

Course guide 340664 - ENSU - Surface Engineering

Last modified: 03/04/2024

| Unit in charge: Teaching unit: | Vilanova i la Geltrú School of Engineering 702 - CEM - Department of Materials Science and Engineering. | | |
|-----------------------------------|--|--|--|
| Degree: | BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject). | | |
| Academic year: 2024 | ECTS Credits: 6.0 Languages: Catalan | | |
| LECTURER | | | |
| Coordinating lecturer: | Josep Anton Picas Barrachina | | |

Others: Josep Anton Picas Barrachina

REQUIREMENTS

Basic knowledge of Material Science

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. CE25. Knowledge and ability to apply material engineering.

2. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

Transversal:

3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

4. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.

5. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.

6. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

TEACHING METHODOLOGY

Theoretical classes and practical examples of the different processes to produce coatings and surface treatments.

Visualization in the laboratory of the main characterization tests used in this field. Presentation of works on topics related to the subject, by students (in groups) and discussion in class.

Visits to several manufacturing plants related with this field.

LEARNING OBJECTIVES OF THE SUBJECT

The requirements modern technology demands of the tools, the equipment and the mechanical components, force the industrial sector to produce advanced Surface Treatments and Coatings with specific characteristics. The objective of this subject is to give sufficient knowledge on "Surface Engineering", from their production to their technological application. Both perspectives are essential for any Engineer who works in several fields: Engineering of Processes, Coatings Manufacture, Technical Office, etc



STUDY LOAD

| Туре | Hours | Percentage |
|-------------------|-------|------------|
| Self study | 90,0 | 60.00 |
| Hours large group | 45,0 | 30.00 |
| Hours small group | 15,0 | 10.00 |

Total learning time: 150 h

CONTENTS

Unit 1: Fundamentals of Surface Engineering

Description:

Surface engineering includes all those processes that modify the surface of the components in order to improve their behavior in service and increase their working life. The purpose of modifying the surface of the material can be very varied, from reducing wear or minimizing corrosion to simply improving the esthetic appearance of the surface.

This first topic introduces the wide variety of processes that exist to make surface treatments and coatings, classified into: Processes that modify the surface of the piece without altering the chemical composition of the substrate; Processes that change the surface layers, altering the chemical composition of the substrate and Processes that involve the addition of layers of material on the surface of the substrate (Coatings).

Specific objectives:

Introduction to the subject of surface engineering

Related activities:

Activity 1: Theory lessons Activity 4: partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

Full-or-part-time: 2h Theory classes: 2h



Unit 2: Surface properties: chemical and tribological properties

Description:

The surface characteristics of materials have a significant effect on the in-service behavior and service life of a component. The components usually have to work in conditions, usually complex, that combine the efforts applied with processes of degradation of the surface (chemical or physical). This topic will explain the most important aspects of the two main mechanisms that can cause the degradation of a material: tribological properties (friction and wear) and chemical properties (corrosion and oxidation).

Specific objectives:

Know the main mechanisms that can cause the degradation of a material: tribological properties (friction and wear) and chemical properties (corrosion and oxidation).

Related activities:

Activity 1: Theory lesson

Activity 2: Laboratory practice

Activity 3: Moodle questionnaire

Activity 4: Partial test

Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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06 URI N3. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

Full-or-part-time: 16h Theory classes: 4h Practical classes: 2h Self study : 10h



Unit 3: Characterization techniques and quality control of coatings

Description:

The study of coatings and surface treatments can be approached from two points of view: Characterization and Quality Control. The characterization techniques allow to know exhaustively the properties of the coatings and surface treatments and to relate them to the production parameters. This information is fundamental in the research and development of new coatings and new processes. While quality control allows to evaluate the validity of the parameters of the process (characterized and established previously) and determine the acceptance or rejection of the coated parts or components.

This topic will describe the main techniques for both characterization of coatings and surface treatments and quality control.

Specific objectives:

Know the main techniques for characterization of coatings and surface treatments.

Related activities:

Activity 1: Theory lesson Activity 2: Laboratory practice Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and / or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 24h Theory classes: 4h Laboratory classes: 10h Self study : 10h



Unit 4: Surface heat treatments (iron based materials)

Description:

This topic will explain the different techniques used to perform surface heat treatments. The aim of a surface heat treatment is to obtain a good surface hardness and a good wear resistance together with a core of lower hardness and good toughness, which allows the absorption of possible impact efforts without breaking the component in service. This type of treatment requires very localized heating, followed by rapid cooling (tempering). Depending on the technique used to perform the heating we can differentiate the treatments in: flame hardening; Induction hardening; Laser hardening; Electron beam hardening.

Specific objectives:

Know the different techniques used to carry out a surface heat treatment.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 14h Theory classes: 4h Self study : 10h



Unit 5: Tractaments mecànics superficials

Description:

Surface mechanical treatments aim to create residual compressive stresses on the surface of the component, which prevent the formation of surface cracks by basically improving fatigue strength and corrosion resistance under stresses. This topic will explain the main techniques of surface mechanical treatments such as the Shot peening technique or the Abrasive blast cleaning process.

