Politecnico di Torino

Metals for Advanced Manufacturing — 5 ECTS

Lecturers: **E. Bassini**

Lectures: 34h	Tutorials: 0h	Labs: 7h	Project: 9h + site visit	Autonomy : 75h	Lang. :

Objectives

This course is organized aims at providing graduates with the scientific fundamentals of metal metals for industrial advanced applications and at providing knowledge to define the technical requirements as function of the selected application.

Keywords: materials engineering, advanced steels, non ferrous metals alloys.

Programme

1. Recall on traditional steels, their application and relative economic values.
2. Advanced steels: properties, related applications and relative added value with respect to the application; modern Steelmaking in relation to the devoted market sector; powder metallurgy as manufacturing route for steel semi-products; decarburization challenge for steel. Site Visit to Steelmaking Shop. Advanced heat treatment processes.
3. Al Alloys: recall on basic alloys and their properties; advanced Al alloys; new applications and markets. Heat treatment processes and their influence on the final components' properties.
4. Cu Alloys: recall on basic alloys and their properties; metallurgy of Cu alloys; new applications and markets. Heat treatment processes and their influence on the final components' properties.
5. Ti and Ti Alloys: Chemical compositions, structure and properties, main sectors of applications; Ti aluminides

Prerequisites

The following knowledge and skills are required for the correct use of the teaching:

- Basic knowledge of material properties and their correlation with structure and microstructure.
- Basic knowledge of characterization methods for materials

Learning outcomes

- The student will learn the science and technology of advanced steels and non ferrous metals alloys and their metallurgical processes.
- The student will be able to apply his/her knowledge to select and describe how to obtain metals with specific properties

Assessment

Written test; Optional oral exam;
Should the oral test be undertaken, the final mark is the average of the marks obtained in the two tests (written test + oral test), otherwise, the score of the written test applies

References

C. Leyens and M. Peters, "Titanium and Titanium Alloys, Fundamentals and Applications", Wiley

Materials & Design — 10 ECTS

Lecturers: P. Fino, D. Ugues, L. Iannucci, D. Manfredi, A. Martucci

Lectures: 50h | Tutorials: 0h | Labs: 20h | Project: 30h | Autonomy : 150h | Lang. :

Objectives

The aim of the course is to make the decisive step to move students' attitude from passive materials users/selectors to pro-active materials designers.

Keywords: multi-scale materials design, materials processing, materials sustainability

Programme

The course will aim at describing:

1. Design tools for Materials Design & Development: review of design criteria; definition of the relation matrix between product performances and materials specification; design and development of materials considering both theoretical aspects and processing needs; design scale up through TRL scale; end of life disposal, re-use and recycling.
2. Consolidated success stories in Materials Design (not exhaustive list): superalloys for high temperature applications; high and ultra- high strength automotive steels; Scalmalloy design; alternative processing routes for poorly processable materials (e.g. aluminides, not forgeable materials, etc.)
3. Materials Design projects and laboratories: Laboratory of Thermocalc: alloy definition; Design Laboratory for specific applications through CES methodology; lectures on Future trends in Materials Design will follow the following programme:
4. Future trends in Materials Design: Nature mimic design of materials; synergy between different manufacturing technologies to fully exploit the materials potentials.

Prerequisites

- Basic knowledge of materials families and processes
- Basic knowledge of materials applied thermodynamics
- Basic knowledge of industrial manufacturing systems

Learning outcomes

- Ability to dominate the architecture and function of materials, with the ultimate target to design engineering products/systems for specific applications in technology
- Ability to apply his/her knowledge to the critical review of consolidated engineering materials and related processes,
- Ability to identify eventual needs for materials substitution/improvement and to design materials capable to fill the residual gaps for product development.

Assessment

The grading system includes evaluation of the project report and related discussion (max 14/30); written test (max 16/30); and optional oral test.

References

M.F. Ashby, Materials selection in mechanical design, Butterworth Heinmann
ASM Handbook, vol. 20, Materials Selection and Design, ASM International

Politecnico di Torino

Materials forming 10 ECTS

Lecturers: **E. Bassini, M. Messori**

Lectures: 72h | Tutorials: 0h | Labs: 20h | Project: 8h | Autonomy : 150h | Lang. :

Objectives

The course provides an overview of the main processing technologies of non-metallic materials for the production of semi-finished and finished products.
The course aims at deepening the knowledge related to the metal forming processes and technologies.

