Semester 3

Modelling of material removal & wear 5 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **C. Courbon**

Lectures: 36h | Tutorials: 0h | Labs: 0h | Project: 0h | Autonomy : 72h | Lang. :

Objectives

This course aims to provide students with a comprehensive understanding of the simulation and modelling of material removal and wear processes using finite element analysis (FEA). Focusing on practical applications using the FEA code Abaqus, students will learn to set up, simulate, and analyse material removal and wear scenarios, optimize processes, and interpret results to enhance manufacturing efficiency. By the end of the course, students will have the skills to apply these techniques to real-world engineering problems.

Keywords: Material removal, Wear, Finite Element Analysis, Tribology, Thermo-mechanical loadings, Process optimisation

Programme

1. Introduction & fundamentals (2h)
2. Introduction to Abaqus Finite Element code (4h)
3. Modelling of a sliding contact (4h)
4. Modelling of a metal cutting operation (4h)
5. Modelling of wear (4h)
6. Optimization (4h)
7. Group work & case studies (12h)
8. Presentation (2h)

Prerequisites

- Basics in manufacturing processes
- Metalworking processes S1
- Thermo-mechanical behaviour of metals (elasticity and plasticity theories)

Learning outcomes

- Explain the principles and mechanisms of material removal through plastic deformation and shear in subtractive processes, and understand their impact on material performance and tool wear.
- Develop and apply finite element models using Abaqus to simulate material removal and wear processes in manufacturing under various conditions;
- Analyse the effects of different processing parameters on wear and process efficiency using computational simulations;
- Formulate and implement strategies to optimize material removal processes and minimize wear through batch simulations and advanced optimization techniques.

Assessment

- Written exam on the theoretical knowledge gained in this course (50%)
- Oral presentation of the final case study (50%)

References

PJ. Arrazola, T. Ozel, D. Umbrello, M. Davies, IS. Jawahir (2013) Recent Advances in Modelling of Metal Machining Processes. CIRP Annals - Manufacturing Technology 62(1):695–718.

S. N. Melkote, W. Grzesik, J. Outeiro, J. Rech, V. Schulze, H. Attia, P.-J. Arrazola, R. M'Saoubi, C. Saldana (2017) Advances in material and friction data for modelling of metal machining, CIRP Annals, Volume 66(2):731-754.

T. Mabrouki, C. Courbon, Y. Zhang, J. Rech, D. Nélias, M. Asad, H. Hamdi, S. Belhadi, F. Salvatore (2016) Some insights on the modelling of chip formation and its morphology during metal cutting operations, Comptes Rendus Mécanique, 344(4–5):335-354.

Semester 3

Modelling of surface integrity — 5 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: F. Valiorgue, J. Stolarz, H. Van Landeghem

Lectures: 18h | Tutorials: 18h | Labs: 0h | Project: 0h | Autonomy : 36h | Lang. :

Objectives

Surface integrity is a key issue nowadays as far as safety components are concerned in sectors such as energy, aerospace, aircraft or medical industries. This course aims at deeply understanding and modelling the various modifications a surface can experience when metalworking processes are applied. It thus has the following objectives i) understanding the phenomena leading to the surface integrity for finishing processes, 2) understanding the effects of surface integrity on critical parts and how to tailor them and 3) modelling of the phase transformations which can occur in a crystalline materials at the near surface.

Keywords: Modelling, residual stresses, microstructure, fatigue life, finishing processes

Programme

1. General background in industry
2. Examples of surface integrity issues
3. Surface integrity evolution during machining
4. Surface integrity modelling
5. Surface integrity customisation
6. Examples

Prerequisites

- Elementary Basics in manufacturing processes.
- Machining principles.
- Thermo-mechanical behaviour of metals (elasticity and plasticity theories.

Learning outcomes

- Being able to list the surface modifications generated by a finishing process.
- Being able to explain how the surface is modified.
- Being able to link surface integrity and fatigue life.
- Being able to choose a finishing process to control the surface.

Assessment

2 written exams with questions based on lectures content.
1 oral presentation in the end of the tutorials.

References

"Machining - Fundamental and recent advances" - Springer - J. Paulo Davim

A. Mondelin, F. Valiorgue, J.Rech, M. Coret, E. Feulvarch (2012) Hybrid model for the prediction of residual stresses induced by 15-5PH steel turning, International Journal of Mechanical Sciences 58(1):69-85

Semester 3

Functional & In-use properties — 5 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **F. Cabanettes, E. Cabrol, C. Bosch, K. Wolski**

Lectures: 36h | Tutorials: 0h | Labs: 0h | Project: 0h | Autonomy : 72h | Lang. :

Objectives

Durability is a science and technology dealing with the evolution of "in service" properties; it is also known as environmentally sensitive damage and cracking. The objectives of the module are to present the various damage phenomena encountered by materials in service and to describe the physico-chemical mechanisms responsible for them. Upon completion of this course, students shall obtain basic knowledge of failure mechanisms (with focus on wear, corrosion resistance and fatigue properties) of mechanical components. They shall be able to analyse tribological problems in industrial applications and propose adapted solutions in terms of surfaces, material, lubrication and protection against corrosion.