Specific objectives:

Know the main techniques of mechanical surface treatment.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and / or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 6h

Theory classes: 2h Self study : 4h



Unit 6: thermochemical treatments

Description:

A thermochemical treatment is a type of heat treatment performed in a diffusive atmosphere. The function of this atmosphere is to provide one or more chemical elements, in order to enrich the surface of the material and produce a diffusion process to a certain depth. These treatments provide the piece with better surface properties from the point of view of wear resistance, corrosion or fatigue. This topic will explain the main characteristics of the most important thermochemical treatments at the industrial level: Cementation (Carbon diffusion), Nitriding (Nitrogen diffusion), Borodizing (boron diffusion) among others.

Specific objectives:

Know the most important thermochemical treatments at the industrial level.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 14h Theory classes: 4h Self study : 10h



Item 7: anodizing (aluminum alloys and titanium) and blued (steel)

Description:

The anodizing process can be defined as an electrolytic process in which a layer of oxide is grown on the surface of aluminum or titanium. These elements have a high chemical affinity for oxygen, so that in contact with air they are spontaneously covered by a thin (0.01 microns) and transparent oxide layer. The artificial growth of the oxide layer in the anodizing process, considerably increases the protective effect of this layer. The oxide layer can be transparent, but can also be translucent or opaque and can also allow coloring to give a wide range of decorative colors. The blueing process is exclusive to some steels in which a layer of magnetite is grown on a black surface.

Specific objectives:

Know the anodizing and blueing processes.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and / or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 7h Theory classes: 2h Self study : 5h



Unit 8: Implantació iònica

Description:

Ionic implantation is a process that modifies the surface characteristics of materials, improving resistance to fatigue, wear and friction. In this process the atoms of the element to be implanted are ionized and subsequently accelerated, by means of an electric field in vacuum conditions, towards the surface of the material. This process is a purely ballistic method, in which ions penetrate the material as a result of its high kinetic energy. It does not depend on the diffusion mechanism.

Specific objectives:

Know the ion implantation process.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

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. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 7h

Theory classes: 2h Self study : 5h



Unit 9: Laser surface treatments

Description:

Laser surface treatments can be differentiated into different techniques depending on the power density of the laser and the interaction time (function of the speed of displacement and the diameter of the beam): Surface heat treatment); Laser melt); Laser alloying); Laser cladding; Laser melt and particle injection.

Specific objectives:

Know the main surface treatments performed with laser.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

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Full-or-part-time: 6h

Theory classes: 2h Self study : 4h



Unit 10: Chemical and electrochemical coatings

Description:

This topic will describe two techniques to produce coatings: Chemical and electrochemical treatments. First of all, a description will be made of the electrodeposition processes to produce electrolytic coatings. The aim of an electrolytic deposition is to produce metallic coatings, by the reduction of the ions present in solution with a electrical current. The second technique is to produce coatings by chemical reduction. This technique differs from electrodeposition processes in that the external contribution of an electric current is not required, and the metallic coating is produced by the chemical reduction of the metal ions by a reductor compound present in the solution.

Specific objectives:

Know the processes to produce chemical and electrolytic coatings.

Related activities:

Activity 1: Theory lesson Activity 2: Laboratory practice Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and / or re-evaluation

Related competencies :

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Full-or-part-time: 18h Theory classes: 4h Laboratory classes: 2h Guided activities: 2h Self study : 10h



Unit 11: Thermal spray coatings

Description:

This topic will describe the different techniques used in the processes of produce coatings by thermal spray. In these processes, a coating is obtained from the contribution of projected materials in form of molten or semi-molten particles on the surface of a substrate. The different thermal spray systems can be divided into two large groups depending on how the thermal energy required for the process is transmitted: Combustion methods and electric current methods.

Specific objectives:

Know the different processes of produce coatings by thermal spraying.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 14h Theory classes: 4h Self study : 10h



Unit 12: Chemical and physivcal vapor deposition tehniques: CVD and PVD

Description:

This topic will describe the processes to produce coatings by vapor deposition. These processes can be divided into two major groups: Chemical Vapor Deposition Processes - CVD and Physical Vapor Deposition Processes - PVD. Both process involve the obtention of a material in vapor form and its subsequent condensation on the substrate forming a coating. While in the PVD process the deposition is purely physical, in the CVD process, as the material is deposited, a chemical reaction with the substrate occurs.

Specific objectives:

Know the main processes to produce coatings by vapor deposition (CVD and PVD)

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Related competencies :

. CE25. Knowledge and ability to apply material engineering.

. CE26. Applied knowledge of systems and fabrication process, METROLOGIA and quality control.

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Full-or-part-time: 16h

Theory classes: 4h Guided activities: 2h Self study : 10h

Topic 13: Paintings and Sol-gel coatings.

Description:

This topic defines what a painting is and the different techniques of deposition. The basic concepts related to the sol-gel coating technology are also defined.

Specific objectives:

Know the processes of deposition of paints and the process of produce coatings by sol-gel technique.

