University of Ljubljana

Advanced Machining Processes 5 ECTS

Lecturers: **F. Pusavec, D. Kramar**

Lectures: 30h | Tutorials: 15h | Labs: 15h | Project: 0h | Autonomy : 0h | Lang. :

Objectives

In order to be competitive in a global industrial environment, transition to sustainable and green machining and production processes appears as a key step. This implies that each segment of machining processes involved in this chain has to be considered, to be transformed, raising strong scientific and technical questions to be answered. This course will thus present the future challenges in manufacturing and browse i) the context in which the principles of machining will be connected with whole production processes, ii) the requirements for modelling and optimization of manufacturing processes, iii) the characterisation of the main input data with a special emphasis on energy efficiency and environmental footprint and iv) how to build a strategic approach to prepare the technological/economical plan and quality of the process.

Keywords: machining, chip formation, thermo-mechanical loads, efficiency, modelling, surface integrity

Programme

1. Basic tool kinematics and chip formation: defined and undefined cutting geometry
2. Chip formation models
3. Determination of machining efficiency, cutting forces & thermal loads
4. Tool-wear and tool-life
5. Cutting tools and Cutting tool coatings
6. Cooling and lubrication of machining processes
7. Productivity, economy and optimization of machining processes
8. Special/modern machining processes and sustainable development
9. Guest lecture by an expert from industrial environment.

Prerequisites

- Good knowledge in mechanics of materials (elastic-plastic behaviour)
- Basic knowledge in heat transfer

Learning outcomes

- In-depth theoretical, methodological and analytical knowledge of the principles of machining processes and chip formation
- Knowledge and management of demanding / complex machining processes, and methodological tools for modelling / predicting behaviour.
- Designing machining technologies based on problem solving.
- Ability to reflect critically and innovate upgrades.

Assessment

- 50% theoretical written exam with the mutual exam.
- 30% laboratory work with the short evaluation/reports.
- 20% seminar work as home assignment. The topic will be related to one of the key aspects from the course and based on a research paper in the literature.

References

Y. Altintas: Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design, 2012, Cambridge University Press.
F. Klocke: Manufacturing Processes 1. Springer-Verlag Berlin, 2011.
F. Pušavec, J. Kopač: Sustainability of modern metal cutting processes: assessment of cryogenic machining. Ljubljana, 2012.
G. Globočki-Lakić, D. Kramar, J. Kopač: Metal cutting: theory and applications. Banja Luka, Ljubljana, 2014.

University of Ljubljana

Quality Engineering 5 ECTS

Lecturers: **D. Kramar, T. Berlec**

Lectures: 30h | Tutorials: 15h | Labs: 15h | Project: 0h | Autonomy : 0h | Lang. :

Objectives

The objectives of this course are to make students aware of the importance of quality in today's world of waste and challenges in the use of raw materials. The future may be uncertain, but good quality management will enable organisations to adapt to the changing demands of a sustainable and people-friendly society.
This course will thus browse i) the introduction to quality engineering with theoretical background and practical knowledge, ii) the overview of the tools and techniques of quality control and assurance and other elements of the quality management system, iii) the methods of design of experiments and their application in empirical modelling and process optimization and iv) the application of tools and techniques of quality assurance/control in all stages of the product quality development, process planning and control.

Keywords: process planning and control, cost of quality, risk management, problem solving, process optimisation, experimental design

Programme

1. Introduction to Quality engineering
2. Quality Tools (7QC) and Statistical Process Control (SPC)
3. Problem solving techniques (8D, A3, 5W)
4. Measurements in industry and Measurement System Analysis (MSA)
5. Risk management and Failure Mode and Effects Analysis (FMEA)
6. Product quality development, process planning and control (APQP)
7. Design of Experiments (DoE)
8. Quality management systems (Lean production, ISO, IATF)

Prerequisites

- Good knowledge in measurements in mechanical engineering
- Good knowledge in technical drawing and 3D modelling
- Basic knowledge in data processing and evaluation

Learning outcomes

- Familiarity with the quality tools and techniques of statistical process control.
- Awareness of the importance of measurement techniques and ability to select appropriate measurement systems in the manufacturing process.
- Knowledge on the methods of design of experiments and their application in empirical modelling and process optimization.
- Ability to apply quality tools and techniques of quality assurance/control in all stages of the product quality development, process planning and control.

Assessment

- 50% theoretical written exam with the mutual exam.
- 20% independent work in exercises
- 30% laboratory work with the short evaluation/reports.