Keywords: Wear of materials, friction, lubrication, surface topographies, durability, corrosion, stress corrosion cracking, fatigue corrosion, hydrogen embrittlement, creep, aging metallic alloys

Programme

1. Introduction: History of tribology, economical and sustainability aspects.
2. Fundamentals of wear, friction, surface topography characterization (Abott Firestone curve, classical roughness parameters, filtering techniques), lubrication (Stribeck curve, Hydrodynamic and Reynolds equations, EHL, Hamrock and Dowson equations) and lubricants as well as the types of contacts (conformal non conformal, rough).
3. Types of wear and solutions: running in, adhesive, abrasive, the Archard Law, surface fatigue wear, fretting, severe wear, corrosive wear and diffusive wear.
4. Opening to other failure mechanisms: component fatigue failure and the role of surface roughness.
5. Phenomena of aqueous corrosion, stress corrosion cracking, fatigue corrosion and hydrogen embrittlement: basics of corrosion, characterization methods and industrial case studies in particular service conditions leading to the degradation.
6. Durability at high temperatures (creep and aging) with case studies relative to the nuclear industry.

Prerequisites

- Elementary Machine elements
- General mechanics
- Basic knowledge (bachelor) in material and mechanical science

Learning outcomes

After attending this course, students will:

- Understand the significance of tribology in industrial applications.
- Understand the behaviour of contacting and sliding surfaces.
- Identify the main wear types and propose solutions to reduce them.
- Understand physical and chemical degradation mechanisms of metallic alloys.
- Apply the knowledge to in service degradation of industrial alloys.

Assessment

2 written exams with questions based on lectures content.
1 oral presentation on the case studies.

References

VAN BEEK, A. Advanced engineering design: lifetime performance and reliability (2006)
STACHOWIAK, GW., BATCHELOR,AW. Engineering tribology (2013)
STOLARSKI, T. A. Tribology in machine design. Industrial Press Inc., (1990)

Component repair by thick coatings 5 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: E. Cabrol, M. Doubenskaia, A. Sova, E. Durand, H. Klöcker

Lectures: 18h | Tutorials: 0h | Labs: 0h | Project: 18h | Autonomy : 72h | Lang. :

Objectives

Additive manufacturing brings together various techniques to build complex three-dimensional objects layer by layer with a fully optimized architecture. Additive manufacturing leads to reduced material and energy consumption compared to conventional manufacturing processes by material subtraction. It is also the process of choice for repairing expensive parts.
We study the manufacture and repair of metal parts using additional fabrication, including: the design of suitable grades (chemistry and surface condition couple), the optimization of process parameters, post-heat treatments, as well as the characterization of in use properties.

Keywords: Repair metallic components, cold spray, laser cladding, wire arc additive manufacturing

Programme

The lectures of this course are divided in two main groups.

1. The first group will be dedicated to powder based repair processes (cold spray and laser cladding). A first series of lectures will be dedicated to the characterization of powders. This series is followed by two cases studies dedicated respectively to laser cladding and cold spray.
2. The second group is dedicated to wire arc deposition. In a first series of lectures, the basics of solidification and underlying microstructures are addressed. The second series is dedicated to a case study from the design of a component to its realization.

Prerequisites

- Basic knowledge in material science
- Basic knowledge in thermal engineering
- Basic knowledge in mechanical science

Learning outcomes

After attending this course, students will:

- Understand physics underlying laser cladding, cold spray and wire arc additive manufacturing.
- Understand microstructures generated by these processes and in service properties.
- Optimize the process parameters in view of the desired in use properties of the component.

Assessment

1 report and/or oral presentations on the case studies tackled in each group

References

I. Gibson, I. D. W. Rosen, I. B. Stucker // Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2014.
J. Villafuerte: Modern Cold Spray: Materials, Process, and Applications, Springer International Publishing Switzerland 2015

Semester 3

Life Cycle Assessment 5 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **N. Gondran + Consultancy company**

Lectures: 36h | Tutorials: 0h | Labs: 0h | Project: 0h | Autonomy : 72h | Lang. :

Objectives

Life-cycle assessment (LCA) is the prevailing framework for evaluation of the environmental consequences of products, services and energy systems to mention a few.
The objective of this course is to provide an introduction to life cycle assessment, present the methodological essentials of LCA and its applications to a variety of systems.

Keywords: Energy, Environmental performance, environmental impacts, life cycle

Programme

1. Life Cycle Assessment: historical background, regulation, procedures, applications.
2. Calculation methodology: mathematical structure of LCA, modelling of production systems and methods for environmental impact assessment.
3. Materials End-of-Life: open and closed-loop recycling, re-use, waste-to-energy process, waste management processes.
4. Case studies on Industrial processes for materials productions such as metals, cements or polymeric materials.

Prerequisites

- Basic university maths.
- Prior experience with programming is advantageous but not required.

Learning outcomes

After attending this course, students will:

- Understand the links between product/process and environmental impacts.
- Understand the concept of product (process, service) life cycle.
- Perform a moderately complex LCA under supervision.
- Assess the environmental performance of energy and production systems.

