Course guide
220303 - 220303 - Aerospace Materials

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Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 702 - CEM - Department of Materials Science and Engineering.

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Miguel Sánchez Soto

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE15. MUEA/MASE: Sufficient knowledge of the materials and manufacturing processes used in propulsion systems.
CG09-MUEA. (ENG) Competència en totes aquelles àrees relacionades amb les tecnologies aeroportuàries, aeronàutiques o espacials que, per la seva naturalesa, no siguin exclusives d'altres branques de l'enginyeria.

Transversal:
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Basic:
CB09. Improve technical communication of results.
CB06. Manage original concepts in research projects.
CB08. Generate decision from incomplete information assuming its social and ethical responsibilities.
CB10. Improve self-learning capacity

TEACHING METHODOLOGY

The teaching methodology consists in three parts:
- Face-to-face sessions of exposition - participation in the contents of the course and exercises.
- Face-to-face sessions of laboratory work.
- Autonomous study and proposed activities

In the exposition sessions -participation of the contents, the teaching staff will introduce the theoretical bases of the subject, concepts, methods and results, illustrating them with suitable examples and requesting, where appropriate, exercises to facilitate their understanding. Activities will be proposed to solve by students either in the classroom or outside the classroom.
In the laboratory work sessions, the teaching staff will guide the students in the application of theoretical concepts to solve experimental activities. Activities will be proposed for the student to solve either in the classroom and outside the classroom.
The students, autonomously, will work with the material provided by the teaching staff to assimilate and fix the concepts. The teaching staff will provide a study plan and follow-up activities (ATENEA).

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student must:
- Know the different groups and types of materials used in aeronautical applications.
- To know the relations and influences between the microstructure, the manufacturing processes and the final properties of the materials.
- Understand the technological capacities, their limits of application and the ways for optimizing the material properties in aerospace applications.
- Acquire experience and ability to properly select materials according to the requirements of the component or application.
- To know and understand the causes of failure of the components in service and to have the capacity to apply predictive tools for estimate the life in service of components and to foresee solutions to possible failures.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	12.00
Self study	80,0	64.00
Hours large group	30,0	24.00

Total learning time: 125 h

CONTENTS

Block 1: Introduction

Description:
Introduction to the subject. General concepts. Historical evolution of materials in the aerospace industry. Economic importance of materials in aeronautics and space.
Applications of materials in aerospace.

Full-or-part-time: 4h
Theory classes: 2h
Self study : 2h

Module 2: Criteria for the selection of materials in the design of aircraft and engines

Description:
Main parameters and equations for design. Material selection criteria. Ashby charts. Selection of materials for structures and engines. Examples

Related activities:
Theorethical and problems session-
Activity 1: Materials selection proposal. Activity where students will work on the concepts and criteria to make a convenient and appropriate selection of materials. Study of the selection charts as a function of the requirements of a certain component.
Activity 8: Work group proposal

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 2h
Self study : 8h

Modul 3: Ferrous metalic alloys and thermal treatment

Description:
3.1. Steels. Types of steels. Iron-carbon diagram. Steels for aeronautical applications (stainless steel, precipitation hardening, HSLA, Dual Phase TRIP etc.)
3.2. Main ferric alloys. Analysis and properties. Influence of elements in alloys. Composition and effect on the properties.
3.3. Thermal treatment of steels

Related activities:
Theorethical and problems session.
Activity 2: Lab practical activity. In this activity the principal features of metalic ferrous alloys will be studied as a function of the previously applied thermal treatment. By means of microscopy and hardness analysis, the students will have to identify different carbon-base ferrous alloys as a function of the previous heat treatment applied.
Activitat 8: Development of work in group.

Full-or-part-time: 14h
Theory classes: 4h
Laboratory classes: 2h
Self study : 8h

Module 4: Non-ferrous metal alloys.

Description:
4.1. Aluminum alloys. Main properties. Aerospace applications.
4.2. Titanium and its alloys Characteristic properties. Main titanium alloys. Effect of alloying elements. Heat treatments and their effect. Aerospace applications. Shape memory alloys
4.3. Magnesium and its alloys Characteristic properties. Main magnesium alloys
4.4. Other metals and alloys. Superalloys. Microstructure and properties. Aerospace applications

Related activities:
Theorethical and problems session.
Activity 3: Lab practical activity. The aim of this activity is to observe the behavior of different areas of a metallic material in a corrosive environment. The differences will be observed due to the chemical reactions associated with the movement of electrons and ions, which are more notable at points and areas that have been subjected to deformation.
The relative stability of different metals will also be determined according to their response when placed in contact in a saline medium, ordering them from the most cathodic to the most anodic.
Activitat 8: Development of work in group.

