Syllabus
Course Program

Design of Electro-Physical and Electric Power Equipment

Specialty
141 – Electric Power, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electric Power Industry

Department
Engineering Electrophysics (135)

Level of education
Masters's level

Course type
Optional

Semester
2

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

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Ph. D., Associate Professor at the Engineering Electrophysics Department of NTU "KhPI".
Authored 6 publications in the domain of strong magnetic field calculations, computation of strong magnetic fields, electromagnetic forming and related areas. Lecturer on “Modelling of Electro-Physical and Electric Power Equipment and Processes”, “High Voltage Measurements”, “High Voltage Equipment”, “High Voltage Pulse Equipment”, etc.
More about the lecturer on the department's website

General information

Summary

This course provides a comprehensive overview of electro-physical and electric power equipment design. Beginning with an introduction to the fundamental concepts and classifications of electrophysical equipment, students will explore various types, with a particular emphasis on electromagnetic applications such as high-speed forming, chemical and electrical explosion forming, and electromagnetic forming. The course also covers techniques like electromagnetic welding, hardening, ion and electron beam technologies, electrical erosion equipment, and ultrasonic processing.
In addition to electrophysical equipment, the course addresses key electric power equipment components like capacitors, inductors, transformers, generators, and insulators. Practical workshops, including Finite Element Method (FEM) calculations, are integrated to reinforce theoretical knowledge. The curriculum is designed to be clear and accessible, providing students with the necessary skills to understand and design electro-physical and electric power equipment.

Course objectives and goals

The primary goal of this course is to equip students with a solid understanding of the design and operation of both electro-physical and electric power equipment. Students will learn to differentiate and classify various types of electrophysical equipment, with a focus on electromagnetic techniques. The course aims to develop students' ability to apply theoretical concepts in practical settings, particularly through workshops and FEM calculations. By the end of the course, students should be proficient in designing basic electro-physical and electric power equipment, understanding their applications, and addressing real-world challenges in the field.

Format of classes

Lectures, workshops, consultations, self-study. Final control in the form of an examination.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 8. The ability to learn and master modern knowledge.
GC 9. Ability to search, process and analyze information from various sources.
PC 1. Ability to use computer-aided design (CAD), manufacturing (CAM) and engineering calculations (CAE) and related application software packages.
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 4. Ability to use professional knowledge in the basics of electric power: electrical part of stations and substations, electrical systems and networks, relay protection and automatics of power systems and high voltage equipment for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 8. Ability to use modern methods of calculations, modeling and analysis of modes of operation of electric power, electrotechnical and electromechanical equipment and design of electric and electromechanical systems.
PC 12. Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
PC 20. Receiving and using professional knowledge and understanding related to the processes of electrophysical highvoltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Learning outcomes

PRT 2. Discuss professional topics.
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 19. Solving professional tasks in the design, installation and operation of electric power, electrical engineering, electromechanical complexes and systems.
PRT 40. Know and understand the processes of operation of electrophysical high-voltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 48 hours, workshops - 32 hours, self-study - 70 hours.

Course prerequisites

Physics, Theoretical Foundations of Electrical Engineering p.1, Theoretical Foundations of Electrical Engineering p.2, Design of Electro-Physical and Electric Power Equipment

Features of the course, teaching and learning methods, and technologies

Lectures employ modern multimedia tools to enhance the learning experience. Workshops are structured around a mix of student preparatory self-study and collaborative team activities. Experiential learning is also an integral part of the coursework, allowing students to learn from real-world scenarios. Knowledge and skills cultivated during practical sessions are further reinforced as students tackle individual computational tasks.