Assessment

Written report and oral presentation on a case studies

References

Life Cycle Assessment: Principles, Practice and Prospects by Ralph Horne, Tim Grant, and Karli Verghese, June 2009
Integrated Life-Cycle and Risk Assessment for Industrial Processes by Marta Schuhmacher, April 2007
Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach by Chris T. Hendrickson, Dr. Lester B. Lave PhD, and H. Scott Matthews, April 2006.

Semester 3

Advanced French 2 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **M. Leplat**

Lectures: 0h | Tutorials: 30h | Labs: 0h | Project: 0h | Autonomy : 10h | Lang. :

Objectives

This course will provide students with an advanced level in French. Course sessions will include: Reading comprehension, Written expression, Oral expression, Listening comprehension, Vocabulary and Grammar.

Keywords: French language

Programme

Dependent on student level, the educational method focuses on practical work:

1. Grammatical exercises with multiple examples and oral practice,
2. Listening to oral materials with increasingly difficult characteristics,
3. Discussions, presentations and debates, role-plays, writing short essays and summaries.

Prerequisites

- Attending French for Beginner or B1/B2 level

Learning outcomes

After attending this course, students will:

- Understand and use common expressions.
- Express themselves through a wide range of sentences (daily life, asking questions, and discussion on familiar topics, speaking in public, efficiently and fluently).
- Categorize information taken in a written document to be able to use it.
- Express their opinion and answer precise questions.

Assessment

Continuous assessment and oral presentations

References

All course materials will be supplied in class

Semester 3

Strategic management 2 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **P. Laurent, alii**

Lectures: 18h | Tutorials: 0h | Labs: 0h | Project: 0h | Autonomy : 36h | Lang. :

Objectives

The objective of this course is to help students to understand the strategic issues of the company, the methods and tools for shaping a strategy.

Keywords: strategic thinking, human and social sciences, value chain, innovation

Programme

1. Introduction: From military strategy to firms strategy
2. Dimensions for a strategic thinking : technico-economic and socio-political dimensions
3. Industry analysis, competition analysis
4. Strategic segmentation and analysis of a company's activities

Prerequisites

-

Learning outcomes

After attending this course, students will:

- Be able to understand firm's environments different levels of analysis
- Be able to take an integrative point of view to predict competitive behaviour, to develop and sustain a competitive edge

Assessment

Each student will have to produce, individually, a text on which he will be assessed.

The produced text will be based on two or three papers issued from peer-reviewed scientific journal, proposed by the lecturer.

The presentation of the main ideas and positions included in the proposed papers is required. Furthermore, students have to develop an argumentation including:

- a problem definition and justifications regarding the chosen problem,
- the definition and justification about the structure of an argumentation,
- the argumentation itself,
- a persuasive conclusion.

Of course, in order to do this, students can use the contents of the strategy course.

References

For instance :

Harvard Business Review publications

Association Internationale de Management Stratégique 's publications

Semester 3

Preparatory R&D project 3 ECTS

Draft version undergoing final validation and provided for information only

Lecturers: **various**

Lectures: 0h | Tutorials: 0h | Labs: 0h | Project: 0h | Autonomy : 120h | Lang. :

Objectives

This module aims to prepare MSc students for their Master thesis by guiding them through the process of conducting a thorough literature review, familiarizing them with their chosen research topic, and equipping them with the necessary tools and techniques, including experimental setups and numerical models. By the end of the course, students will be well-prepared to undertake their Master thesis with a solid foundation in both theoretical knowledge and practical skills.

Keywords: -

Programme

1. **Topic selection and introduction**
   - Students define a research topic with a supervisor or apply for a research topic proposed by a researcher.
   - Discussion of potential research areas and alignment of student interests
   - Introduction to the research environment and resources available
2. **Methodology**
   - Conducting a comprehensive literature review on the chosen research topic.
   - Developing a research plan with objectives, methodology, and expected outcomes.
   - Training sessions on using experimental setups and tools for numerical simulations.
   - Students work independently on their research project, conducting experiments, performing numerical simulations, and analysing data.
3. **Follow-up and final deliverables**
   - Regular meetings with the supervisor to discuss progress, refine research questions, and finalize the research plan.
   - Preparation of a final presentation and submission of a written report both summarizing/documenting the research process, results, analysis, and conclusions.

Prerequisites

-

Learning outcomes

After attending this course, students will be able to:

- Conduct a comprehensive literature review on a chosen research topic, identifying key studies, gaps, and trends.
- Develop a research plan with objectives, methodology, and expected outcomes.
- Gain proficiency in using experimental setups and numerical modeling tools
- Critically analyze and synthesize research findings
- Present their research plan and preliminary findings effectively to peers and faculty.

Assessment

Evaluation will be based on the quality of the literature review, the development and execution of the research plan, the proficiency in using experimental setups and numerical modelling tools, the ability to work independently, and the quality of the final presentation and report.

References

Relevant references will be provided in agreement with the selected R&D topic