References

T. Pyzdek, P. A. Keller: Quality engineering handbook. Marcel Dekker, Inc., New York, 2003.
R. Basu: Implementing Quality – A Practical Guide to Tools and Techniques, Thomson Learning, London, 2004
J. Antony: Design of Experiments for Engineers and Scientists; Elsevier 2014

University of Ljubljana

Micromanufacturing technologies 5 ECTS

Lecturers: **J. Valentinčič, A. Lebar, I. Sabotin, M. Jerman**

Lectures: 30h | Tutorials: 15h | Labs: 15h | Project: 0h | Autonomy : 0h | Lang. :

Objectives

Micromanufacturing is a recent trend of development in the manufacturing sciences. Being able to produce parts with microscopic features in desired tolerances enables the development of new products with higher added value. By incorporating microfeatures the products gain new functionalities, can integrate many functionalities in one product and, if produced with a mass micromanufacturing technology, can be relatively cheap. The objectives of this course are to teach students about the principles, capabilities and performances of micromanufacturing technologies and to demonstrate a specific approach towards microproduct design.
This course will thus browse i) Silicon based microfabrication technologies, ii) microengineering technologies, derived from conventional scale manufacturing technologies, iii) additive technologies suitable for micromanufacturing, iv) micro process chain development v) the characterisation of microproducts and vi) how to approach microproduct design.

Keywords: microtechnologies, micromanufacturing, process chains, manufacturing, characterisation of microproducts

Programme

1. Introduction to micromanufacturing technologies in terms of physical processes and their technological capabilities,
2. Understanding the use/role of microtechnologies in modern production processes,
3. Application of knowledge from the literature to practice,
4. Identification of appropriate technologies and/or process chains for micro product manufacturing,
5. Building numerical models and perform simulations of some micromanufacturing processes.

Prerequisites

- Basic knowledge on conventional manufacturing technologies
- Basic knowledge of computer aided design

Learning outcomes

- Mastering micro-manufacturing technologies and applications.
- Ability to find technological solutions for microproduct manufacturing.
- Ability to search for information, critical judgment and practical applications.
- Ability to design products that can be effectively fabricated with micromanufacturing technologies.

Assessment

- 50% theoretical written exam with the mutual exam.
- 20% laboratory work with the short evaluation/reports.
- 30% seminar work

References

M. Madou: Fundamentals of Microfabrication and Nanotechnology, 3rd edition, CRC Press, 2011.
Y. Qin: Micromanufacturing Engineering and Technology, 2nd edition, Elsevier, 2015.
V.K. Jain: Introduction to Micromachning, Alpha Science, 2010.
G. Tosselo: Micro injection molding, Carl Hanser Verlag GmbH & Co. KG, 2019.

University of Ljubljana

Additive Technologies 5 ECTS

Lecturers: **E. Govekar, D. Klobčar**

Lectures: 30h | Tutorials: 15h | Labs: 15h | Project: 0h | Autonomy : 0h | Lang. :

Objectives

Additive technologies drive industrial development and enable new industrial solutions. Human resources are the cornerstone of fully exploiting the potential of these technologies, and the content addresses them. In this course, students will strengthen their knowledge and competences in the field of principles, capabilities and performances of additive manufacturing technologies and to demonstrate a specific approach towards AM product design. Objective are accordingly aligned: a) Learning the possibilities and potentials of additive manufacturing technologies, b) Learning the elements of the entire production chain from product model, c) AM simulations to the final functional product, d) Learning the systems and processes of AM for metals, e) Identifying cost-effective technology and business opportunities for successful implementation to achieve added value.

Keywords: additive manufacturing, process chains, manufacturing, characterisation of surface integrity

Programme

1. Introduction and basic concepts of additive manufacturing technologies (AM), and basic physical principles of AM of metals and multiple material metals
2. Product design specifics for AM according to variations of AM systems and processes
3. Direct arc deposition of metals and laser based AM systems and processes for metals
4. AM based on selective laser melting processes (SLM) and direct laser deposition (DLD)
5. Software in the field of AM with post processing needs for providing functional characteristics to the products

Prerequisites

- Basic knowledge on conventional manufacturing technologies
- Basic knowledge of computer aided design

Learning outcomes

- Mastering additive manufacturing technologies and applications.
- Ability to find technological solutions for AM products.
- Ability to search for information, critical judgment and practical applications.
- Ability to design products that can be effectively fabricated with AM technologies.

Assessment

- 50% theoretical written exam with the mutual exam.
- 30% laboratory work with the short evaluation/reports.
- 20% seminar work

References

I. Gibson, D. W. Rosen, B. Stucker: Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

2. John I. Milewski,Additive Manufactoring of Metals From Funadamental Technology to Rocket Nozzles, Medical Implants and Custom Jewellery, Springer series in material sciences, 2017

3. L. Bian, N. Shamsaei, and J. M. Usher Laser-Based Additive Manufacturing of Metal Parts Modeling, Optimization, and Control of Mechanical Properties, CRC Press, 2017.

4. O. Diegel, A. Nordin, D. Motte: A Practical Guide to Design for Additive Manufacturing, Springler series in Advanced Manufacturing, 2020.

5. Milan Brandt: Laser Additive Manufacturing: Materials, Design, Technologies, and Applications, 2017.

6. A. B. Badiru, V.V. Valencia, D. Liu: Additive Manufacturing Handbook: Product Development for the Defense Industry, CRC Press, 2017.

