suggest feasible alloying systems that are specific and unique to certain applications.
Students are expected to gain knowledge on methods and mechanisms by which novel alloys are strengthened and calculations that are useful to simulate the properties such as free energy, diffusivity, strength of bulk materials.
Students are expected to gain knowledge on how to modify the alloys based on the effect of each alloying additions with respect to alloy system and differentiate their properties based on their alloying additions and analyze microstructures.

COMMENTS

LECTURER

DO YOU KNOW

Dimensional stability of superalloys is prime selling factors of such alloys. These alloys can maintain their strengths up to 900 C at a tensile strength of 800MPa with a dimensional change of less than 1 % compared to vastly dropping strength and dimensional change of more than 23 % of most structural alloys in a similar range of temperature.



Entropy concept calculation is alloy making

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

Topic 1

Introduction to alloy theory and high temperature alloys

An introduction to alloy definition and alloying in metallic materials with reference to classical and entropic alloys; physical metallurgy of alloys and present theories; high temperature working requirements and reactions in air; order-disorder concept; characteristics of high temperature materials

Topic 2

Alloying processes for special alloys

Melting and re-melting processes in metallic materials; alloying through mechanical alloying and the properties of mechanically alloyed parts; sintering with diffusion alloying; other processes of alloy production; property enhancement and strengthening processes for materials through alloying

Topic 3

Selection criteria for high temperature materials

Larson Miller approach criteria for ranking creep behavior in metallic materials; superalloy concept in metallic systems and types of superalloys available in industry; high entropy alloy concept and intermetallics (aluminides) alloying principles for high temperature applications; Heusler intermetallic alloys

Topic 4

Superalloys: Nickel Alloys, Cobalt Alloys and others

Introduction to the superalloys and their classification with respect to base element; superalloys classification with respect to performance and places where they are used; composition-usage relationships in nickel based superalloys and Co based alloys; strengthening effects; fatigue and creep behaviors; and other properties of superalloys

Topic 5

Superalloys: Microstructures and physical metallurgy

The FCC phase formation in superalloys and its importance with respect to microstructural properties; the importance of gamma prime phase in nickel based superalloys; other phases in super alloys; strengthening (dispersion and matrix hardening) and defects; fatigue and creep behaviors; alloying properties of superalloys

Topic 6

Intermetallics: Introduction and principles

Introduction to intermetallic and their characteristics, problems and opportunities; historical background of intermetallic materials; bonding-structure and stability in intermetallic alloys; intermetallics from the alloying point of view; general rules for intermetallic formation; thermodynamics of intermetallics and phase diagrams

Topic 7

Intermetallics: Nickel aluminides

Nickel based aluminide intermetallics and crystal structures; mechanical and microstructural properties of phases with respect to types of AB and A3B i.e. NiAl and Ni3Al; effect of alloying additions on the mechanical and high temperature properties of nickel based intermetallics; industrial applications

LEARNING OUTCOMES

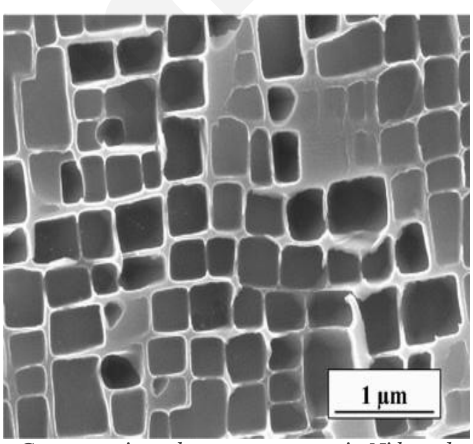
Students are expected to gain knowledge of types of high entropy alloys, superalloys, intermetallics and bulk metallic glasses and alloying design principles about novel alloys. Students are expected to gain knowledge of various properties of novel alloys and suggest feasible alloying systems that are specific and unique to certain applications.
Students are expected to gain knowledge on methods and mechanisms by which novel alloys are strengthened and calculations that are useful to simulate the properties such as free energy, diffusivity, strength of bulk materials. Students are expected to gain knowledge on how to modify the alloys based on the effect of each alloying additions with respect to alloy system and differentiate their properties based on their alloying additions and analyze microstructures.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Superalloys have a wide range of uses across many industries. Such as the aerospace industry for jet engine components due to their ability to withstand extremely high temperatures generated by jet engines during flight. They are also commonly used in medical implants due to their biocompatibility and corrosion resistance properties.



Gamma prime phase appearance in Ni based superalloys

Topic 8

Intermetallics: Titanium aluminides

Titanium based aluminides and their types that are viable in alloy making and also for industrial applications; crystal structures of titanium aluminides and relevant intermetallic phases in Ti-Al phase diagram; effect of alloying additions on mechanical and high temperature properties; examples for applications

Topic 9

Intermetallics: Iron aluminides

Iron based aluminides and their types that are viable in alloy making and for industrial applications; crystal structures of iron alloys in general but specific to FeAl and Fe3Al types and phases in Fe-Al phase diagram; effect of alloying additions on properties of Fe based intermetallics; industrial applications

Topic 10

Other types of intermetallics

The electronic and structural properties of nickel and molybdenum silicides and their general properties with respect to types of silicides; problems in industrial applications such as resistance; molybdenum, nickel, cobalt and titanium silicides in electronics industry; copper, gold and tin based intermetallics

Topic 11

High Entropy Alloys: basics, principles and synthesis

Theory and concept of entropy and enthalpy in alloy systems and high entropy alloying process in detail; physical metallurgy of high entropy alloys; designing and calculation models for high entropy alloys; problems and advantages regarding applications; the casting and other fabrication routes for HEAs

Topic 12

Metallic glasses: principles and requirements

Physical metallurgy of metallic glasses and the concept of glass forming ability in alloy stsems; bulk metallic glasses definitions; phase formation rules and theories; Solidification and Crystallization behavior in forming BMGs; various fabrication routes and methods to synthesize the metallic glasses

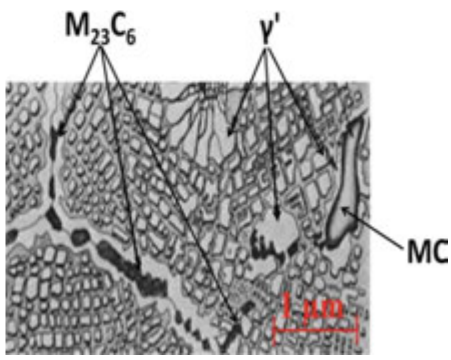
Topic 13

High entropy alloys and Metallic Glasses: Applications

Comparative structures and phase transformations in both HEAs and metallic glasses; HEA metallic glasses, HEA high temperature superalloys types; HEA coatings on various substrates; potential applications and prospects; physical properties of both alloys; corrosion behavior; mechanical behavior magnetic properties; examples of applications

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

None



Various carbide formation in Ni-based superalloys, which are present at grain boundary

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. Duboi, J and Belin-Ferre, E (Eds); Complex Metallic Alloys: Fundamentals and Applications, 2011

2. D. A. Molodov (Ed by) Microstructural Design of Advanced Engineering Materials, Wiley, 2013

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 50 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics.

GRADING POLICY

There are two exams regarding the evaluation of the course; midterm exam and final exam. The contribution from the midterm exam is 30% and the contribution from the final exam is 50%. There are 5 essay reports to be prepared during the course; the contribution of essays will be 20% to the sum marks.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				

Assignment Weights	Percent
Midterm Exam	30%
Essay Reports	20%
Final	50%
Total	100%

1 Midterm Exam- max 30 points
5 Essay reports max. 20 points
1 Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
5				

KINETICS OF METALLURGICAL PROCESSES

Code: KMP

Field of study

Materials Science and Engineering

Level of study

Master Study

Semester

2

Language

English

Thematic block

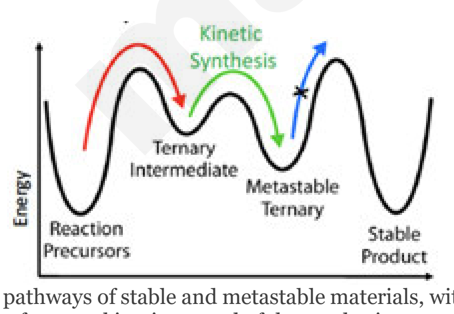
Materials and Manufacturing

Form of tuition and number of hours*:

Lecture: 42 h

ECTS

4



pathways of stable and metastable materials, with a focus on kinetic control of the synthesis process

COURSE DESCRIPTION

The kinetics of reactions in multi element system with regards to temperature and element homogenization is one of the most extensive research fields in metallurgy. The first set of lectures will introduce the fundamental issues of kinetics and its thermodynamic basics and it will continue with specific subjects that are very important in kinetical studies of reactions in mostly solid state transformations. The course will also cover the basics of crystal growth techniques and related phenomena.

Most practical experiments tend to be performed under conditions which are dominated by rate defined reactions and these rates are the prime factors in the determination of the resulting phases in a thermodynamically driven system. These results may be heavily related to the kinetics of processes such as grain growth, phase transformations or particle coarsening, and hence mechanical properties and physical properties such as hardness, strength and toughness are also affected. By controlling the kinetics of a reaction one can ensure a controlled positive outcome on the microstructural characteristics of strengthening particles in the bulk material as well as eliminate them completely. The lecture is intended to increase the awareness of students to relate the microstructural properties of bulk and surface properties of most alloys with the theoretical background of effective processes and related mechanisms. The last section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience based on industrially important applications and the perspective of kinetics. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about kinetics and rate oriented reactions related to materials and metallurgical processes occurring in bulk and surfaces. By the end of the course, students will have sufficient theoretical background on chemical mechanical and growth aspects of kinetics. Students will also gain an understanding of the background of the techniques that are commonly used for the production of crystalline and non crystalline structures.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain main kinetically important processes related to metallurgical and materials preparation routes for semi product and final products that can be utilized in industry.
MS_O_02	Can demonstrate competency on various data exploration means for kinetics studies that can be used in both academic and industrially important manufacturing processes.
MS_O_03	Can explain and elaborate on theories and their details by which advanced evaluations are made on microstructures and their constituents.
MS_O_04	Can suggest on kinetics related processes that are used in specific applications and their scientific basis.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** critical analysis, synthesis and conclusions; individual and team work	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	39	Exam	MS_O_01, MS_O_02 MS_O_03, MS_O_04	Meth_01
FT_02	Essay Report	3	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	Preparation for classes	Preparation for the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

LEARNING OUTCOMES

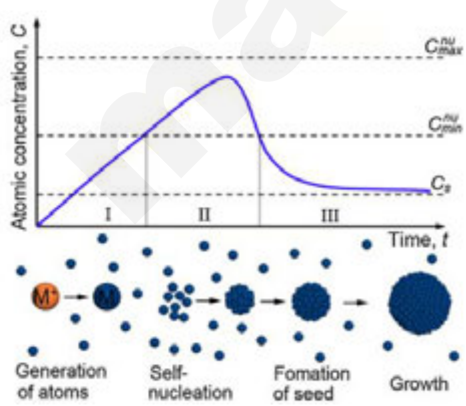
Students can explain main kinetically important processes related to metallurgical and materials preparation routes for semi product and final products that can be utilized in industry.
Students can demonstrate competency on various data exploration means for kinetics studies that can be used in both academic and industrially important manufacturing processes.
Students can explain and elaborate on theories and their details by which advanced evaluations are made on microstructures and their constituents.
Students can suggest on kinetics related processes that are used in specific applications and their scientific basis.

