Advanced Composite Materials

Academic Year: (2021 / 2022) **Review date: 09-06-2021**

Department assigned to the subject: Department of Materials Science and Engineering and Chemical Engineering

Coordinating teacher: MOLINA ALDAREGUIA, JON MIKEL

Type: Compulsory ECTS Credits : 3.0

Year : 1 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

None

OBJECTIVES

CB6, Acquire and understand concepts that provide the foundation or opportunity to be original on the development and/or application of ideas, often in a research context.
CB7, Students will be able to apply the acquired knowledge and skills on problem resolution in new or hardly known environments in the context of wide (or multidisciplinary) contexts related to the area under study
CB8, Students will be able to integrate knowledge to face the complexity of making assessments based on limited or incomplete information, but considering the ethical and social responsibilities associated to the application of their knowledge and assessments.
CB9, Students will be able to communicate their conclusions and the knowledge and reasons that support them to specialized and the wide public in a clear and unambiguous manner
CB10, Students will acquire learning skills that allow them to continue studying in an autonomous and self-paced way.
CG1, Understand the challenges associated to Materials Science and Engineering in an industrial and research environment
CG3, Develop team working skills in a research environment
CG4, Develop skills to apply the acquired knowledge to the research and development of new materials or in technologies for their processing in strategic sectors.
CG5, Combine the interest on innovation and process optimization, with the need of doing so in an environmentally friendly manner.
CG6, Acquire the required skills to defend a research project and its results.
CG7, Develop creative strategies for decision making to solve problems associated with materials, their design, processing and behaviour.
CE1, Discover the latest tendencies in development of new materials and be aware of their potential advantages with respect to more traditional materials.
CE2, Be able to design new ways of optimizing the properties of different materials for specific applications, through the modification of their structure and composition.
CE3, Acquire knowledge in advanced processing and synthesis methods, to obtain materials with improved properties.
CE4, Acquire knowledge to contribute to the optimization of a processing technology for specific applications
CE7, Acquire knowledge and understanding on the environmental impact of materials during their life cycle, being able to develop new materials and processing techniques based on sustainability
CE9, Consolidate specific research skills in Materials Science and Engineering
CE10 Acquire knowledge and useful scientific and technical skills to solve specific problems associated with the work in a research laboratory in the field of material development and characterization

LEARNING RESULTS
After the course, students should be able to:
-Apply novel processing techniques for specific designs
-Select the most appropriate matrices and reinforcements available to design composite materials for specific applications
-Select among the most widely used quality control methods in composite materials.
-Apply the foundations of the laminate theory to the design of composite components

DESCRIPTION OF CONTENTS: PROGRAMME

Common topics for all subjects:

All subjects contribute to complement basic knowledge in Materials Science and Engineering that students have acquired during their previous university degree, strengthening the following topics:
- Structure and properties of advanced materials.
- Advanced material processing techniques.
- Advantages and drawbacks of advanced materials with respect to more traditional ones.

Specific topics in Advanced Composite Materials:

1. Introduction
1.1. Present and future of composite materials
1.2 Multifunctional composites

PART 1. Structure and properties of composite materials

2. Types of matrices
2.1 Ceramic and metallic matrices.
2.2 Polymeric matrices: thermosets and thermoplastics: curing parameters.

3. Types of reinforcement
3.1 Carbon, glass, polyamides, carbides, alumina and aluminosilicate reinforcements. Structure and properties.
3.2 Geometry and architecture of the reinforcement: short fibers, continuous fibers, textiles and laminates.
3.3. Interphases. Adhesion mechanisms. Mechanical characterization of interfaces.

4. Processing of metal-matrix composites
4.1. Solid-state processing
4.2 Liquid state processing

5. Processing of ceramic matrix composites
5.1 Powder consolidation, impregnation and infiltration techniques.

6. Processing of polymer matrix composites
6.1 Prepreg consolidation
6.2 Infiltration methods
6.3 Other techniques: filament winding, pultrusion,¿

7. Quality control
7.1 Certification
7.2 Non-destructive evaluation: ultrasounds and X-Rays.

8. Recycling of composite materials

PART 2. Mechanics of composite materials

9. Elastic behavior of long fiber composites
9.1 Elastic anisotropy
9.2 Stiffness tensor
9.3 Effect of fiber length. Shear Lag models

10. Laminate theory
10.1 Orthotropic lamina
10.2 Elastic constants of a unidirectional lamina
10.3 Classical theory of laminates

11. Failure of composite materials
11.1 Failure modes: longitudinal, transversal, shear, compression
11.2 Failure criteria

12 Damage in composite materials
12.1 Mechanisms and contributions to the fracture energy
12.2 Damage tolerance
12.3 Continuum damage models

12.4 Cohesive elements

LEARNING ACTIVITIES AND METHODOLOGY

LEARNING ACTIVITIES
AF1, Lectures: 16.5 hours
AF2, Lab sessions: 3 sessions of 1.5h of computer simulations (4.5 hours)
AF3, Tutorials: student attendance will be fostered (2.5 hours)
AF4, Work in groups: Computer simulations will be done in groups of 2
AF5, Individual work: 32 hours of individual work by the student

METHODOLOGY
MD1, Lectures by the instructor
MD3, Resolution by the students in groups of the practical cases proposed by the instructor during the computer sessions
MD4, Debates in class, moderated by the instructor, about topics relevant to the course
MD5, Computer sessions, under the instructor supervision
MD6, Reporting in groups about the computer sessions

ASSESSMENT SYSTEM

- Individual work during the course (partial evaluation test) (SE2): 20%
- Team work during the course (lab reports) (SE3): 30%
- Final exam (SE4): 50%

% end-of-term-examination:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

BASIC BIBLIOGRAPHY

- D. Hull and T.W Clyne An Introduction to Composite Materials, Cambridge University Press.
- R. F. Gibson Principles of Composite Materials Mechanics, Taylor and Francis.

ADDITIONAL BIBLIOGRAPHY

- M.C.Y. Niu Composite Materials Handbook, vol. 3., Department of Defense, USA. - Composites for Aircraft design.