Course guide
220126 - TM - Thermodynamics of Materials

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.

Degree: BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Calventus Sole, Yolanda

Others: Roman Concha, Frida Rosario

TEACHING METHODOLOGY

The course is divided into parts:
Theory classes
Practical classes (Laboratory Sessions)
Self-study for doing exercises and activities.
In the theory classes, teachers will introduce the theoretical basis of the concepts, methods and results and illustrate them with appropriate examples to facilitate their understanding.
The practical classes will take place in the Laboratory, and in them, students will observe the different phenomena presented in the theory classes.
Students need to work independently on the materials provided by teachers in order to assimilate the concepts.
The teachers control activities by ATENEA.

LEARNING OBJECTIVES OF THE SUBJECT

- Analyse the thermal behavior of materials, specially polymeric materials. Glass transition phenomenon, crystallisation process, melting process, curing process.
- Main characteristics of other phenomena such as superconductivity
- Learn how to handle some of the experimental techniques of thermal analysis used in industry (pharmaceutical, electronics...) and in laboratories/research centers.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	40.00
Self study	45,0	60.00

Total learning time: 75 h

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

CONTENTS

Module 1: First and Second order phase transition

Description:
Study and analyze the thermal transitions that occur in materials and the consequences they have on their structure, properties and technical applications.
It is seen experimentally using the DSC technique how these phase changes occur in practise

Specific objectives:
Know how to identify the technical transitions that appear in a material and what they mean in terms of its structure and properties. What technical advantages can these phase changes bring us?

Begin to develop in the use of the technique of Differential Scanning Calorimetry (DSC)

Related activities:
Activity 1: Theory and Problem Classes
Activity 2: Problem solving
Activity 2: Find the foundamentals and the main applications of a certain thermal transition
Activity 3: Laboratory Session 1

Full-or-part-time: 15h
Theory classes: 8h
Self study : 7h

Module 2: Polymer overview

Description:
It gives an overview of what a polymer is, what kind of polymers we have, its main characteristics and properties. Industrial applications and in daily life

Specific objectives:
- What is a polymer
- What is a thermoplastic, a thermostable and an elastomer
- How they are formed and how they behave
- How they can be identified
- Know its properties

Related activities:
Activity 4. (The presentation will be done at the end of the semester)

Full-or-part-time: 12h
Theory classes: 2h
Self study : 10h

Module 3: Crystallisation process in polymers

Description:
- Introduction and concepts of amourphous and crystalline structure
- Crystallisation kinetics. Nucleation and Growth
- The crystallization morphology: spherulites
- Factors which affect the crystallisation process
- Properties related to the crystalline structure
- Melting temperatures, enthalpies and entropies of melting
- Crystallisation study using DSC technic

Specific objectives:
Know how to distinguish between amorphous phase and crystalline phase
Know that polymers can be semicrystalline or amorphous (never fully crystallines)
Know how to interpret in a DSC curve the different thermal transitions in thermoplastic polymers
Know how to calculate the crystallized fraction and the degree of crystallinity using DSC results
Introduce the use of experimental technic TGA (Thermogravimetric Analysis)

Related activities:
Activity 1: Theory classes
Activity 3: Laboratory Session 2
Activity 3: Laboratory Session 3

Full-or-part-time: 18h
Theory classes: 6h
Self study : 12h

Module 4: Glass transition phenomenon

Description:
Introduction
Factos affecting glass transition temperature
How to obtai glass transition temperature
Changes in physical properties
Pseudo second order thermal transition
Phenomenology
Fictive Temprature
Physical Aging

Specific objectives:
Concept of glass transition
Concept of vitreous state - rubbery state
Concept of physical aging

Related activities:
Activity 2: Solve an Athenea Quizz in class
Activity 2: Class activity on physical aging
Activity 4: Laboratory session 4

Full-or-part-time: 15h
Theory classes: 7h
Self study : 8h

Module 5: Curing reaction thermosetting polymers

Description:
- What is a thermoset
- How to produce a thermoset:
- Main concepts:
- Curing process
- Gelation
- Time of gel
- Vitrification

Specific objectives:
Know the main characteristics, properties and applications of thermosets

Related activities:
Activity 2: Make a search about thermosets applications
Activity 4: Laboratory session 5

Full-or-part-time: 15h
Theory classes: 7h
Self study : 8h

ACTIVITIES

Activity 1: Theory and Problem Classes

Description:
Presentation of the content using audiovisual media

Specific objectives:
Explain the contents of the subject and learn to relate the concepts to be able to solve practical problems

Material:
Computer
Blackboard
Video

Full-or-part-time: 18h
Theory classes: 18h

Activity 2: Continous Assessment Activities

Description:
- Solving problems.
- Solving Athenea quizzes
- Do searches to delve into certain concepts in the syllabus

Specific objectives:
Do tasks and quizzes that help to achieve the contents of the subject

Material:
Computer

Delivery:
Via Athenea

Full-or-part-time: 15h
Self study: 15h

Activity 3: Laboratory sessions

Description:
Laboratory sessions

Specific objectives:
Learn how to use the DSC and TGA. These techniques are widely used in industry and in research centers and laboratories.

Learn to identify correctly the meaning of the peaks obtained in the curves.

Perform the necessary numerical calculations, based on the experimental data obtained, in order to obtain the values of the properties needed to understand the behavior of the material

Material:
Lab guide
Differential scanning calorimeter (DSC)
Thermogravimetric analizer (TGA)
Computer
Samples of different materials in order to carry out different experiments and studies: Indium, zinc and different polymeric materials

Delivery:
In groups of 2 students via Athenea

Full-or-part-time: 30h
Theory classes: 10h
Self study: 20h

Activity 4: Present an essay about a polymeric material studied in the laboratory

Description:
Carry out a essay about the manufacturing process of a given polymer, its chain structure, its properties and its applications.

The polymer will be chosen from those studied in the laboratory

It will be done in groups of 2 students

It will be presented in the last class. The presentation should be about 15 minutes per group.

Specific objectives:
Do an activity that includes everything that has been worked in the subject

Material:
Computer

Delivery:
Upload in Athenea the presentation file (pdf or ppt)

Full-or-part-time: 12h
Theory classes: 2h
Self study: 10h

GRADING SYSTEM

The final grade depends on the following criteria:

- Continous assessment: 25%
- Write and present an essay about a polymer studied in laboratory: 25%
- Laboratory Reports: 50%

BIBLIOGRAPHY

Basic:

- Adkins, C. J. Equilibrium thermodynamics. 3rd ed. Cambridge [etc.]: Cambridge University Press, 1983. ISBN 0521254450.
- Billmeyer, Fred W. Textbook of polymer science. 3rd ed. New York: Wiley-Interscience. Division of John Wiley & Sons, 1984. ISBN 0471828343.
- Smith J. M. [et al.]. Introduction to chemical engineering thermodynamics. 8th ed. New York: McGraw-Hill, 2018. ISBN 9781259696527.
- Mandelkern, L. Crystallization of polymers. Vol. 1, Equilibrium concepts. 2nd ed. Cambridge: Cambridge University Press, 2010. ISBN 9780521020138.

Complementary:

- Dusek, K. Epoxy resins and composites. Springer-Verlag, 2013. ISBN 9783662159644.