Syllabus of the educational component
Course Program

Electrical Machines

Specialty
141 – Electric power, electrical engineering and electromechanics

Institute
Scientific and Educational Institute of Energy, Electronics and Electromechanics

Educational program
Electromechanics

Department
Electrical machines (126)

level of higher education
first (bachelor's)

Course type
Special (professional), Mandatory

Semester
5

Language of instruction
English

Lecturers and course developers

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Doct. Tech. Sciences, Associate Professor, Professor of the Department Electrical Machines

She has more than 300 publications in scientific journals, 10 patents, 8 monographs and manuals. May of the title "ING-PAED IGIP" (International teacher in the gallery of engineering pedagogy IGIP). Basic courses - Electrical machines, Electrical machines and devices, Reliability and diagnostics, Electric generators for HPPs and mini-HPPs, Power supply of industrial enterprises, Operation and modes of operation of power plants electrical equipment, Prospects for the use of superconductivity in electromechanics.
Learn more about the teacher on the department's website

General information

Summary

The discipline studies the device and principle of operation of electrical machines (EM) and transformers, their characteristics, features of operation and maintenance.

Course objectives and goals

The purpose of the discipline is to prepare bachelors in specialty 141 - Power Engineering, Electrical Engineering and Electromechanics, which provides a base of theoretical and practical knowledge of future professionals in the field of manufacture, installation, operation of electric machines (EM), methods and means of measuring EM parameters. and during operation. Know the principle of operation and basic characteristics of EM; to choose the necessary EM for the electrical equipment of industrial enterprises, to check their operability, to know how to start, brake, adjust and reverse the EM.

Format of classes

Lectures, laboratory and practical works, independent work, consultations. The final control is an exam.

Competences

Ability to solve specialized problems and make decisions practical problems during professional activity in the field electrical engineering, electrical engineering and electromechanics, which involves the application of theories and methods of physics and engineering sciences and are characterized complexity and uncertainty of conditions.
Ability to abstract thinking, analysis and synthesis.
Ability to apply knowledge in practical situations.
Ability to communicate in the state language both orally and yes and in writing.
Ability to search, process and analyze information from various sources.
Ability to identify, pose and solve problems.
Ability to work autonomously and in a team.
The ability to realize one's rights and responsibilities as a member of society, to be aware of the values of a civil (free democratic) society and the need its sustainable development, rule of law, rights and freedoms person and citizen in Ukraine.
The ability to solve practical problems using automated design and calculation systems (CAD).
The ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drives.
Awareness of the need to improve efficiency electric power, electrotechnical and electromechanical equipment.
Awareness of the need to constantly expand own knowledge about new technologies in electricity, electrical engineering and electromechanics.
The ability to promptly take effective measures in emergency (emergency) situations in electric power and electromechanical systems.

Learning outcomes

The student must know the purpose, types, classification, areas of use of transformers and electrical machines (EM). Have fundamental theoretical and practical knowledge and skills in the field of electrical engineering, be able to conduct experimental research of EM and transformers, develop a program of their research and analyze experimental data, present them in graphical, tabular and other forms, draw conclusions about the parameters and characteristics of EM and transformers.
Apply application software to solve practical problems in professional activities. To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.
Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate its relevance and reliability.
Communicate freely about professional problems in national and Ukrainian languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue one's position from discussion points questions. Understand the basic principles and tasks of technical and environmental safety of electrical engineering and electromechanics objects, take them into account when making decisions.
To understand the importance of traditional and renewable energy for the successful economic development of the country.
Understand the principles of European democracy and respect for the rights of citizens, take them into account when making decisions.

Student workload

The total scope of the discipline is 180 hours. (6 ECTS credits): lectures – 48 hours, laboratory work – 16 hours, practical work – 16 hours; independent work - 100 hours.

Course prerequisites

Introduction to the specialty, Higher mathematics, Physics, Informatics, computer engineering and programming, Theoretical mechanics, Theoretical foundations of electrical engineering, Electrotechnical materials, Fundamentals of metrology and electrical measurements, Fundamentals of electronics, Computer Graphics, Theory of electric drive.