Related activities:

Activity 1: Theory lesson Activity 3: Moodle questionnaire Activity 4: Partial test Activity 6: Final exam and/or re-evaluation

Full-or-part-time: 6h

Theory classes: 2h Self study : 4h



ACTIVITIES

(ENG) ACTIVITAT 1: THEORY LESSON

Description:

Theory lesson with practical examples (videos) of the different processes in the field of surface engineering to produce coatings and carrying out surface treatments.

Specific objectives:

Acquisition of fundamental knowledge that will be used in the rest of the activities.

Material:

Material provided by the teacher via Digital Campus and bibliography.

Delivery:

The knowledge acquired will be evaluated in the tests, in the partial exam and if it is the case, in the final exam.

Full-or-part-time: 75h

Theory classes: 40h Self study: 35h

ACTIVITY 2: LABORATORY PRACTICE

Description:

Practices of knowledge of materials by means of laboratory equipment.

Specific objectives:

Acquire skills in the characterization of coatings and surface treatments.

Material:

Practice-specific laboratory material or specific software, practice document and bibliography.

Delivery:

The corresponding report must be submitted on the set date. The work evaluation will contribute to 20% of the final mark.

Full-or-part-time: 17h Laboratory classes: 14h Self study: 3h

(ENG) ACTIVITAT 3: QÜESTIONARI MOODLE

Description:

The student will have to carry out moodle questionnaires on the contents of the different topics to complete the achievement of the knowledge.

Specific objectives:

consolidate the newly acquired knowledge.

Material:

Test statement in Moodle.

Delivery:

The moodle solution of the proposed questions. Contribute 10% to the final mark.

Full-or-part-time: 10h

Self study: 10h



ACTIVITY 4: PARTIAL EXAM

Description:

The student will have to do a exam on the contents 1 to 8, in which he will have to solve different questions.

Specific objectives:

Consolidation of the acquired knowledge.

Material: Examination statement

Delivery:

The written and individual solution of the proposed questions. It contributes 30% to the final mark.

Full-or-part-time: 14h Theory classes: 2h Self study: 12h

ACTIVITY 5: ORAL PRESENTATION OF GROUP WORK

Description:

In groups of 2-3 students there will be a work on some application related to the contents of the subject. Each group will have to present a work and make an oral presentation of it. An evaluation will be carried out between classmates by means of a rubric that together with the evaluation of the teacher will give the mark of the work.

Specific objectives:

Select coatings or surface treatments based on the mechanical, tribological, chemical or esthetic requirements of a particular industrial application.

Material:

Statement of work, bibliography.

Delivery:

The corresponding work must be delivered on the set date and the oral presentation must be made. The work evaluation will contribute to 10% of the final mark.

Full-or-part-time: 16h

Theory classes: 2h Self study: 14h

ACTIVITY 6: FINAL EXAM and/or RE-EVALUATION

Description:

Written test in which the student must show the degree of achievement of the knowledge acquired on the topics explained during the course. In this test it will be necessary to interrelate knowledge acquired in the different subjects.

Specific objectives:

Consolidation of the knowledge acquired during the course and its interrelation.

Material: Statement of the exam.

Delivery:

The written and individual solution of the proposed questions. It contributes 60% to the final mark.

Full-or-part-time: 14h Theory classes: 2h Self study: 12h



ACTIVITY 7: VISITS TO COMPANIES

Description:

Students will visit companies related to the topics explained in the course.

Specific objectives:

Get in touch with the industrial world with companies in the surface treatment and/or coatings sector.

Material:

Information about the company to visit. Report template.

Delivery:

The corresponding report must be submitted on the set date. The evaluation of this task will contribute to 10% of the final grade.

Full-or-part-time: 4h

Guided activities: 4h

GRADING SYSTEM

The average mark between the marks of the work carried out in the laboratory (20%),), questionnaires via Atenea (15%) and the visits to manufacturing plants (10%), the mark of two tests with different questions based on the theory classes (mark of the two theory-based tests : 25% each). Moreover a work on some topics related to the subject will be carried out with a 10% of the final mark. This work must be presented orally by the authors.

The laboratory practices, the tests carried out via Campus Digital and the activities carried out in the classroom or others during the regular period of classes will not be re-evaluated.

BIBLIOGRAPHY

Complementary:

- ASM handbook. Vol. 5, Surface engineering. Materials Park, Ohio: ASM International, 1996. ISBN 087170384X.

- Strafford, K. N. Surface engineering : processes and applications [on line]. Lancaster [Pa.] [etc.]: Technomic, 1995 [Consultation: 20/03/2024]. Available on:

https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/edit/10.1201/9780203737798/surface-engineering-ken-strafford. ISBN 1566761549.

- Bunshah, R. F. Handbook of hard coatings : deposition technologies, properties and applications. New Delhi: Elsevier India, 2015. ISBN 9789351072959.

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- Ciencia e ingeniería de la superficie de los materiales metálicos. Madrid: Consejo Superior de Investigaciones Científicas, 2000. ISBN 8400079205.

- Pawlowski, Lech. Protective coating and paints. Foxit Software Company, 2004.

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