COMMENTS

LECTURER

DO YOU KNOW

Kinetics is a branch of science that deals with the effects of intrinsic forces upon the motions of material bodies or with changes in a physical or chemical system by certain parameters such as temperature and composition.



Nucleation and growth sequence in graphics with atomic mass transport versus time

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

Topic 1

Introduction to Metallurgical Kinetics

Thermodynamics and kinetics concepts in metallic and non metallic systems; irreversible reaction kinetics; characteristics of rate processes; energy barrier for a reaction; driving forces for reactions in general; diffusion in crystalline and non crystalline systems, atomistic models for diffusion in short

Topic 2

Kinetics in materials and diffusion

General rate equation, evaluation of kinetics parameters such as E and A, metallurgical systems in kinetic analysis and rate laws, empirical and semi empirical approaches, rate of thermally activated reactions, mechanistic approach in kinetic analysis, diffusion in crystals, diffusion mechanisms in crystals, vacancy; interstitial; equilibrium concentration in crystal and kinetic analysis

Topic 3

Time dependency and kinetics

Variations of sigmoid like reactions; kinetic model for nucleation and grain growth in solid state and liquid states; Johnson Mehl equation and its modified version from the perspective of thermodynamics; preliminary treatment of kinetic equations for chemical reactions; reduced time plots and their use

Topic 4

Chemically controlled reactions and diffusion

Chemically controlled reactions and their classifications in metallic systems; Reactions steps and rate controlling steps, reactions between solids and liquids, interfacial reaction control, chemisorptions and total internal reactions, chemical reaction kinetics: order of reactions, Arrhenius equation

Topic 5

Diffusion through reaction layer

Brief introduction to diffusive reactions in solid and liquid state; interface concept and interface formation principles at atomic level; generalized reaction mechanisms leading to segregation process in metallic systems and related rate theories; formation reaction of spherical solid product

Topic 6

Motion of dislocations and interfaces

Definition and determination of motion of dislocations in metallic systems; driving forces for dislocation formations and movements; curvature, osmotic and mechanical forces; dislocation glide; dislocation glide and climb; diffusion limited and source limited kinetics; motion of crystalline interfaces

Topic 7

Morphological evolution due to capillary and applied forces: coarsening and sintering

Capillary forces definition and their effect in the formation of microstructures and liquid systems and mass transfer across a boundary layer; mechanism at the solid liquid layer; concept of mass transfer coefficient; capillary forces and diffusion limited growth; diffusional creep processes, sintering

LEARNING OUTCOMES

Students can explain main kinetically important processes related to metallurgical and materials preparation routes for semi product and final products that can be utilized in industry.
Students can demonstrate competency on various data exploration means for kinetics studies that can be used in both academic and industrially important manufacturing processes.
Students can explain and elaborate on theories and their details by which advanced evaluations are made on microstructures and their constituents.
Students can suggest on kinetics related processes that are used in specific applications and their scientific basis.

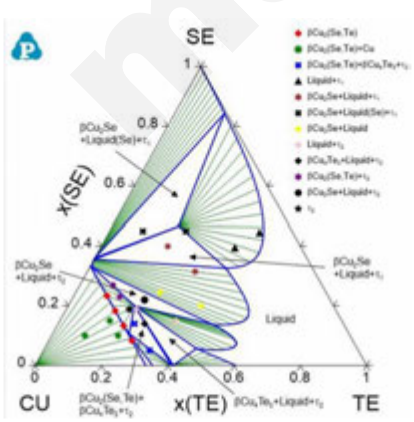
COMMENTS

INSTRUCTOR

DO YOU KNOW

Kinetics in any system is related to the ambient temperature and dominated by diffusion processes. It is interesting that global warming of the world is rather good examples of this process; we can see this in ice cap meltings in Antarctica.

One of the beneficial effects of the kinetics in materials is the manufacturing of single crystal engine blades that use the heat energy to refine the composition by and make a single crystal.



A ternary phase system

Topic 8

Segregation

Introduction to segregation concept and its reactions and the effect of segregations on mechanical and microstructural properties of alloys; segregation reactions during phase changes; lever rule, Scheil equation, zone refining, diffusion at a moving interface, segregation 3 dimensions

Topic 9

Phase transformations kinetics

Definitions of phase diagrams with one and two components including examples from metallic systems; Order-disorder reactions in general and in super regular crystal lattice systems; definitions and continuous and discontinuous transformations and examples; calculations of ordering parameters; decomposition and phase field methods; coherency – strain effects

Topic 10

Nucleation and growth

Introduction to classical theory of nucleation in metallic systems; Gibbs reactions and calculations of energy or the phase changing systems; homogeneous nucleation; heterogeneous reactions; critical nucleus sizes versus undercooling and overheating; transformation effects with and without strain energy

Topic 11

Crystal growth methods

Melting at atomic level; crystal growth principles with thermodynamic background; the concept of melt growth process and its practical applications; floating zone; methods of growth: Bridgman, Chalmers, horizontal gradient; growth from aqueous solution and hydrothermal growth; vapour phase growth

Topic 12

Non equilibrium crystallization of alloys

Non equilibrium metallurgical processes and solid liquid interface advancement parameters; interface roughening in high cooling rates; quasi equilibrium treatment of solutions; computer and analytical model of solidification in non equilibrium solutions, crystallization of glasses from the melt

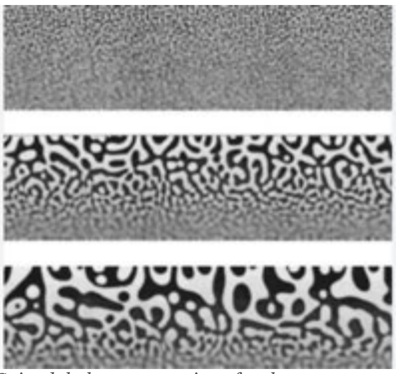
Topic 13

Martensitic reactions and Kinetics in specific applications

Lattice interactions, exchanges of atoms, deformations and related issues during phase changes; definitions of invariant plane strain and its theory and application in high speed phase transformation s i.e. martensitic systems; nucleation of martensite; Glissile interface; examples of martensitic reactions

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

None



Spinodal phase separation of a glass

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. Jackson, K. A., Kinetic processes, 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 20 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding phase transformations and alloy systems.

GRADING POLICY

During case study and end class activity, students will be given a topic to prepare an essay and they should submit 7 different essay reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points but contributes to 30% of total sum of marks. The average of 7 reports will be taken as a Report score.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

THEORY OF WELDING AND JOINING TECHNIQUES FOR INDUSTRIAL MATERIALS

Code: TWJTIM

Field of study
Materials Science and Engineering

Level of study
Master Study

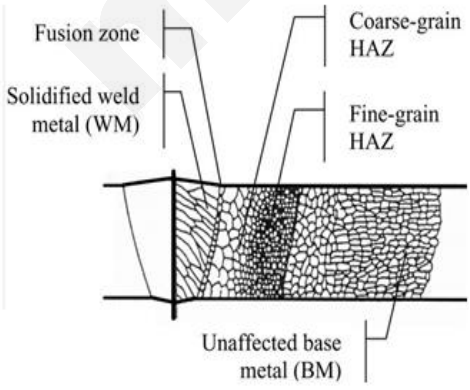
Semester
2

Language
English

Thematic block
Materials and Manufacturing

Form of tuition and number of hours*:
Lecture: 42 h

ECTS
6



Heat Affected Zones of arc welds

COURSE DESCRIPTION

The joining process of materials is the most practiced field of industry due to the need for producing intrinsic shapes and practicality. The first set of lectures will introduce the basics of welding and joining processes and their related micro and macro definitions. The course later proceeds towards details about principles of important joining methods with more detail about their mechanical and physical properties researched over the years. The course will also cover the other industrial joining processes.The joining of materials is the fundamental component in a product, part, or process creation alongside forming. Most materials are formed, assembled, fastened, glued, or somehow else attached by two or more components. The methods used to join industrial materials can be classified in many different ways depending on the joint needs to be permanent or semi-permanent. In general, permanent joining of materials is dominantly preferred in industry; these include welding, brazing, soldering, riveting, adhesives, knock-down fittings. Emerging trends in manufacturing such as light weighting, increased performance and functionality increases the use of multi-material, hybrid structures and thus the need for joining of dissimilar materials. The properties of the different materials are jointly utilized to achieve product performance. The joining processes can, on the other hand be challenging due to the same different properties. The lecture is intended to increase the awareness of students to relate the microstructural properties of materials with bulk and surface properties. Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different techniques available for joining of various materials systems by giving detailed background principles with a theoretical decoration of the subjects. By the end of the course, students will be able to know the operating principles of main joining techniques and their applied background in detail. Students will also gain an understanding of the background of the non arc joining techniques and deformation that are commonly used for the joining of industrial structural materials, their bulk properties and their quantitative relationships with microstructures.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can present broad knowledge of main joining methods and their parametric, operating and working principles with respect to their importance in industry.
MS_O_02	Can explain on principles of an arc welding and the effect of plasma formation and gas metal reactions in plasma on microstructural and other important properties of the welds.
MS_O_03	Can elaborate on non arc methods some which are becoming more popular due to their practicality and accuracy with methods that are proven to be effective in joining different metals and materials.
MS_O_04	Can differentiate between methods of use for special case and with respect to the class of materials being joined.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** critical analysis, synthesis and conclusions; individual and team work	MS_O_01, MS_O_02, MS_O_03, MS_O_04
Meth_03	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_02, 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	39	Exam	MS_O_01, MS_O_02, MS_O_03, MS_O_04	Meth_01, Meth_03
FT_02	Essay preparation	3	Course work	MS_O_01, MS_O_02 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 the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

LEARNING OUTCOMES

Students are expected to gain broad knowledge of main joining methods and their parametric, operating and working principles with respect to their importance in industry.
Students are expected to gain knowledge of theoretical principles of arc welding and the effect of plasma formation and gas metal reactions in plasma on microstructural and other important properties of the welds.
Students are expected to gain knowledge on non arc methods some which are becoming more popular due to their practicality and accuracy with methods that are proven to be effective in joining different metals and materials.
Students are expected to differentiate between methods of use for special case and with respect to the class of materials being joined.

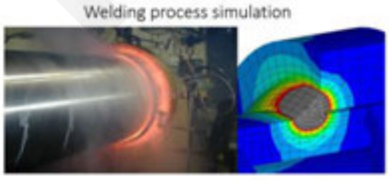
COMMENTS

LECTURER

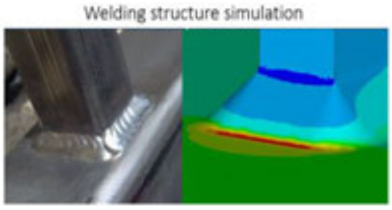
DO YOU KNOW

Resistance spot welding is the oldest and most commonly used in the automobile industry. Some say that it has nearly been used in the auto sector for about 150 years. On average, an ordinary car has about 5,000 spot welds for joining different metal sheets and add-ons.
Spot welding has become a staple welding process in manufacturing and assembly, especially in the sheet metal fabrication sector and automotive industry. Suitability for automation plays a big part in its rise in popularity as robotic spot welding excels at speed and efficiency.