Program of the course

Topics of the lectures

Topic 1. Introduction to Electrophysical Technologies: Principles and Applications
Explore the fundamental principles of electrophysical technologies and their diverse applications across various industries.
Topic 2. High-Speed Metal Forming Techniques: Fundamentals
Delve into the core principles and mechanisms behind high-speed metal forming, highlighting its advantages and challenges.
Topic 3. Explosive Forming: Concepts and Practical Approaches
Uncover the concepts behind explosive forming, discussing its unique approach to shaping materials through controlled detonations.
Topic 4. Electrohydraulic Forming: Mechanism and Applications
Examine the electrohydraulic forming process, its underlying mechanisms, and its industrial applications.
Topic 5. Electromagnetic Forming: Principles and Process
Understand the principles of electromagnetic forming, including the interaction between magnetic fields and metals during the forming process.
Topic 6. Tool Coils in Electromagnetic Forming: Multi-Turn Coils
Analyze the design and function of multi-turn coils in electromagnetic forming, and their impact on the efficiency of the process.
Topic 7. Massive Solenoids in Electromagnetic Forming
Study the role of massive solenoids in electromagnetic forming, focusing on their design, application, and influence on the forming process.
Topic 8. Field-Shaper Design in Electromagnetic Forming
Discuss the purpose and design principles of field-shapers in electromagnetic forming, emphasizing their contribution to field uniformity and efficiency.
Topic 9. Achieving High Field Uniformity in Tool Coils
Investigate the techniques to achieve high field uniformity in tool coils, and its significance in improving the quality of the formed parts.
Topic 10. Computational Modeling of Electromagnetic Forming Processes
Explore the use of computational modeling in simulating and optimizing electromagnetic forming processes.
Topic 11. Material Properties and Behaviors in Electrophysical Processes
Examine how different material properties affect their behavior in electrophysical processes, with a focus on parameters like skin depth and conductivity.
Topic 12. Electromagnetic Welding: Techniques and Technologies
Delve into electromagnetic welding, discussing the various techniques and technologies involved, and their industrial applications.
Topic 13. Electromagnetic Hardening: Processes and Equipment
Explore the processes of electromagnetic hardening, the equipment used, and its role in enhancing material properties.
Topic 14. Introduction to Beam Technologies: Basics and Applications
Introduce the basics of beam technologies, including their principles and applications in various industrial settings.
Topic 15. Ion Beam Technology: Principles and Applications
Examine the principles of ion beam technology and its diverse applications in material processing and analysis.
Topic 16. Electron Beam Technology: Fundamentals and Industrial Uses
Study the fundamentals of electron beam technology, focusing on its industrial uses and the advantages it offers.
Topic 17. Laser Beam Technology: Mechanism and Applications
Discuss the mechanism of laser beam technology and its broad range of applications in cutting, welding, and surface treatment.
Topic 18. Magnetron Deposition Technology: Principles and Applications

Explore the principles of magnetron deposition technology and its applications in coating and material fabrication.

Topic 19. Electrical Erosion Shaping: Mechanisms and Implementations

Understand the mechanisms behind electrical erosion shaping and its practical implementations in precision material removal.

Topic 20. Finite Element Method (FEM) in Electrophysical Technology Design

Delve into the use of Finite Element Method (FEM) in designing and optimizing electrophysical technology processes and equipment.

Topic 21. Power Equipment in Electrophysical Technologies: Basics and Calculations

Examine the basics of power equipment used in electrophysical technologies, focusing on their design and the calculations involved.

Topic 22. Safety and Environmental Considerations in Electrophysical Technologies

Discuss the safety protocols and environmental considerations crucial in the operation of electrophysical technologies.

Topic 23. Case Studies and Quality Control in Electrophysical Manufacturing

Analyze various case studies to understand the importance of quality control measures in electrophysical manufacturing processes.

Topic 24. Future Directions and Innovation in Electrophysical Technologies

Explore the future directions and ongoing innovations in electrophysical technologies, looking ahead at potential advancements and applications.

Topics of the workshops

.Topic 1. Hands-On Introduction to Electrophysical Technologies

Engage in a practical exploration of electrophysical technologies, familiarizing with the basic equipment and techniques.

Topic 2. Demonstrating High-Speed Metal Forming

Experience high-speed metal forming firsthand, understanding the setup, process, and immediate outcomes.