Keywords: materials engineering, forming technologies

Programme

1. Non metallic materials forming Technologies
   - Rheology of thermoplastic polymers. Chemo-rheology of thermoset polymers.
   - Processing technologies for thermoplastic and thermoset polymers.
   - Processing technologies for polymer-matrix and ceramic-matrix composites.
   - Advanced processing for ceramic materials: additive manufacturing
   - Group project and teamwork
2. Metal forming technologies
   - Foundry
   - Plastic deformation
   - Powder metallurgy; FAST Techniques: SPS, EDS, CDS; Free-form processes and 3D printing. Additive Manufacturing.
   - Machining
   - Spraying
3. Design criteria and cost analysis

Prerequisites

- Fundamentals of science and technology of polymeric and ceramic materials.
- Introduction to materials for advanced manufacturing
- Knowledge related to the properties of metals and their alloys

Learning outcomes

- Knowledge and understanding on conventional and emerging forming technologies for plastics, polymer-matrix and ceramic-matrix composites, ceramics and metals.
- Ability to select appropriate materials and processes for the production of a specific object/part.
- Ability to use professional databases for the selection of materials / processes

Assessment

Group project; written and oral tests.

References

Slides and notes provided by the professors.
C. Bonten, Plastics technology, Hanser, 2019 (ISBN 978-1-56990-767-2; E-Book ISBN 978-1-56990-769-9); - Kalpakjian, Mechanical Technology, Pearson, 2014; J. Beddoes, Principles of Metals Manuafcturing Processes, Elsevier, 2006; Salak, Ferrous Powder Metallurgy, Cambridge International Science Pub., 1995; G. Dieter, Mechanical Metallurgy, McGraw.Hill, Tokio, 1988; M.P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 2012

Surface Science and Technology — 5 ECTS

Lecturers: **M. Quaglio, F. Gobber, G. Massaglia**

Lectures: 35h | Tutorials: 0h | Labs: 9h | Project: 6h | Autonomy : 75h | Lang. :

Objectives

This course aims at providing graduates with the fundamental knowledge of surface science and technology with an application-driven design of surface engineering.

Keywords: Surface science, tribology, corrosion, coatings

Programme

The Course is organized into three main parts :

1. Tribological applications: cutting tools & forming dies; Wear mechanisms and related surface requirements; Plasma physics; physical vapor deposition; Special focus on Arc PVD deposition techniques; Coating materials & specific characterization
2. Functional applications: surface requirements in electronic devices; surface cleaning processes; organic coatings and paints; hybrid surface treatments and coatings; surface micro and nanopatterning
3. Environmental degradation protection: high temperature applications; thermal spraying processes; EBM-PVD; TBC; oxidation protection layers; EBC.

Prerequisites

- Elementary physics (mechanics, thermodynamics, wave optics, fluidics, elements of structure of matter)
- Basic knowledge of material science and technology
- Basic knowledge of Advanced Manufacturing

Learning outcomes

- Ability to describe and compare different materials that show similar surface properties,
- Ability to describe and distinguish between different processes for designing and engineering,
- Ability to appraise reasons for selecting the best process for modification, structuring and coating of a surface for a given application.

Assessment

The grading system includes a written test and an optional oral test.

References

The students will be provided with various teaching resources, such as slides, reports and handouts. For some specific topics, books could be available, and they will be highlighted.

Semester 2 – Elective 2

Politecnico di Torino

Failure analysis: method and practice 5 ECTS

Lecturers: **D. Ugues et al.**

Lectures: 20h | Tutorials: 0h | Labs: 10h | Project: 10 | Autonomy : 75h | Lang. :

Objectives

This course aims at providing students with the theoretical and practical tools to investigate failures in materials, components, and systems.

Keywords: Failure analysis, materials characterisation, Virtual Reality

Programme

The theoretical lessons will review:

- the rules and practice for failure analysis;
- the most common causes for failure analysis in mechanical
- fabrication methods and production cycles of components that will be subject of the failure analysis laboratory;
- review of instruments that can be used for failure analysis investigation, aim of the experiments, types of information that can be derived, limits and benefits of the different techniques.

The laboratory events will include:

- Virtual Reality (VR) laboratory session to make steps of the investigation that cannot be performed in real experimental environment;
- experimental characterization of samples related to specific studies with real laboratory instruments;
- session of discussion between students to organize the presentation of results to the professor(s).

Prerequisites

All knowledge derived by courses on general engineering and materials engineering, as by the study plan for industrial engineering and especially for Materials Engineering for Industry 4.0. Basic knowledge on materials science, mainly metallic materials structure and microstructure, mechanical and thermal properties, metallic materials processing and fracture mechanisms.

Learning outcomes

- To Know and apply the methodology used to organize the analysis of a failure event.
- To learn the theoretical knowledge and practice of using experimental set up for analyse a failed component.
- To know and apply tips & tricks to use evidences derived by the failure investigation.
- To know and apply the rules for building relations between the failure events and the potential sources for failure.
- To know how to organize documents presenting the evidences of a failure investigation, to present the results of the investigation, and propose corrective actions.
- To develop active team working abilities.

Assessment

The grading system includes evaluation of the project report and related discussion (max 16/30); written test (max 14/30); the discussion of the project report and the written test are mandatory, whereas the oral test is optional.

References

Mobley, R. Keith. Root Cause Failure Analysis. Burlington: Elsevier Science, 1999. Print.