Welding process simulation



Welding structure simulation



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

Topic 1

Welding, joining, weldability of materials

Definition of welding processes in general and joining capacity of materials available in industry; the need for joining; reliability in joining and welding; classification of welding and joining processes; atomistic approach to joining and welding; definition of weldability and joinability

Topic 2

Arc, plasma and reactions with gases

Electrical discharge and plasma formation between high voltage and high current electric fields; electric current and voltage drop across the plasma; the formation of heat and transfer efficiency; heat transfer over the weld zone; gas – metal reactions in the plasma and its effect on the weld metal composition

Topic 3

Arc welding of metallic materials

Fusion zone in weld joints and sub regions of a fusion zone; slow and fast solidification of a weld metal; solid phase separation; macroscopic aspects of weld metal solidification; effect of travel speed and temperature gradient; microscopic aspects of weld metal solidification; HAZs and recystallization and grain growth

Topic 4

Arc welding: electrode, carbon arc & Submerged Arc Welding

Brief definition of arc welding methods of carbon and submerged arc welding with historical background; theoretical background and parametric principles of arc welding with electrode; operational principles, types, consumables and comparative cross table; mechanical and physical properties of joints; defect formation and prevention suggestions

Topic 5

Arc welding: GMAW, TIG and plasma arc welding

Brief definition of methods of GMAW, TIG and plasma arc welding with historical background; theoretical background and parametric principles; operational principles; types, consumables and comparative cross table; mechanical and physical properties of joints; defect formation and prevention suggestions

Topic 6

Non arc joining techniques and principles: High energy beam welding

Brief definition of high energy beam and related joining methods with historical background; theoretical background and parametric principles; operational principles; types, consumables and comparative cross table; mechanical and physical properties of joints; defect formation and prevention suggestions

Topic 7

Solid state welding: diffusion bonding

Non arc welding principles and definitions; solid state welding basics: diffusion bonding; joinability definitions for diffusion solid state welding with historical background; theoretical background and parametric principles of DB; operational principles; types of consumables and comparative cross table; mechanical and physical properties of joints; defect formation and prevention suggestions

LEARNING OUTCOMES

Students are expected to gain broad knowledge of main joining methods and their parametric, operating and working principles with respect to their importance in industry.

Students are expected to gain knowledge of theoretical principles of arc welding and the effect of plasma formation and gas metal reactions in plasma on microstructural and other important properties of the welds.

Students are expected to gain knowledge on non arc methods some which are becoming more popular due to their practicality and accuracy with methods that are proven to be effective in joining different metals and materials.

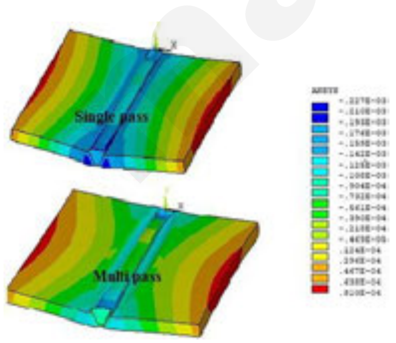
Students are expected to differentiate between methods of use for special case and with respect to the class of materials being joined.

COMMENTS

INSTRUCTOR

DO YOU KNOW

TIG welding was created during the 1940s by a welder named Russell Meredith who worked for Northrop Aircraft Corporation in Southern California. He created the technique because the methods of the day were inadequate for welds on aluminum and magnesium alloys.



Modelling of single and multipass arc welds

Topic 8

Solid state welding: ultrasonic, friction and cold welding

Brief definition of methods of ultrasonic, friction and cold welding processes with historical background; theoretical background with atomic interactions and parametric principles; operational principles of processes; types of consumables and comparative cross table; mechanical and physical properties of joints; defect formation and prevention suggestions

Topic 9

Resistance welding: spot, projection and flash welding

Brief definition with historical background of resistance spot, projections and flash welding methods; spot welding equipment and its examples from industry; parametric and operational principles; types, consumables and comparative cross table; mechanical and physical properties of joints; defects and prevention suggestions

Topic 10

Other welding methods: Gas-fuel and thermite welding

Brief definition of gas fuel and thermite welding methods; historical background and present need analysis of gas fuel and thermite welding processes; theoretical background and parametric principles welding operation; consumables and comparative cross table; mechanical and physical properties of joints; defects and prevention suggestions

Topic 11

Adhesives and adhesive bonding

Brief definition of adhesives and related bonding methods; historical background on adhesives and their applications; theoretical background and parametric principles; operational principles of bonding; types, consumables and comparative cross table; mechanical and physical properties of joints; defects and prevention suggestions

Topic 12

Soldering and brazing

Brief definition of soldering and brazing methods with historical background; theoretical background with specific attention to wetting of surfaces; parametric and operational principles; types, consumables and comparative cross table; mechanical and physical properties of joints; defects and prevention suggestions

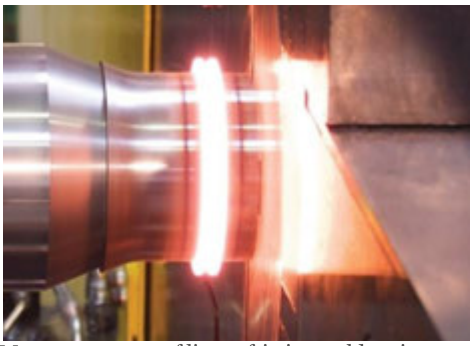
Topic 13

Joining methods for exemplary structural applications and material properties

Introduction of potential industrial materials divided into categories such as plastics, metals and alloys, composites, as well as structural materials; In addition to a general perspective on the joining of structural materials and alloys, light alloys and materials, and hybrid structures, as well as reactive materials and alloys for industrial applications, a brief description of the joining methods will be given, and information will be given on the capacities of joining a large number of materials and material systems.

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

None


Macrosturucture of linear friction weld region with dissimilar materials

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. R. W. Messler; Principles of Welding Processes Physics Chemistry and Metallurgy, (1999 Edition), Wiley

2. J. C. Lippold, Welding metallurgy and weldability, 2015, Wiley

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding welding method or weld microstructures.

GRADING POLICY

During lectures, students should submit 7 different essay reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 reports will be taken as a essay report score. Students will get 30% from midterm and 40% from final exams to be contributed to the sum of marks.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

NUMERICAL SIMULATIONS FOR METAL PROCESSING

Code: NSMP

Field of study
Materials Science and Engineering

Level of study
Master Study

Semester
2

Language
English

Thematic block
Computational methods and their applications in materials science

Form of tuition and number of hours*:
Lecture: 45 h

ECTS
6


Shaping of sheet metals with mold press

COURSE DESCRIPTION

Numerical simulation of production systems help engineers move from trial and error to computer simulation software to build quantitative models and give qualitative understanding of the studied problems. The first set of lectures will introduce the fundamental background of numerical analysis such as finite element analysis methods and plastic forming of metals into desired shape. The lecture will proceed towards detailed cutting and bulk forming and also semi solid forming techniques. The course will also cover the pressure assisted forming of metals which are widely used in aluminum industry.

It is frequently necessary to obtain quantitative measurements and simulations for a mechanical or metallurgical process to be successful and also to compare experimental observations with theoretical or experimental predictions. It is an endeavoring work to calculate out the results for any industrially compelling procedure using mathematical expression but easier to carry out using software and complex processes such as forging, forming and welding can be accurately modeled and simulated. Extreme conditions which are difficult to perform can also be modeled with very small cost and time. This course is intended to increase the awareness of students to relate the mechanical properties of materials which can be modeled using numerical methods with shaping and forming of materials in the form of sheet or bar etc... The case studies given in every lecture is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 45 hrs of in class training and learning and 68 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different techniques available for structural analysis and modelling of various materials and metal manufacturing and forming process. By the end of the course, students will be able to differentiate between techniques by which materials are shaped with a focus on specific numerical and computerized analysis. Students will gain an understanding of the background of the basic forming techniques and modeling that are commonly used for industrial materials and metals.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic and mechanical properties of materials prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain how to correlate metal processing and mechanical properties and types of processing methods and metals, alloys and some materials.
MS_O_02	Can elaborate on various numerical analysis techniques through mathematical expression via finite element qualitative and quantitative analysis on common industrial manufacturing problem.
MS_O_03	Can explain methods by which metals and alloys are processed; the processing principles of these methods and their general applications in industry.
MS_O_04	Can analyse and explain modeling applications of industrially classified metals and alloys processing techniques or methods.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** critical analysis, synthesis and conclusions; individual and team work	MS_O_01, MS_O_02, MS_O_03, MS_O_04
Meth_03	Programming Methods: Work with computer	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	Lecture	39	Exam	MS_O_01 MS_O_02 MS_O_03 MS_O_04	Meth_01, Meth_03, Meth_04
FT_02	Work with computer	3	Course work	MS_O_02	Meth_02, Meth_03
FT_03	Essay preparation	3	Course work	MS_O_02, MS_O_03	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 the subject by reading the lecture sources	NO
a_02	Computer use	Preparation of the exercise report	YES
A_03	Preparation of reports	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

LEARNING OUTCOMES

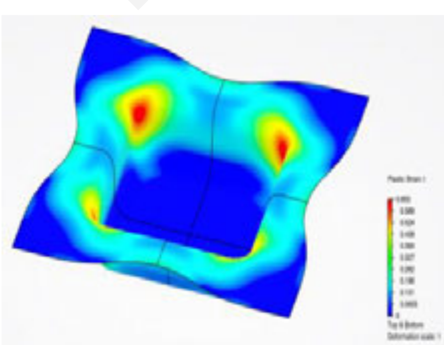
Students are expected to gain knowledge of how to correlate metal processing and mechanical properties and types of processing methods and metals, alloys and some materials.
Students are expected to gain knowledge of various numerical analysis techniques through mathematical expression via finite element qualitative and quantitative analysis on common industrial manufacturing problem.
Students are expected to gain knowledge on methods by which metals and alloys are processed; the processing principles of these methods and their general applications in industry.
Students are expected to gain knowledge on modeling applications of industrially classified metals and alloys processing techniques or methods.

COMMENTS

LECTURER

DO YOU KNOW

One of the great benefits of finite element analysis is that it allows for the safe simulation of conditions that may be dangerous or difficult to replicate in a physical test environment. It is very detrimental to calculate the volume changes and dimensional stability of sheet metals and mould that are used to shape the metal sheets in manufacturing conditions. It is becoming a must have tool for fabricators and even small manufacturing companies to showcase their products and also their ability to produce difficult and complicated shapes.