Topic 3. Simulating Explosive Forming Techniques

Simulate explosive forming techniques in a controlled environment, observing the effects of variable detonation parameters.

Topic 4. Electrohydraulic Forming: A Practical Approach

Participate in an electrohydraulic forming exercise, learning to manage the equipment and process parameters.

Topic 5. Building and Testing Multi-Turn Coils for Electromagnetic Forming

Construct multi-turn coils and test their effectiveness in an electromagnetic forming setup.

Topic 6. Designing and Implementing Massive Solenoids

Design massive solenoids tailored for specific electromagnetic forming applications and evaluate their performance.

Topic 7. Crafting and Utilizing Field-Shapers

Craft field-shapers and integrate them into an electromagnetic forming setup, assessing their impact on field distribution.

Topic 8. Techniques for Achieving High Field Uniformity

Apply various techniques to achieve high field uniformity in tool coils and evaluate their effectiveness through practical tests.

Topic 9. FEM Simulation of Electromagnetic Forming

Use Finite Element Method (FEM) software to simulate electromagnetic forming processes and analyze the results.

Topic 10. Analyzing Material Properties in Electrophysical Processes

Conduct experiments to analyze how different material properties affect their behavior in electrophysical processes.

Topic 11. Practical Aspects of Electromagnetic Welding

Get hands-on experience with electromagnetic welding, focusing on technique, equipment setup, and safety measures.

Topic 12. Electromagnetic Hardening: A Workshop Approach

Perform electromagnetic hardening processes, understanding the practical considerations and assessing the outcomes.
Topic 13. Exploring Beam Technologies: A Practical Perspective
Engage in practical exercises to understand the basics of ion, electron, and laser beam technologies.
Topic 14. Ion Beam Applications: A Hands-On Exploration
Experiment with ion beam technology, applying it to material processing and analysis tasks.
Topic 15. Working with Electron Beams in Industrial Contexts
Operate electron beam equipment, focusing on its industrial uses and the operational nuances.
Topic 16. Implementing Laser Beam Techniques
Practice with laser beam technology, exploring its versatility in cutting, welding, and surface treatment applications.

Topics of the laboratory classes

Self-study

In this course, students will connect theoretical aspects of electrophysical technologies with practical applications by examining a case study relevant to their region. This analysis will illuminate the practical impacts and potential innovations within the field.
Students will undertake computational exercises to simulate and optimize various electrophysical processes, providing a hands-on understanding of the interplay between physical parameters and process outcomes.
A research project will complement these tasks, offering a panoramic view of the electrophysical technology landscape, including its challenges, advancements, and prospects within the national context.
Supplemental resources will be provided to deepen understanding of specific topics, and although the coursework is primarily computational, students are encouraged to expand their learning through homework and independent research, utilizing online and literature-based resources. This self-study component not only broadens theoretical knowledge but also sharpens practical skills essential in electrophysical technologies.

Course materials and recommended reading

1. Psyk, Verena, et al. "Electromagnetic forming—a review." Journal of Materials Processing Technology 211.5 (2011): 787-829.
2. Daehn, Glenn S. "High-velocity metal forming." Metalworking: Sheet Forming(ASM Handbook Volume 14 B) 14 (2006): 405-418.
3. Steen, William M., and Jyotirmoy Mazumder. Laser material processing. springer science & business media, 2010.
4. Orloff, Jon, ed. Handbook of charged particle optics. CRC press, 2017.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final score for this course is calculated based on a combination of evaluations from final exam, workshop achievements, and the execution of individual assignments.
1. Exam.
Students can earn up to 40 points from the final exam. The exam evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshop Assignments.
Engaging and participating in laboratory sessions, including quizzes and tasks, can earn students up to 30 points.
3. Individual Assignments.
For the completion of individual assignments students can receive up to 30 points.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by

Date, signature
2023

Head of the department
Serhii MOSTOVYI

Date, signature
2023

Guarantor of the educational program
Halyna OMELIANENKO