Syllabus
Course Program

High Frequency Currents and Ultrasound in Engineering

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
Master's level

Course type
Special (professional)

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

The course "High Frequency Currents and Ultrasound in Engineering" focuses on the fundamental principles and applications of high-frequency electromagnetic fields in engineering. Students will explore the theory and practical aspects of induction heating of metals and delve into electromagnetic processes in systems with finite cross-sections. The curriculum also covers thermal calculations for induction heating, high-frequency equipment, and ultrasonic material processing.

Course objectives and goals

The main goal of this course is to impart a comprehensive understanding of high-frequency currents and ultrasound in engineering. Students will learn to design and analyze high-frequency systems, focusing on their life cycle, from development to disposal. The course aims to enhance the ability to apply natural science principles to solve engineering tasks, critically evaluate results, and make informed decisions. It prepares students to address specialized challenges in the field, combining theoretical knowledge with practical applications.

Format of classes

Lectures, workshops, consultations, self-study. Final control in the form of a module test.

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 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.

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 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 120 hours (4 ECTS credits): lectures - 32 hours, workshops - 16 hours, self-study - 72 hours.

Course prerequisites

Physics, Higher Mathematics, Theoretical Foundations of Electrical Engineering p.1, Theoretical Foundations of Electrical Engineering p.2

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

Lectures employ modern multimedia tools to enhance the learning experience. Workshops classes 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 High Frequency Currents and Ultrasound in Engineering
An overview of the course, outlining the historical development and fundamental concepts of high frequency currents and ultrasound in engineering applications.
Topic 2. Physical Principles of Induction Heating in Metals
Exploration of the basic principles of induction heating, focusing on the physical processes occurring in metals under high frequency electromagnetic fields.
Topic 3. Electromagnetic Processes in Finite Cross-Section Systems
Delving into the analysis of electromagnetic processes, particularly in systems with finite cross-sectional areas like cylinders and flat conductors.
Topic 4. Inductor Design and Resistance Calculations
Understanding the design aspects of inductors and calculating the electrical and magnetic resistance in ferromagnetic environments.
Topic 5. Load Resistance Concepts and Short Inductor Calculations
Introduction to the concepts of load resistance and practical approaches to calculating short inductors without a magnetic core.

Topic 6. Cylindrical Inductor Calculation Algorithms
A detailed look at the algorithms and methodologies for calculating the parameters of cylindrical inductors.
Topic 7. Fundamentals of Thermal Calculations in Induction Heating
Exploration of the basic thermal calculation modes in induction heating, including an introduction to heating regimes and surface temperature control.
Topic 8. Heating Modes and Surface Temperature Regulation
Discussing various heating modes in induction processes and the techniques for regulating surface temperature.
Topic 9. High-Frequency Equipment Components and Characteristics
An overview of the components and characteristics of high-frequency equipment used in engineering applications.
Topic 10. Electromagnetic Converters and Lamp Generators
Study of electromagnetic converters and lamp generators, focusing on their design, functionality, and applications.
Topic 11. Thyristor Converters and Frequency Multipliers
Insight into the workings of thyristor converters and electromagnetic frequency multipliers and their role in high-frequency systems.
Topic 12. High-Frequency Installation Capacitors and Transformers
Understanding the role and design of capacitors and transformers in high-frequency installations.
Topic 13. Induction Melting Furnaces: Classification and Applications
Classification and application areas of induction melting furnaces, with a focus on channel and crucible furnaces.
Topic 14. Design and Functionality of Induction Channel Furnaces
Detailed analysis of the design principles and operational functionality of induction channel furnaces.
Topic 15. Induction Crucible Furnaces and Metal Circulation
Exploring induction crucible furnaces, focusing on metal circulation processes and design considerations.
Topic 16. Physical Basics and Applications of Ultrasonic Processing
A comprehensive look at the physical principles of ultrasonics and their wide range of applications in material processing.

Topics of the workshops

Topic 1. Practical Applications of Induction Heating and Electromagnetic Fields
Hands-on exploration of induction heating, understanding the practical applications of electromagnetic fields in industrial settings.
Topic 2. Electromagnetic System Analysis and Design
Focused on analyzing and designing electromagnetic systems, applying theoretical knowledge to real-world scenarios.
Topic 3. Thermal and Inductor Resistance Calculations
Workshop dedicated to the practical calculation of thermal processes and inductor resistances in high-frequency systems.
Topic 4. Advanced Techniques in Induction Heating Systems
Exploring advanced techniques and methodologies in induction heating, enhancing skills in system design and optimization.
Topic 5. High-Frequency Equipment: Operation and Maintenance
Understanding the operational nuances and maintenance requirements of high-frequency equipment used in engineering.
Topic 6. Analysis of High-Frequency Converters and Generators
Deep dive into the analysis of high-frequency converters and generators, understanding their roles and functionalities.
Topic 7. Induction Furnaces: Design, Operation, and Maintenance
Exploration of induction furnaces, focusing on design principles, operational strategies, and maintenance practices.
Topic 8. Ultrasonic Processing in Material Engineering
Hands-on experience with ultrasonic processing techniques, understanding their applications in material engineering.

Topics of the laboratory classes

Self-study

As the self-study component of "High Frequency Currents and Ultrasound in Engineering," students will independently explore real-world applications of high-frequency currents and ultrasound in engineering. This involves analyzing case studies on induction heating and ultrasonic processing, applying the theoretical knowledge gained from lectures.
The primary task is to evaluate different high-frequency systems and ultrasonic processes using simulation tools, focusing on their efficiency and practicality in industrial settings. Students will then compile a report summarizing their findings and analyses, demonstrating a clear understanding of the course material.
Supplementary resources, including reading materials and software tutorials, are recommended to enhance their understanding of complex topics and support a well-rounded learning experience. This approach aims to deepen theoretical knowledge with practical insights, culminating in a comprehensive understanding of the subject.

Course materials and recommended reading

1. Kazimierczuk, Marian K. High-frequency magnetic components. John Wiley & Sons, 2009.
2. Da Silva, Ed. High frequency and microwave engineering. Newnes, 2001.
3. Han, Qingyou. "Ultrasonic processing of materials." Metallurgical and Materials Transactions B 46 (2015): 1603-1614.

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 module tests, workshop task achievements, and the execution of individual assignments.
1. Module Tests.
Students can earn up to 40 points from the final module tests. These tests evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshops Assignments.
Engaging and participating in workshop 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