Deep drawing modeling of a sheet metal

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

Topic 1

Introduction to forming and processing of metals

This lecture provides an extensive exploration of metal forming and processing. It begins with examining metal production, detailing the extraction, refining, and initial casting of metals into primary forms like ingots, billets, and slabs. The lecture then targets various metal forming techniques, distinguishing between bulk forming methods such as forging, extrusion, and rolling, and sheet forming processes, including bending, deep drawing, and stamping. This lecture is structured to provide a thorough and practical understanding of the various aspects of metal forming and processing.

Topic 2

Mechanical principles of forming and shaping

This topic is designed to understand the complexities of forming and shaping metallic materials. It emphasizes the critical production processes that involve deforming metals into specific forms and sizes, maintaining their inherent material qualities. The lecture also addresses hot working, the process of shaping metals at temperatures above their recrystallization points and highlights how metals become more ductile and easier to deform at these elevated temperatures. This section also considers the advantages of hot working in enhancing grain structure and mechanical properties, alongside the need for precise temperature control.

Topic 3

Numerical analysis principles and ANSYS

This lecture focuses on the principles and applications of numerical analysis in engineering and physical sciences. The lecture begins by highlighting how computerized analysis has expanded numerical analysis capabilities, enabling complex computations and simulations that were once unfeasible. The practical application of these methods is exemplified through engineering simulation software, primarily ANSYS. The lecture introduces ANSYS as an integrated platform for FEM and BEM, suitable for a wide range of engineering applications

Topic 4

Sheet metal forming and springback problem

This topic comprehensively covers the techniques and challenges of shaping metal sheets into various forms and sizes. The lecture discusses the fundamentals of sheet metal forming, including bending, stretching, and compressing metal to achieve desired shapes. Different forming techniques like deep drawing, bending, and stretching are discussed, each selected based on the desired product shape and the specific properties of the metal being used. Additionally, the evolution of technology in sheet metal forming is examined, emphasizing how advanced machinery and computational tools have enhanced the precision and efficiency of these operations

Topic 5

Rolling, forging and extrusion processes

This part of the lecture is centered on the fundamental metal-forming processes of rolling, forging, and extrusion, each critical to modern manufacturing. The lecture begins by examining rolling, a widely used process where metal stock is passed through rolls to reduce and uniformize its thickness and impart desired mechanical properties. The roll force and torque variables are explored, influenced by roll geometry, friction at the roll-material interface, and material properties. The focus is on how the deformation of the material during rolling is modeled using principles of plasticity and elasticity

LEARNING OUTCOMES

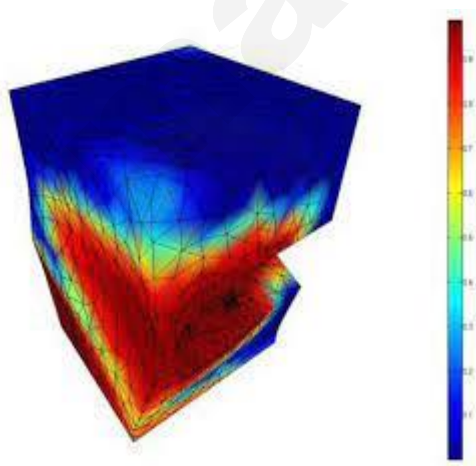
Students are expected to gain knowledge of how to correlate metal processing and mechanical properties and types of processing methods and metals, alloys and some materials.
Students are expected to gain knowledge of various numerical analysis techniques through mathematical expression via finite element qualitative and quantitative analysis on common industrial manufacturing problem.
Students are expected to gain knowledge on methods by which metals and alloys are processed; the processing principles of these methods and their general applications in industry.
Students are expected to gain knowledge on modeling applications of industrially classified metals and alloys processing techniques or methods.

COMMENTS

LECTURER

DO YOU KNOW

Metal forming is a process where materials are subjected to plastic deformation to obtain the required size, shape, and/or change the physical and chemical properties. Metal forming is divided into two groups, bulk forming, and sheet forming. Bulk forming process is usually preferred for voluminous parts that require great changes in shape and volume but sheet metal forming is usually employed to produce automotive parts etc..



Simulation of crack initiation

Topic 6

Cutting process

This course segment addresses the cutting process of metals, an essential element in manufacturing and engineering. The lecture introduces the fundamental concepts of shear force and stress, the driving forces in metal cutting. It explains how shear force causes material layers to slide past each other and how shear stress resists this sliding. The importance of these forces is emphasized in mechanical cutting techniques such as milling and turning, where hard and sharp tools remove material through cutting deformation

Topic 7

Semi solid metal processing

This lecture's topic is Semi-solid Metal Processing (SSMP), a notable advancement in metalworking technology. SSMP, distinct from traditional methods, processes metals in a semi-solid state, exhibiting both solid and liquid characteristics. This state is achieved by heating the metal to a temperature where it partially melts, forming a slurry-like mixture of solid particles in a liquid matrix. The lecture emphasizes the energy efficiency of SSMP, as less force is needed to shape metals in this state, and its ability to precisely control the alloy's microstructure enhancing mechanical properties like strength and ductility. Through this lecture, students comprehensively understand SSMP, its applications, and its significant impact on modern metal forming and manufacturing processes.

Topic 8

Welding and molten metal operations

This lecture comprehensively covers the field of welding, a fundamental process in joining materials, primarily metals and thermoplastics. It introduces welding basics, including the coalescence of materials through melting and adding filler material to form a strong joint. Various welding methods, each with specific applications and advantages, are elaborated. The selection of a welding process is discussed in the context of material type, thickness, and desired joint strength. Overall, the lecture provides an in-depth understanding of welding processes, specialized techniques, and the role of advanced software in enhancing the precision, reliability, and efficiency of welding and casting operations in the metalworking industry

Topic 9

Electromagnetic and explosive metal forming

This lecture covers the advanced manufacturing techniques of electromagnetic and explosive metal forming, which have revolutionized industrial processes, especially in sectors requiring precision and complex shaping of metals. These methods stand out for their efficiency and capability to form complex shapes, which are challenging to attain through traditional forming techniques. The lecture series provides a comprehensive understanding of electromagnetic and explosive metal forming, emphasizing their applications, advantages, and the science behind these innovative manufacturing techniques.

Topic 10

Particulate material forming

This segment of the course addresses the topic of particulate material forming, a key component in modern manufacturing, and powder metallurgy. The lecture explores powder manufacturing, covering metals, ceramics, and composites. It highlights how the properties of these powders, including size, shape, and distribution, are crucial in defining the characteristics of the final product. Various powder production methods and their impact on powder properties are detailed. It presents a detailed overview of how these diverse processes and advancements contribute significantly to modern manufacturing, providing customized solutions with enhanced material properties.

Topic 11

LEARNING OUTCOMES

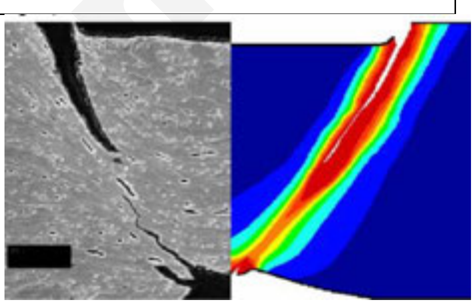
Students are expected to gain knowledge of how to correlate metal processing and mechanical properties and types of processing methods and metals, alloys and some materials.
Students are expected to gain knowledge of various numerical analysis techniques through mathematical expression via finite element qualitative and quantitative analysis on common industrial manufacturing problem.
Students are expected to gain knowledge on methods by which metals and alloys are processed; the processing principles of these methods and their general applications in industry.
Students are expected to gain knowledge on modeling applications of industrially classified metals and alloys processing techniques or methods.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Time and money are precious commodities to any business, and the advantages of the finite element analysis method mean that time, effort and costs are saved. In addition, improved efficiency and accuracy prevent expensive mistakes; without using this method, there is the risk that products will not perform as they are intended.



Damage development during scoring

Fundamentals of metal machining and tools

This lecture covers the topic of metal machining, a vital process in the manufacturing industry for shaping and finishing metal parts with precision and accuracy. The topic addresses various machining operations designed for specific shapes and finishes. Turning, an essential operation, involves cutting a rotating workpiece with a stationary tool, typically on lathes, and is crucial for producing cylindrical parts. The lecture focuses on critical parameters in turning, such as cutting speed, feed rate, and depth of cut, which significantly influence the part's surface finish and dimensional accuracy. This lecture thus equips students with a comprehensive understanding of metal machining, including operational parameters, tool design, and material behavior, crucial for manufacturing success.

Topic 12

Production and forming of lightweight alloys

This section focuses on the role and processing of lightweight alloys in modern engineering and manufacturing. These alloys, crucial in industries like aerospace, automotive, and defense where weight reduction is essential, include materials such as aluminum, magnesium, titanium, and their composites. The lecture begins with an examination of the properties of these alloys. Aluminum alloys are noted for their strength-to-weight ratio, corrosion resistance, and formability; magnesium alloys for their lightweight and high strength and stiffness; and titanium alloys for their exceptional strength and high-temperature performance. In conclusion, the lecture provides an in-depth understanding of lightweight alloys, their properties, manufacturing challenges, and processing techniques

Topic 13

Injection and pressure assisted forming

This lecture explores injection and pressure-assisted forming of metals in advanced manufacturing processes that shape materials under high-pressure conditions. These methods have transformed the production of complex metal parts, enhancing material properties and design flexibility. A detailed look at techniques like hydroforming, injection molding, Hot Isostatic Pressing (HIP), and Cold Isostatic Pressing (CIP) is included, which use fluid or gas pressure to shape or densify metal and metal powders at various temperatures. Case studies are presented to illustrate the effectiveness of these forming processes in industries like automotive and aerospace. Examples include hydroformed components in automotive chassis and aerospace applications of HIP for manufacturing critical turbine components with enhanced properties

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

None

Co-funded by the European Union


sheet metal engine part made by superplastic forming and diffusion bonding

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. Sinan Müftü, Finite Element Method: Physics and Solution Methods (2022 Edition) Academic Press.

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Essay Reports: Case reports, which constitute 30% of total marks, are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding modeling of shaping method or microstructures.