Full-or-part-time: 21h
Theory classes: 4h
Laboratory classes: 2h
Self study : 15h

Block 5: Ceramic materials for engineering

Description:
Advanced structural ceramics. Coatings. Thermal barriers. Applications in aeronautics. The failure in ceramics (Weibull)

Related activities:
Theorethical session.
Activity 4: Lab practical activity.: manufacturing of a ceramic/polymer composite. Students will be subdivided into smaller groups. Each subgroup, according to the guidelines set out in the script and the teacher's indications, will separately. carry out the preparation of the composite to be manufactured. Of the different systems that the students elaborate, only one of them will be later infuse with resin. Before proceeding with the infusion, the various assemblies are tested to verify that the vacuum tightness is maintained. With the assembly that best retains the vacuum condition, the resin is infused, which is allowed to cure for 24 hours. Subsequently, this laminate will serve for the characterisation of properties that will be carried out in the following practical activity.
Activitat 8: Development of work in group.

Full-or-part-time: 13h
Theory classes: 3h
Laboratory classes: 2h
Self study : 8h

Block 6: Composite materials

Description:
Composite materials. Components, matrix and reinforcement. Types of matrices and fibers. Equations for composite design. Models. Metal matrix composites. Ceramic matrix composites. Polymer matrix composites. Forming methods.

Specific objectives:
Theorethical and problems session.
Activity 5: Lab practical activity about characterisation of a composite part. The objective of the practical activity is to characterise the previously manufactured composite materials and compare their behaviour based on the properties of the components and the fibre/matrix architecture. From the previous manufactured composite, the students know the type of fibre and resin used and the technical characteristics of each component. From this laminate, specimens must be extracted in a suitable arrangement to be able to evaluate the mechanical and physical properties (density, percentage of fibre, percentage of matrix and voids, etc.)

Full-or-part-time: 23h
Theory classes: 4h
Laboratory classes: 4h
Self study : 15h

Module 7: Behavior in service: Structural integrity

Description:
7.1. Welding types and characteristics. Friction welding. Diffusion welding. Applications.
7.2. Creep in metallic, ceramic, polymer and composite materials. Curves and creep tests.
7.3. Fracture and fatigue Types of fracture. Introduction to fracture mechanics. Fatigue at high and low cycles, S-N curve. Factors affecting fatigue. Problems.
7.4. Corrosion: Types of corrosion. morphology of attacks. Chemical resistance. Corrosion protection. Importance. Case studies.

Related activities:
Theorethical and problems session.
Activity 6: Lab practical activity. Fracture and fatigue behaviour of materials. Using samples of different polymeric materials and also of the previously manufactured composites the fracture mechanics method will be applied to estimate the fracture toughness of the tested materials. Moreover, the fatigue resistance of the composites manufactured by the students will be determined.
Activity 8: Development of work in group.

Full-or-part-time: 28h
Theory classes: 8h
Laboratory classes: 2h
Self study : 18h

Block 8: Non destrcutive analysis

Description:
Introduction to the analyis of defects. Defects detection. Non-destructive testing. Superficial and internal defect inspection techniques. Real case study. Foresight of new materials and applications.

Related activities:
Theorethical session.
Activity 7: Project presentation. In this activity, the students will present the work they have done in groups throughout the course. The presentation will be made orally, assessing both the work and the exhibition and the answer to the questions that will be asked.
Activity 8: Development of work in group.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h
Self study : 6h

GRADING SYSTEM

First exam: 25%
Second exam: 25%
Deliverables: 25%
Proposed work: 15%
Lab activities: 10%
Note:
Deliverables: These are short application problems or questions proposed by the teacher in the field of the subject.
Attendance at the lab activities and the presentation of the work are necessary conditions to pass.
Any student may recover the marks through the corresponding final exam. In this exam, the students could recover/improve their marks by carrying out a final exam, substituting the two previous first and second exam . The mark obtained in this final exam will replace the ones previously obtained at first and second exams.

BIBLIOGRAPHY

Basic:

- Cantor, B.; Assender, H.; Grant, P. Aerospace materials. Bristol [etc.]: Institute of Physics, 2001. ISBN 0750307420.
- Ashby, Michael F. Materials selection in mechanical design [on line]. 4th ed. Burlington (Massachusetts): Butterworth-Heinemann, 2011 [Consultation: 03/05/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9781856176637/materials-selection-in-mechanical-design. ISBN 9781856176637.

Complementary:

- Asthana, R.; Kumar, A.; Dahotre, N. B. Materials processing and manufacturing science [on line]. Amsterdam [etc.]: Elsevier Academic Press, 2006 [Consultation: 03/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=274692. ISBN 9780750677165.
- Anderson, T. L. Fracture mechanics: fundamentals and applications. 3rd ed. Boca Raton: Taylor and Francis/CRC Press, 2005. ISBN 0849316561.

RESOURCES

Other resources:

Journals of the UPC electronic library:
Journal of aerospace engineering
IEEE transactions on aerospace
Aircraft engineering and aerospace technology
Encyclopedia of aerospace engineering. Vol 4.
Fracture mechanics