University of Ljubljana

Energy Conversion Systems 5 ECTS

Lecturers: **M. Sekavčnik, M. Mori,**

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

Objectives

The objective is to teach the students the methodologies used in the framework for the sustainability assessment of production processes, technologies and processes in the whole life cycle of the products. Three pillars of the sustainable development will be addressed: environmental impacts, costs, and social impacts of the technology. This course will thus involve i) the basic framework for sustainable development assessment, ii) directives, guidelines and commitments at the EU level, iii) environmental evaluation using life cycle assessment, iv) cost evaluation using life cycle costing assessment, v) social impacts evaluation using social life cycle assessment, vi) experimental work with software and vii) project work on case studies.

Keywords: sustainability assessment, production processes, use phase, end-of-life, life cycle assessment, life cycle costs, social life cycle, eco-design

Programme

1. Introduction to the sustainable development framework
2. Basic screening of the carbon footprint in the companies
3. Basics of the methodology in the life cycle of the products and production processes
4. Life cycle costing and relevant cost categories in production processes
5. Social life cycle assessment and impacts of technologies
6. Eco-design framework and eco-design principles

Prerequisites

- Understanding of basic production processes
- Understanding of mass end energy balance in production process
- Basic knowledge regarding data process and evaluation
- Recognition of environmental impacts importance in life cycle of technologies

Learning outcomes

- Knowledge regarding sustainable assessment framework
- Ability to assist the companies in assessing the carbon footprint in all relevant scopes
- Ability to define the goal, scope, inventories relevant for assessment of environmental, economic, and social impacts of processes and technologies
- Knowledge regarding software and codes for assessing the previous aspects
- Ability to identify hot spots in the production process relevant for eco-design actions.
- Ability to evaluate sustainability of eco-designed products

Assessment

- 50% theoretical written exam with the mutual exam.
- 20% laboratory work with the short evaluation/reports.
- 30% coursework/seminar work

References

GHG protocol: A Corporate Accounting and Reporting Standard, World resources Institute, World Business Council for Sustainable Development
ILCD Handbook, General guide for Life Cycle Assessment (2010), Joint Research Centre
ILCD Handbook, Specific guide for Life Cycle Inventory (2010), Joint Research Centre
ILCD Handbook, Life Cycle Impact Assessment Guide: Framework and requirements for Life Cycle Impact Assessment (LCIA) models and indicators (2010), Joint Research Centre
B.S. Dhillon, Life Cycle Costing for Engineers, 2017
Life Cycle Initiative, Social Life Cycle Assessment of Products and Organizations 2020

University of Ljubljana

Laser Processing Technology 5 ECTS

Lecturers: **M. Jezeršek**

Lectures: 30h | Tutorials: 15h | Labs: 15h | Project: 10h | Autonomy : 0h | Lang. :

Objectives

The objective of the course is to equip students with a comprehensive understanding and practical skills necessary for the manipulation and application of lasers in materials processing. The students will learn the underlying physics of laser-material interactions, explore various laser sources, and gain hands-on experience in employing laser systems in wide area of modern manufacturing. Those cover: i) Understand the fundamental principles of laser physics and laser-material interactions, ii) Distinguish between different types of lasers and their suitability for various processing applications, iii) Demonstrate knowledge of the safety protocols and guidelines related to laser processing, iv) Apply analytical methods to optimize laser parameters for specific materials processing tasks, v) Troubleshoot common issues in laser processing technology and develop solutions, vi) Evaluate the benefits and limitations of laser processing in comparison to traditional manufacturing processes, and vii) Foster an innovative mindset towards the evolving capabilities of laser technology and its potential impact on sustainable manufacturing.

Keywords: Laser techniques, laser in manufacturing, laser concepts, surface integrity, safety and cleanliness

Programme

1. Introduction and overview of laser sources and their characteristics
2. The process of developing laser systems, environmental influences and optomechanical characteristics of materials
3. Optical aberrations and computer design of optical systems
4. Attachment and adjusting of optical elements, laser beam guidance systems, and laser focusing systems
5. Ensuring the safety of laser system and trends for clean manufacturing processes

Prerequisites

- Understand the structure and operation of laser systems
- Understand the process of laser systems development
- To learn the methods of designing and construction of optomechatronic systems

Learning outcomes

- Thorough theoretical, methodological and analytical knowledge with elements of a research work that form a basis for very demanding professional work in the field of laser systems.
- Planning and managing of the working process on the basis of creative solving of problems that are linked to the teaching and training of the laser systems.
- Ability to acquire original knowledge, creations and critical judgments in the field of laser systems.

Assessment

- 50% theoretical written exam with the mutual exam.
- 50% laboratory work (work on exercises, preparation, collaboration, individual work).

References

1. E. Kannatey-Asibu, Principles of Laser Materials Processing, Wiley, 2009.
2. Malacara, Optical Shop Testing, 3rd ed., Wiley, 2007.
3. J.T.Luxon, D.E. Parker, Industrial lasers and their applications, Prentice-Hall Inc., Englewood Cliffs (NJ) USA, 1985.