GRADING POLICY

The average of 7 reports will be taken as a Report score. During the classroom study or working with computer, students should submit 7 different essay reports. The average of 7 reports will be taken as essay report score. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Students will get 30% from midterm and 40% from final exams to be contributed to the sum of marks.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

WEAR PREVENTION AND IMPROVEMENT OF SURFACE PROPERTIES

Code: WPISP

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: 42 h

ECTS

6

Surface wear of steel rollers due to fretting

COURSE DESCRIPTION

Wear can be defined as the damage or removal of material that a solid surface has undergone due to sliding, rolling, or impacting against another solid surface. It is not a material property, but rather a system response. Typically, wear is undesirable as it can lead to increased friction, and ultimately to material failure or loss of functionality. For this, the first set of lectures will introduce the fundamental issues of surface characterization and properties and wear of surfaces involving main causes such as abrasion, adhesion and fatigue etc… The course will also cover the in depth analysis of wear mechanisms and measuring the friction related values using experimental techniques. Tribology is the science that studies friction, wear, and lubrication of touching surfaces in relative motion. It relies on concepts coming from materials science, physics, and chemistry among others, making it a multidisciplinary domain. From these three points (friction, wear, and lubrication), wear constitutes a large concern for industrials, as it accounts for over 50% of loss of machine usefulness. Therefore, controlling the conditions that affect it would not only prevent machine failure, but would ultimately allow optimizing the industrial process. The lecture is intended to increase the awareness of students to relate the properties of materials with service life and wear of parts when used as a part of mechanical systems or extreme conditions. All lectures contain experimental and in situ examples showing wear and related microstructures dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience. Students are expected to spend 42 hrs of in class training and learning and 65 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about wear and wear mechanisms focusing on metallic and non metallic materials. This course also presents different techniques available for the characterization of wear mechanisms through some analytical and technical means. By the end of the course, students will be able to differentiate between wear mechanisms and will gain an understanding of the background of the surface protection and prevention.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials and microstructures prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain wear in metallic and non metallic systems and their mechanisms with respect to type of alloy and other materials.
MS_O_02	Can explain basic causes of causes of wear and their technical background in order to differentiate between various mechanisms of wear.
MS_O_03	Can elaborate on the procedures for surface protection techniques such as hardfacing and hard layer formation in addition; the effect of lubrication is also within the scope of this course.
MS_O_04	Can select the alloys and materials that are resistant to wear and the use of them to make wear prediction of materials with experimental techniques available to researchers.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_01, MS_O_02, 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	39	Exam	MS_O_01, MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	3	Course work	MS_O_01, MS_O_02 MS_O_03	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	Query of materials and review of activities necessary to participate in classes.	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students are expected to gain knowledge of wear in metallic and non metallic systems and their mechanisms with respect to type of alloy and other materials.
Students are expected to gain knowledge of basic causes of causes of wear and their technical background in order to differentiate between various mechanisms of wear.
Students are expected to gain knowledge on surface protection techniques such as hardfacing and hard layer formation in addition; the effect of lubrication is also within the scope of this course.
Students are expected to gain knowledge on the alloys and materials that are resistant to wear and the use of them to make wear prediction of materials with experimental techniques available to researchers.

COMMENTS

LECTURER

DO YOU KNOW

A materials science team has engineered a platinum-gold alloy believed to be the most wear-resistant metal in the world. It's 100 times more durable than high-strength steel, making it the first alloy, or combination of metals, in the same class as diamond and sapphire, nature's most wear-resistant materials. In truth, the combination of 90 percent platinum with 10 percent gold isn't new at all.

Surface hardfacing for wear prevention

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

Topic 1

Introduction to surface characterization and tribology

Introduction to surface energy concept and atomic representation of surfaces; tribology and its types; hardness introducing mechanisms and morphology of surfaces; wetting behaviour with different substances; the effect of microstructure on the surface roughness, polishing effect; hardening effect on the surface of metals, plastic and ceramics surfaces

Topic 2

Friction on surfaces

Principles of friction and its action mechanisms on a surface; surface- to- surface interactions under load and strain, atomistic approach to surfaces under load, coefficients obtained from surface tests; friction and resulting surface degeneration; dry sliding process: heat generation process and its effect on friction

Topic 3

Lubrication of surfaces and lubricants

Lubrication process and its cons and pros; reduction of shear stress to allow relative motion on a surface; friction and surface degeneration on luvircated surfaces; lubrication types: solid, liquid and gas, lubrication film; atomistic mechanisms for prevention of wear using lubricants, tribo-corrosion and passive layers

Topic 4

Wear processes

Wear definition and its cost in industrial applications; the definitions and examples of abrasion, adhesion, erosion and corrosion processes aiding to wear in mechanically working components; mechanisms involving four main causes, i.e. abrasion, adhesion, erosion and corrosion in addition to fretting and fatigue wear

Topic 5

Wear of ceramics and polymers

Wear processes occurring on non metallic materials such as ceramics, polymeric materials and composite materials; introduction to atomic structure of ceramics and polymeric materials, various properties of polymers and ceramics; wear mechanisms in ceramic materials, wear mechanisms in polymeric materials

Topic 6

Surface protection technologies 1

Introduction to surface modification processes available in industry; theory and practice of wear resistance surfaces: strain hardening and mechanically deformed surfaces, microstructural treatment, laser surface hardening, electron beam surface hardening, local heat treatment processes for surface hardening

Topic 7

Surface protection technologies 2

Theory of thermochemical process and determination of layer thickness; various thermochemical surface modification processes available for industry for applications regarding the manufacturing various parts or components: atmospheres and application notes for nitriding, boriding, carburizing, results and evaluation

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LEARNING OUTCOMES

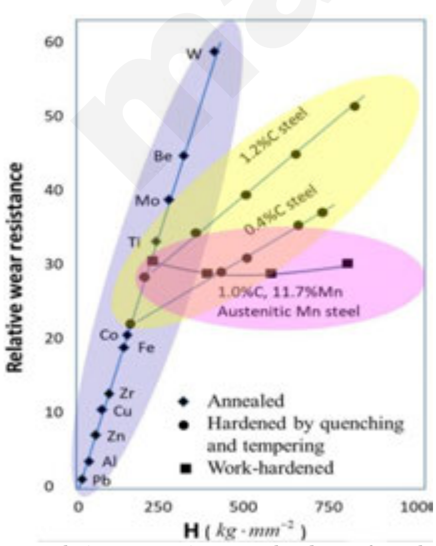
Students are expected to gain knowledge of wear in metallic and non metallic systems and their mechanisms with respect to type of alloy and other materials.
Students are expected to gain knowledge of basic causes of causes of wear and their technical background in order to differentiate between various mechanisms of wear.
Students are expected to gain knowledge on surface protection techniques such as hardfacing and hard layer formation in addition; the effect of lubrication is also within the scope of this course.
Students are expected to gain knowledge on the alloys and materials that are resistant to wear and the use of them to make wear prediction of materials with experimental techniques available to researchers.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Wear in machine elements, together with other processes such as fatigue and creep, causes functional surfaces to degrade, eventually leading to material failure or loss of functionality. Thus, wear has large economic relevance in any industry. Abrasive wear alone has been estimated to cost 1-4% of the gross national product of industrialized nations.



Relative wear resistance vs hardness of metals

Topic 8

High temperature tribology

Principles of tribological processes at room temperature and high temperature tribology with a critical comparison; high temperature behaviour of materials and surfaces; working principles of tribometers for high temperatures and resulting chemical effect on surfaces and tribological outcomes

Topic 9

Effect of surface and manufacturing conditions for friction

Surface roughness definitions, parameters and the effect surface roughness on wear and wear volume loss; definition of porous surfaces and materials; powder metallurgy products and their surface properties; wear of arc welded specimens, wear of laser welded specimens, wear of mechanically alloyed and sintered specimens

Topic 10

Friction and adhesion measurement devices

Principles and theory behind the static friction concept and its measurement methods; theory of dynamic friction process and dynamic friction testers, the calculation of coefficient of friction; examples on how to make a simple device to measure the coefficient of friction, dry and lubricated sliding

Topic 11

Design of surfaces against wear

Wear resistant design principles in metallic and non metallic materials for various applications in industry and special cases; short introduction to wear resistant materials, wear resistant coatings & surface treatments; design examples for better wear resistive surfaces

Topic 12

Wear resistant materials and coatings tribology, thin (film) coatings

Wear resistant materials in general and theory of wear resistance for surface and matrix; the concept of coating tribology with application examples; tribological contact processes; coating with high hardness and carbide containing alloys and compounds; thin coatings and characterisation

Topic 13

Life cycle and surface wear: cost and assumption

An introduction to life cycle of metallic and non metallic components; the wear cycle in industrial components and their effect on cost determination; prognosis of surface wear, methodologies for wear prognosis, economics of surface modification processes with real industrial examples

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

None

Surface fatigue wear during sliding on metals

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. P. J. Blau, Tribosystem Analysis - A Practical Approach to the Diagnosis of Wear Problems. CRC Press, 2016

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics regarding wear and its prevention, surface modifications.

GRADING POLICY

During the lectures, students should submit 7 different essay reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 reports will be taken as a essay report score. Students will get 30% from midterm and 40% from final exams to be contributed to the sum of marks.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

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MATERIALS FOR ELECTRONICS AND SENSORS

Code: MES

Field of study
Materials Science and Engineering

Level of study
Master Study

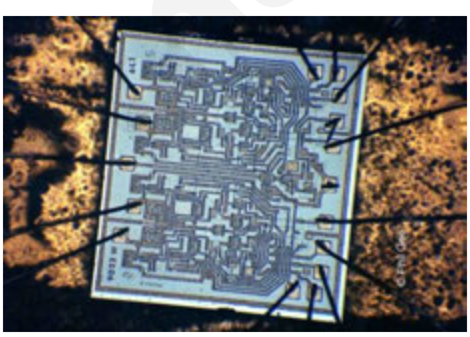
Semester
3

Language
English

Thematic block
Applied Materials Science

Form of tuition and number of hours*:
Lecture: 42 h

ECTS
3



... total of 3.1 billion transistors on a chip measuring 18.2mm x 29.9mm.

COURSE DESCRIPTION

The electronic component industry is mostly dependent on advances in materials science and engineering for developing improved and better performing semiconductors, magnetic, piezzo, pyro materials, and superconductors. For this, the first set of lectures introduces the fundamentals of electronic structure and general intrinsic and derived properties of materials. The course also covers the basics of sensors and sensory materials and their utilization in detecting the certain properties of materials under external and internal effects.

It is frequently necessary to obtain quantitative and qualitative measurements of internally occurring and externally inflicted reactive features to determine certain values from experimental observations and verify with theoretical predictions. The use of appropriate sensors for such incidents require a broad knowledge of how and what these sensors measure. It is also interesting that superconductivity and piezzo effect of certain materials are first discovered and used by materials scientists for low level of applications, however, it is now almost delinquent to deny the fact that such materials are largely employed by measuring the weight of commercial plane and also moves the laser beam into position by 0.0001 mm precision to make sure that correct line is selected. This lecture is intended to increase the awareness of students to relate the electronic properties of materials with measurable properties such as magnetism, heat, strain and radiation of any sort. The last section of the course is dedicated to sensors and their operating principle in addition to measurement values obtained from such devices Students are expected to spend 42 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview about different electronic properties of materials available for structural and specific applications in various sensory device systems. By the end of the course, students will be able to know how sensors work and what they measure in response to externally and internally occurring reaction. Students will gain an understanding of the background of the specific electronic materials that are commonly used for the high end technical applications such as superconductors.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain how externally inflicted defects of any kind and intrinsic properties of materials affect the electronics properties that are in question.
MS_O_02	Can fully explain of various qualitative and quantitative measurements by sensors and use the measured data to determine some properties of materials being tested.
MS_O_03	Can suggest and define the structure and capacity of materials by which technically advanced electronic components are produced.
MS_O_04	Can determine and define the semiconductors, passive and active electronic components and working principle of these components.

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, MS_O_03, MS_O_04
Meth_02	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_01, 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	39	Exam	MS_O_01, MS_O_02 MS_O_03, MS_O_04	Meth_01
FT_02	Essay preparation	3	course work	MS_O_01, 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	Preparation for classes	Preparation for the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

Students can explain how externally inflicted defects of any kind and intrinsic properties of materials affect electronics properties that are in question.
Students can fully explain of various qualitative and quantitative measurements by sensors and use the measured data to determine some properties.
Students can suggest and define the structure and capacity of materials by which technically advanced electronic components are produced.
Students can determine and define the semiconductors, passive and active electronic components and working principle of these components.

COMMENTS

LECTURER

DO YOU KNOW

A typical semiconductor fabrication plant, or fab, will use as much power in a year as about 50,000 homes. In fact, the larger "megafabs" can consume more electricity than auto plants and refineries. Some facilities have even built their own captive power plants. While the power consumed by semiconductor chips has been reduced significantly in the past decade, improvements in the energy used during the chip-production process have lagged behind. Energy costs can account for 5 to 30 percent of fab operating expenses, depending on local electricity prices.

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

Topic 1

Introduction to electronic materials and role of defects

Electronic properties and devices, production of single crystals, electronic structure of materials at atomic levels, defects in crystals, Thermodynamic basis for defects, defect types; dislocation movement, edge and screw dislocations, dislocation motion, planar defects: twin boundaries and grain boundaries, 3D defects

Topic 2

Electronic structures of solids

Electromagnetic waves and background information on the wave definitions; electrons and wave function relationship; energy bands and graphical representation of real energy band structures; other aspects of electron energy band structure, Fermi energies with specific relation to conductivity

Topic 3

Diffusion in solids and electronic materials

Solid state diffusion in metals, gases and liquids; Atomistic theory of diffusion, diffusion barriers, random walk problem and other mass transport mechanisms; steady state and non steady state diffusion regimes; diffusion definition in conductors and their effect on conductivity and superconductivity

Topic 4

Assembly, miniaturisation, hybridisation in microelectronics

Classification of custom and non-custom materials for microelectronics; classification of miniaturisation processes; hybrid circuits and their structure, printed and wired boards and their development; chip design and its productions; commercial, military and space applications, assembly problems

Topic 5

Semiconductors

Historical background of semiconductors; semiconductors: intrinsic and extrinsic semiconductors, n and p type doping and their working mechanism; temperature dependence of conductivity and self resistance; electronic behaviour of organic materials; detailed production methods of semiconductors

Topic 6

Junctions and devices

Metal – metal junctions and metal semiconductor junctions for diodes and transistors; semiconductor PN junctions and characteristics; zener breakdown; BJT and JFET transistors; LEDs, MOSFETs, solar cells; schottky junction: diodes and solar cells; piezoresistivity, ohmic contacts and thermoelectric coolers.

Topic 7

Magnetic properties and superconductivity

Magnetization effect in matters; natural and noon unnatural magnetic materials and their classification; definitions of ferromagnetism, saturation magnetization and curie temperature; magnetic domains: ferromagnetic materials, soft and hard magnetic materials, superconductivity phenomena

LEARNING OUTCOMES

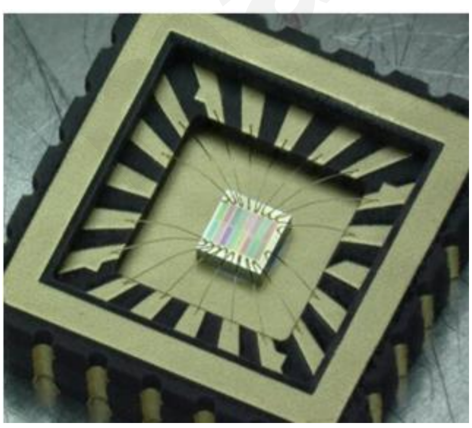
Students can explain how externally inflicted defects of any kind and intrinsic properties of materials affect electronics properties that are in question.
Students can fully explain of various qualitative and quantitative measurements by sensors and use the measured data to determine some properties.
Students can suggest and define the structure and capacity of materials by which technically advanced electronic components are produced.
Students can determine and define the semiconductors, passive and active electronic components and working principle of these components.

COMMENTS

INSTRUCTOR

DO YOU KNOW

Integrated Circuits are made of a mixture of p and n doped layers, from about 0.000005 to 0.1 mm thick that are built on the semiconductor substrate one layer at a time, with perhaps 30 or more layers in a final chip.



Miniature near infrared sensor

Topic 8

Optical properties of materials

Generalised optical properties of materials: definitions and terms; light waves and refractive index of transparent materials; dispersion effect versus wavelength behaviour, magnetic field and its resemblance to light waves; Snell's law and total internal reflection; optical materials and measuring optical properties

Topic 9

Dielectric materials and insulation

Relative permittivity of materials; electronic polarization and relative shift of positive and negative electric charges induced by an external electric field: covalent solids and polarization mechanisms; frequency dependence of dielectric materials; gauss law; capacitor dielectric materials

Topic 10

Piezoelectricity, ferroelectricity and pyroelectricity sensors

Definitions of Piezoelectric, pyroelectric, and ferroelectric materials; dielectric crystals and asymmetric centers; conversion of primary forms of energy in the environment, such as sunlight, mechanical energy, and thermal energy, into secondary energy, such as electricity and chemical energy

Topic 11

Sensors: more information; strain and pressure sensors

Introduction to active and passive sensors and their functions and classifications; mechanical strain and measurement circuits for external forces such as loads and impacts; sensor response under strain and force, load cells, interferometry, fibre optic method, pressure gauges; ionization gauges

Topic 12

Position, direction, distance and motion sensors

Position sensors for reference points and moving objects; magnetic direction sensors and hall effect sensors for magnetic materials and objects; large and small scale distance measurement sensors; LVDT distance sensors, accelerometers, encoders and their working principles; exemplary studies

Topic 13

Radiation sensors

Nature of radiation with detailed definitions; solar radiation; a relationship between radiation, colour and temperature; various nuclear radiation types and the detection of these radations; radiation detecting sensors; dosimetry, principles of working of radiation sensors, ionizing radiation sensors

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

None

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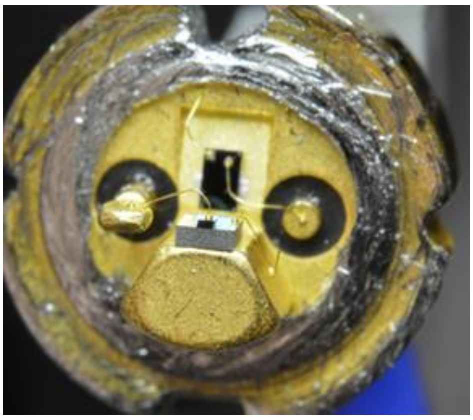


Laser diode case and window removed

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. I. R. Sinclair, Sensors and transducers, Newnes publishing house, Oxford, 2002

2. E. A. Irene, Electronic materials science, Wiley interscience, 2005

Assignment Weights	Percent
Midterm Exam	40%
Final	60%
Total	100%

1 Midterm Exam- max 40 points
1 Final exam – max. 60 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 40% and Final exam contributes to 60 % of total sum of marks.

GRADING POLICY

Students will get 40% from midterm and 60% from final exams to be contributed to the sum of marks.

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

SUSTAINABLE WASTE AND RECYCLING MANAGEMENT IN MANUFACTURING PROCESSES

Code: SWRMMP

Field of study

Materials Science and Engineering

Level of study

Master's Study

Semester

2

Language

English

Thematic block

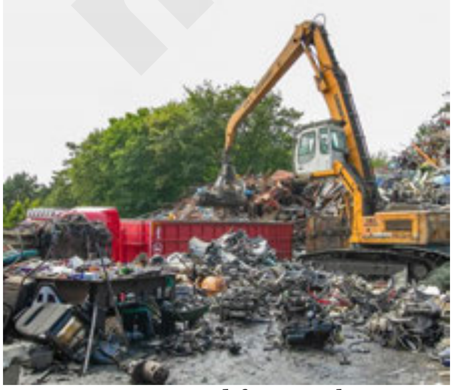
Materials and Manufacturing

Form of tuition and number of hours*:

Lecture: 39h

ECTS

3



Scrapyard for metals

COURSE DESCRIPTION

The metals (and alloys) and materials consumed by the manufacturing industry are in vast amounts by weight and volume to sustain the manufacturing activity at full throat. For this, the first set of lectures will introduce the fundamental issues of waste production in various sectors and the management of waste in terms of self-made regulations and generally accepted precautions imposed by governing bodies. The lecture will then proceed towards details about specific waste management with respect to types of industry. Recycling of metals and alloys in the manufacturing industry is an important part of the saving process. For example, the amount of aluminum available for recycling is estimated to be doubled by 2050, which shows that the metallurgical sector is one of the most sustainable ones and creates a circular economy. Post-consumer scraps contain high levels of elemental contamination and have to be taken into account in more sustainable alloy design strategies. The use of green alloys in industry is encouraged, and this trend may lead to limits on the use of less sustainable materials in future products. The shift from ore reduction to scrap melting requires knowledge of how to deal with multiple scrap-related contaminant elements acting on alloys and how future alloys can be designed to make them scrap-compatible and composition-tolerant. The course is intended to increase the awareness of students to relate the microstructural properties of materials with bulk and surface properties. The experimental section is dedicated to strengthening the knowledge gained during the course and aims to give the best practical experience using real experimental data and images. Students are expected to spend 39 hrs of in class training and learning and 60 hrs of independent work during the course of study.

COURSE OBJECTIVES

The objective of the course is to provide a broad overview of recycling and sustainability techniques available for metal and alloy production of various manufacturing systems. By the end of the course, students will be able to differentiate between techniques by which alloys and materials are recycled for the purpose of specific use. Students will gain an understanding of the background of the techniques that are commonly used for recycling and waste management.

PREREQUISITES FOR TAKING THE COURSE

Students are not required to take any prerequisite course in order to complete this course, but are expected to know the basic properties of materials, metallography, and microscopy prior to starting the course.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Can explain the procedures for waste management in general and the importance of recycling due to global challenges in many industries.
MS_O_02	Can suggest various qualitative and quantitative waste management paths and methodology with respect to the type of materials and respective industries.
MS_O_03	Can elaborate on methods by which major industrial alloys such as Al5xxx and Al2xxx series, stainless and structural steels etc.. are recycled and green alloys are made.
MS_O_04	Can analyse the recycling procedures for dangerous substances and suggest on self made regulations, governing body regulations and globally accepted regulations of waste management and recycling, especially lead containing solders and hazardous chemicals etc...

METHODS OF CONDUCTING CLASSES

Code	Description	Learning outcomes of the program
Meth_01	**Lecture**s: lectures with problem interpretation, interactive lectures with discussion, lectures with multimedia support	MS_O_01, MS_O_02, MS_O_03, MS_O_04
Meth_02	**Lectures:** Problem Methods: Activating methods: a case study	MS_O_01, MS_O_02, 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	39	exam	MS_O_01, MS_O_02 MS_O_03, MS_O_04	Meth_01, Meth_02
FT_02	Essay preparation	3	Course work	MS_O_01, MS_O_02 MS_O_03, MSO_04	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 the subject by reading the lecture sources	NO
a_02	Preparation of reports	Preparation and development of reports. Consultation.	YES

LEARNING OUTCOMES

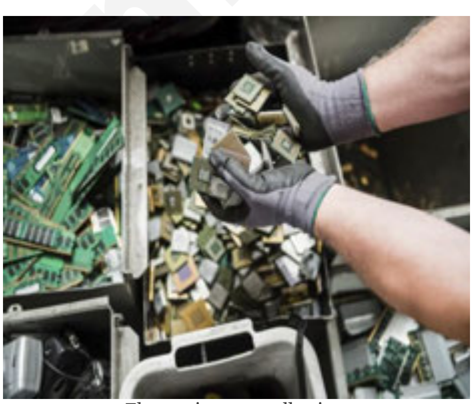
Students are expected to gain knowledge of waste management principles in general and importance of recycling due to global challenges in many industries.
Students are expected to gain knowledge of various qualitative and quantitative waste management paths and methodology with respect to the type of materials and respective industries.
Students are expected to gain knowledge on methods by which major industrial alloys such as Al5xxx and Al2xxx series, stainless and structural steels etc.. are recycled and green alloys are made.
Students are expected to gain knowledge on self made regulations and governing body regulations and globally accepted regulations of waste management and recycling, especially lead containing solders etc...

COMMENTS

LECTURER

DO YOU KNOW

The extraction of aluminum is extremely energy intensive; it requires **190-230 megajoules** of primary energy per kilogram of aluminum extracted and processed. However, the energy required to produce a kilogram of aluminum from from 100 % recycled aluminum is **11.35-17MJ** (3,150 to 4,750 watt-hours), which in most cases corresponds to approximately 5% of ore production.



Electronic waste collection

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

Topic 1

Introduction to recycling and waste management

This lecture is centered on recycling and waste management, specifically focusing on their roles and impacts in the manufacturing industry. It starts by introducing the concept of recycling, emphasizing its importance in conserving resources, reducing energy use, and minimizing environmental pollution. This section sets the stage for understanding recycling as a critical element in sustainable development (3 hr)

Topic 2

Sustainability issue and manufacturing

This lecture focuses on the critical theme of sustainability in manufacturing. It explores how manufacturing processes can be aligned with sustainable practices to achieve environmental friendliness, economic viability, and social responsibility. The lecture emphasizes the triple bottom line of sustainability: planet, profit, and people, and how they intersect in the manufacturing sector (3 hr)

Topic 3

Waste production in industry and recycling methods

This lecture addresses the critical issue of industrial waste production and the various recycling and sustainable waste management methodologies. It begins by addressing the origins and types of waste generated in industrial settings. Additionally, it involves a thorough classification of industrial waste, segmenting it into categories like hazardous, non-hazardous, and special wastes, each with its specific challenges and handling requirements (3 hr).

Topic 4

Sustainable waste utilization in heavy metal industry

This topic targets sustainable waste utilization in the heavy metal industry, emphasizing iron production. The scope of this lecture is meticulously crafted to provide students with a comprehensive understanding of the environmental challenges and innovative recycling opportunities within this sector (3 hr).

Topic 5

Sustainable waste utilization in light metal industry

The topic centers around sustainable waste utilization in the light metal industry, encompassing aluminum, titanium, and magnesium. The lecture introduces the primary production routes of these light metals and their alloys, emphasizing the unique processes like the Bayer and Hall-Héroult methods for aluminum, the Kroll process for titanium, and the Pidgeon process for magnesium. Each process is dissected to understand the types of waste generated, such as red mud and SPL for aluminum, chlorides for titanium, and slag for Mg, highlighting the environmental challenges these byproducts pose (3 hr).

Topic 6

Plastic waste treatment and sustainability issue

This topic is committed to exploring the critical issue of plastic waste treatment and its related sustainability challenges. The thematic scope of this lecture is meticulously structured to provide students with a comprehensive understanding of the complexities surrounding plastic production, waste generation, recycling (3 hr).

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LEARNING OUTCOMES

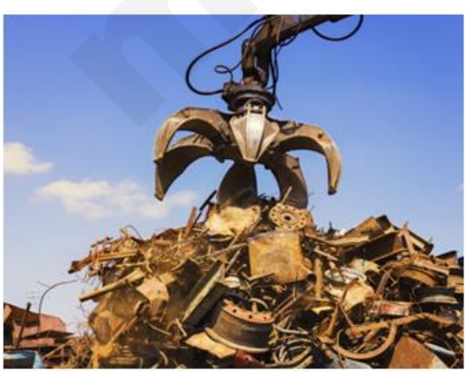
Students are expected to gain knowledge of waste management principles in general and importance of recycling due to global challenges in many industries.
Students are expected to gain knowledge of various qualitative and quantitative waste management paths and methodology with respect to the type of materials and respective industries.
Students are expected to gain knowledge on methods by which major industrial alloys such as Al5xxx and Al2xxx series, stainless and structural steels etc.. are recycled and green alloys are made.
Students are expected to gain knowledge on self made regulations and governing body regulations and globally accepted regulations of waste management and recycling, especially lead containing solders etc...

COMMENTS

LECTURER

DO YOU KNOW

One of the effective way of recycling in metal industry is to sort them through labels, bins, and bags can be used to segregate different types of metal waste, such as ferrous (iron-based) or non-ferrous (aluminium, copper, etc.), large or small, clean or dirty, and so on. Sorting your metal waste can help you manage it and locate the best disposal option for it.



Recycling through metal scraps

Topic 7

Wood waste management

The scope of this lecture is carefully designed to provide students with an in-depth understanding of the complexities and solutions related to the efficient handling and repurposing of wood waste in various industries. The lecture introduces the extensive use of wood in different industrial sectors, such as construction, furniture manufacturing, and paper production. This section aims to build basic knowledge about the sources and types of wood waste, setting the stage for further discussions on waste management strategies (3 hr).

Topic 8

Waste management and recycling in textile industry

The lecture begins with exploring the various types of textiles used in industrial and domestic settings. It highlights the unique properties of natural fibers like cotton and wool, synthetic fibers like polyester and nylon, and specialized fabrics used in technical applications. The lecture emphasizes the environmental implications of home textile waste, including common household items like bedding and curtains, and the complexities involved in their recycling due to the blend of different fibers (3 hr).

Topic 9

Green composites

The scope of this segment is carefully crafted to provide a comprehensive understanding of green composites, emphasizing their environmental benefits and applications compared to traditional composite materials. The lecture reviews various green composites, such as eco-composites and hybrid green composites. Eco-composites, made from natural fibers and biodegradable resins, and hybrid composites, which blend natural fibers with synthetic materials, are examined in detail. It is aimed to enhance students' knowledge of material selection and design considerations in green composites (3 hr).

Topic 10

Advanced materials from waste

The scope encompasses the innovative conversion of waste into valuable materials for industrial use, emphasizing sustainable practices in manufacturing. The lecture initially introduces students to the classification of wastes, categorizing them based on their origin and potential for reuse in the manufacturing industry. This classification is vital for understanding the different kinds of waste streams, such as industrial waste (like slag and fly ash) and consumer waste (including plastics and glass), and their respective properties that make them suitable for repurposing (3 hr).

Topic 11

Sustainable waste utilization in construction materials

This lecture segment examines the evolving practices in the construction industry aimed at reducing environmental impacts through the innovative use of recycled materials. It starts by categorizing construction materials into natural and manufactured, discussing their characteristics, uses, and the importance of choosing materials based on criteria like strength, cost, and environmental impact. The lecture emphasizes the shift from traditional materials to alternatives incorporating waste products, conserving natural resources and minimizing ecological footprints (3 hr).

Topic 12

Thermal power plants and recycling of ash and other wastes

The topic examines the role of thermal power plants in electricity generation and the environmental challenges associated with their operation, particularly regarding waste production and carbon dioxide emissions. The scope of this week encompasses understanding the fuel-burning processes in these plants, the types of waste generated, and the innovative recycling methods for these wastes (3 hr).

LEARNING OUTCOMES

Students are expected to gain knowledge of waste management principles in general and importance of recycling due to global challenges in many industries.
Students are expected to gain knowledge of various qualitative and quantitative waste management paths and methodology with respect to the type of materials and respective industries.
Students are expected to gain knowledge on methods by which major industrial alloys such as Al5xxx and Al2xxx series, stainless and structural steels etc.. are recycled and green alloys are made.
Students are expected to gain knowledge on self made regulations and governing body regulations and globally accepted regulations of waste management and recycling, especially lead containing solders etc...

COMMENTS

INSTRUCTOR

DO YOU KNOW

Plastics save energy and CO_2 emissions during their use phase. If we were to substitute all plastics in all applications with the prevailing mix of alternative materials, and look from a life cycle perspective, then 22.4 million additional tons of crude oil per year would be required. The total global production of plastics has grown from around 1.3 million tonnes (MT) in 1950 to 245 MT in 2006.

Recycling process for small metallic items

Topic 13

Electronic waste and regulations

The topic is designed to explore the complexities of electronic waste management, the role of solders in electronic device manufacturing, and the impact of regulatory frameworks like the RoHS Directive on these practices. The lecture provides an in-depth analysis of the types and properties of solders, their application in electronic equipment manufacturing, and the environmental implications of these materials. Case studies provide practical insights into the industry's adaptation to RoHS regulations and the challenges encountered in transitioning to lead-free solders (3 hr).

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

None

Around 100 tonnes of recycled glass and plastic have been used in a road resurfacing project in Melbourne's City of Yarra.

TEXTBOOK/READINGS

There is no required textbook for the class.

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

1. Pardeep Singh, Pramit Verma, Rishikesh Singh, Arif Ahamad, André C. S. Batalhão (Eds), Waste Management and Resource Recycling in the Developing World (2022 Edition), Elsevier

ASSESMENT

Exam: There are two written exams: Midterm and Final. Midterm exams contribute to 30% and Final exam contributes to 40 % of total sum of marks.

Reports: Case reports and review studies are expected as reports from the students for each discussion subjects or on one of the predetermined topics.

GRADING POLICY

During lectures, students should submit 7 different essay reports. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points. The average of 7 reports will be taken as essay report score and contribute to 30% of total marks. Students will get 30% from midterm and 40% from final exams to be contributed to the sum of marks.

Assignment Weights	Percent
Reports	30%
Midterm Exam	30%
Final	40%
Total	100%

7 reports – max. 30 points
1 Midterm Exam- max 30 points
1 Final exam – max. 40 points
Total points – max. 100 points

Grading Scale

90 – 100 points = AA
85 – 89 points = BA
70 – 84 points = CB
60 – 69 points = CC
50 – 59 points = DC
40– 49 points = DD
30– 39 points = FD
0 – 29 points = FF

Day	Date	Topic	Assignment	Due Today
1				
2				
3				
4				
5				

INTRODUCTION TO SCIENTIFIC RESEARCH TECHNIQUES

Code: ISRT

Field of study
Materials Science and Engineering

Level of study
Master Study

Semester
1

Language
English

Thematic block
R&D

Form of tuition and number of hours*:
Lecture: 39 h

ECTS
2

Research design branches out into several categories; one of the is data analysis which branches out into big data and machine learning etc..

COURSE DESCRIPTION

The course 'Methodology of Scientific Research' covers the methods, techniques, instruments, and processes used in conducting scientific research in the field of economics. Its objective is to equip students with the theoretical knowledge and practical skills necessary for scientific work.

The course is divided into three parts. The text covers the general introduction to the methodology of scientific research. It includes topics on the principles of science, scientific research, and basic concepts and principles of scientific creative work. The second part focuses on the logic of realizing scientific work, elaboration of the research model, research methods, and techniques for thesis defense. The third part of the lecture covers academic journals and their submission guidelines. This section covers the classification of journals based on their credentials, such as impact factors and JCR quality grades (Q1 to Q4 ratings), as well as citation statistics. The lecture aims to provide students with a foundation for evaluating their work during and after the thesis study or research process. This is carried out during R&D work in their respective facilities.

The lecture is intended to increase the awareness of students to relate the microstructural properties of materials with bulk and surface properties. The experimental section is dedicated to strengthen the knowledge gained during the course and aimed to give the best practical experience using real experimental data and images. Students are expected to spend 39 hrs of in class training and 65 hrs of independent work during the course of study.

COURSE OBJECTIVES

The course aims to introduce students to science theory concepts and issues, as well as basic research methods in science and technology, particularly computer science. Students will become familiar with scientific language by summarizing scientific papers. The course will also provide practice in information retrieval and developing a source-critical attitude when writing and presenting a scientific article. The students enhance their analytical skills and critical thinking abilities as they review and critique the articles of others.

PREREQUISITES FOR TAKING THE COURSE

Student are not required to take any prerequisite course in order to complete this course, but are expected to know the basics of internet sourcing of scientific literature and aware of thesis and manuscript concepts.

LEARNING OUTCOMES OF THE MODULE

Code	Description
MS_O_01	Explain principles of research methodology for a research project and use pre-learned scientific thinking for general scientific studies.
MS_O_02	Analyse the scientific literature and be familiar with reading, summarizing and reviewing scientific papers.
MS_O_03	write a scientific paper (based on own work or information found in scientific papers or similar), relate the paper to science theory and research methods, and present the paper.
MS_O_04	Apply knowledge in practice, employ a critical approach to knowledge, science and research and scientifically oppose or put forward an opposing view based on the evidence obtained from previous works.

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, MS_O_03
Meth_02	Programming Methods: Work with computer	MS_O_02, MS_O_03
Meth_03	**Lectures:** Problem Methods: Activating methods: a case study	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	39	Exam	MS_O_01 MS_O_02 MS_O_03	Meth_01
FT_02	Essay preparation	3	course work	MS_O_01 MS_O_02 MS_O_03	Meth_03
FT_03	Work with computer	3	Course work	MS_O_02	Meth_02, Meth_04

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 the subject by reading the lecture sources	NO
a_02	Work with computer	Preparation of the essay case report	YES
A_03	Essay preparation	Preparation and development of reports. Consultation.	YES

Co-funded by the European Union

LEARNING OUTCOMES

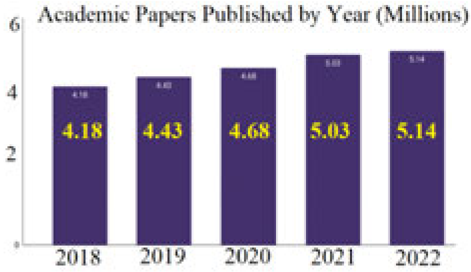
Students are expected to gain to gain knowledge about principles of research methodology and scientific thinking in and during the thesis study.
Students are expected to gain knowledge of be familiar with reading, summarizing and reviewing scientific papers.
Students are expected to gain knowledge on write a scientific paper (based on own work or information found in scientific papers or similar), relate the paper to science theory and research methods, and present the paper.
Students are expected to gain knowledge on practice a critical approach to knowledge, science and research and scientifically oppose or put forward an opposing view based on the evidence obtained from previous works.

COMMENTS

LECTURER

DO YOU KNOW

Publishing is one of the most ballyhooed metrics of scientific careers, and every researcher hates to have a gap in that part of his or her CV. Here's some consolation: A new study finds that very few scientists—fewer than 1%—manage to publish a paper every year.
But these 150,608 scientists dominate the research journals, having their names on 41% of all papers. Among the most highly cited work, this elite group can be found among the co-authors of 87% of papers. Medical sciences dominate the science publishing in journals.



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

Topic 1

Introduction to research and scientific thinking

Scientific Research and its Importance, The Place and Importance of Technology in Scientific Research, Research Education; Concepts of knowledge, science, scientific research, scientific method; ways of acquiring knowledge, authority and traditions; common sense, media and tools; personal experiences. What is science? And the basic principles of scientific research (3 hr).

Topic 2

Science, scientific ethics and morality

Definitions of science and academic research concept with historical views and development; the ethics issues in science and possible clash with reality of scientific findings; scientific ethics in special cases such as plagiarism and self citations; morality and linked ethical comparison (3 hr)

Topic 3

Good and bad examples of ethical issues in publications

Academic publishing rules according to different disciplines; examples of ethical issues from literature or published works; the role of scientific journals in ethical issues; good examples and bad examples in natural and social sciences; predator journals and open access journals and their differences in publishing a manuscript (3hr).

Topic 4

Copyright issues and (common) publication rules in research: research concepts, R&D concepts

Copyright issues and predetermined solution to this problem via journal and book publishers point of view; open source publishing and open source or common publishing rules for non subscription journals; publication rules in common and related content building such as the R&D quality of manuscript; rules to be considered in writing a project and manuscript (3 hr).

Topic 5

Scientific journals and indexing

Institute for Scientific Information (ISI), SCI (Science Citation Index –Core journals), SCIE (Science Citation Index Expanded, ESCI (Emerging Sciences Citation Index) impact factors and, JCI and JCR factors, Social Sciences Citation Index (SSCI) and Arts and Humanities Citation Index (AHCI), indexing concepts in research (3hr).

Topic 6

Thesis proposal or Project preparation: Hypothesis

Hypothesizing of your study and research, finding the right research problem and related purpose for your research, industrial effect on your research, what is the importance of hypotheses and how deal with general research with curiosity, correct documentation of your research and keeping a log (3 hr).

Topic 7

Thesis proposal or Project preparation: literature survey

Thesis concept and proposing a research based on literature study; proposing a research based on academic or commercial concern such as finding a solution to a problem; project and defining project outputs; literature review and collection, utilisation of the Internet, Follow-up of Periodicals. (3 hr).

Topic 8

UNIVERSITY OF SILESIA IN KATOWICE
UNIVERSITY OF ŽILINA

LEARNING OUTCOMES

Students are expected to gain to gain knowledge about principles of research methodology and scientific thinking in and during the thesis study.
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Students are expected to gain knowledge on write a scientific paper (based on own work or information found in scientific papers or similar), relate the paper to science theory and research methods, and present the paper.
Students are expected to gain knowledge on practice a critical approach to knowledge, science and research and scientifically oppose or put forward an opposing view based on the evidence obtained from previous works.

COMMENTS

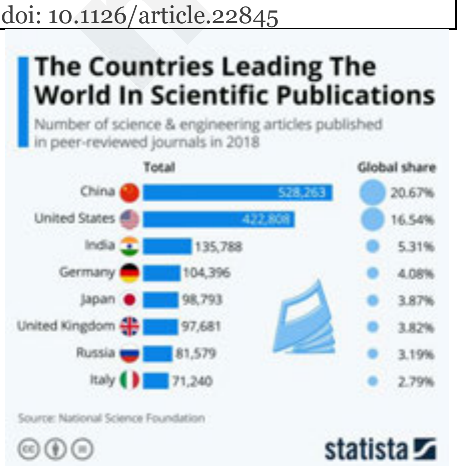
INSTRUCTOR

DO YOU KNOW

The ranks of scientists who repeatedly published more than one paper per year thin out dramatically. Here are the results for 1996-2011 term:

- Two or more: 68,221
- Three or more: 37,953
- Four or more: 23,342
- Five or more: 15,464
- 10 or more: 3269

doi: 10.1126/article.22845



Thesis proposal or Project preparation: writing aim, content and benefits

How to write the aim and content of a project or thesis proposal; the focus on the outputs of the project proposal and combining it with general/expected benefits for national and international outputs; benefits of project for a commercial output; benefits for raising students for second and third cycles (3hr).

Topic 9

Thesis proposal or Project preparation: Methodology

Research and research methodology concepts in natural science and social sciences; methodology in a project and its role in validation of the project; methodology and its preparation in science and engineering; device brand and model writing, parameter writing; presentation of methods for project proposal, (3 hr).

Topic 10

Preparation and design of conclusion and discussion writing/presentation

Finishing up writing of your thesis proposal and the revising the subject of your thesis, viable aims and expected outputs based on your initial studies; the design of conclusions based on the importance of your project at national and international levels; writing the conclusion of your manuscript and how to write effective discussion (3hr).

Topic 11

Poster and presentation of results: application

This topic will focus on the developing the ability of students regarding poster/presentation of their research outputs in public events such as conferences or project evaluation commissions; the organization of your prime outputs from your project; the presentation strategies in front of project evaluation commission and conferences and thesis jury; common presentation rules and tricks for conferences; practice runs (3hr).

Topic 12

Defending your thesis or manuscript: tips and tricks and general rules

Preparation for your thesis defense and evaluation of your thesis; revision of your work by experts and its importance; what outcomes should be expected and corrections or failures; what replies should be given for comments and the methodology of manuscript evaluation; reject, major/minor correction and accept (3hr).

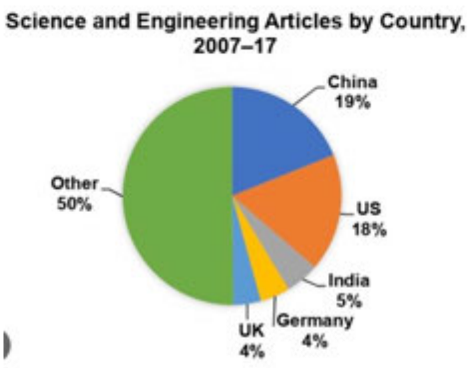
Topic 13

What happens after defending your thesis: future studies and completion of your research

Following the completion of your thesis, finish up your thesis corrections and submit and get your PhD title; and what?; prepare yourself for your first manuscript if you have not done so yet; find a time to replenish your literature knowledge and interest yourself in a possibly new project or further your study if you have a facility(3 hr).

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

None



TEXTBOOK/READINGS

There is no required textbook for the class.

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

American National Standards Institute, Inc. 1979. American national standard for the preparation of scientific papers for written or oral presentation. ANSI Z39.16-1979. American National Standards Institute, Inc., New York.

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GRADING POLICY

The average of 7 reports will be taken as a Report score. During the classroom study or working with computer, students should submit 7 different essay reports. The average of 7 reports will be taken as a essay report score. Reports should include some answers to the questions about the topic. Reports also have some discussion of the experimental findings and required data evaluations such as graphics or microstructure pictures. Each report is 100 points and contribute to 30% of total marks. Students will get 30% from midterm and 40% from final exams to be contributed to the sum of marks.

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The document was prepared as part of the "Materials Science Ma(s)ters - developing a new master's degree" project (2021-1-PL01-KA220-HED-000035856).

MATERIALS SCIENCE MASTERS

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