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

Different teaching methods are used in lectures, laboratory and practical classes in accordance with the content of the work program and to enhance the educational and cognitive activities of students in the discipline (active forms of classes, methods of interaction between teacher and students): lecture, lecture-dialogue, lecture survey, laboratory and practical classes, engineering seminar, interview, consultation.

Program of the course

Topics of the lectures

Topic 1. Transformers

Topic 1.1. Basic laws of electromechanics. Law of electromagnetic induction. The law of total current. Electrical materials used in electrical engineering. Classes of heat resistance of insulating materials. Purpose of transformers. Design and principle of the transformer operation. Classification of transformers.

Topic 1.2. Circuits and connection groups of windings of three-phase transformers. The transformer is reduced. Experience of non-operating transformer. Experiment of laboratory short circuit of transformer. Determination of nominal parameters of the transformer based on the results of idling mode and laboratory short circuit.

Topic 1.3. Substitution schemes, equations and vector diagrams of the transformer. Transformer operation at rated load. Transformer characteristics. External characteristics of the transformer. Transformer loss and efficiency.

Topic 1.4. Conditions for turning on transformers for parallel operation. Analysis of nonfulfillment of one of the conditions for the inclusion of transformers for parallel operation. Transients in transformers. Transient process in case of sudden short circuit of transformer. Overvoltage in transformers.

Topic 1.5. Modern directions of improvement of transformers. Use of amorphous steels for transformer cores. Development of transformer cooling systems (use of SF6-s, cryogenic cooling, windings from high-temperature superconductors). Complete transformer substations (CTS): acquisition, place of installation, ensuring magnetic compatibility of CTS elements.

Topic 2. General issues of AC machines

Topic 2.1. The concept of "electric machine". The principle of reversibility of electric machines (EM). Designs of alternating current machines. EM classification.

Topic 2.2. AC stator windings. Obtaining a rotating magnetic field. EMF and MMF AC windings. Choice of the number of stator and rotor grooves.

Topic 2.3. High harmonics in the stator current of the AC machine. Harmonic spectrum. Means of struggle (reduction) of high harmonics in the stator current of the alternating current machine.
Reduction and distribution of windings. Winding factor.

Topic 3. Asynchronous machines

Topic 3.1. Design and principle of an asynchronous machine operation in generator mode and in engine mode Operation of an asynchronous machine with a fixed and movable rotor. Equation and replacement scheme of asynchronous motor (AD). Vector diagrams of asynchronous motors in different modes of operation.

Topic 3.2. Loss and efficiency of asynchronous motors (AD) in different modes of operation. Construction of the power diagram of the AD. Electromagnetic torque of an AD. AD performance. Speed control and reverse of an AD.

Topic 3.3. Start AD. Problems and ways to solve startup problems. Using the skin effect as a means of improving the starting characteristics of AD.

Topic 3.4. The design of the phase rotor AD. Explanation of the need to use a phase rotor AD. Calculation of starting rheostats of AD with a phase rotor in case of restriction of starting currents or increase in starting moment.

Topic 3.5. Single-phase AD. Start-up problems, schemes and selection of starting and working capacitors. AD series. The use of copper for winding rotors AD. New efficiency classes of AD pressure (IE code). AD energy efficiency classification system (EFF3, EFF2, EFF1).

Topic 4. Synchronous machines

Topic 4.1. Design and principle of synchronous generator (SG) operation. Designs of SG rotors. Methods of SG excitation.

Topic 4.2. The anchor reaction in SG. The MMF equation of a synchronous generator. Vector charts of synchronous generators.

Topic 4.3. Characteristics of SG taking into account the design of the rotor and different types of load: idle, short circuit, external characteristics, load and control characteristics. Angular characteristics of synchronous turbo and hydro generators.

Topic 4.4. U-shaped characteristics of SG. SG fluctuations. SG operation with overload, automatic excitation control system (ARZ).

Topic 4.5. Parallel operation of SG with the network. Conditions for switching SG to parallel operation with the network with precise and coarse synchronization. Synchronoscopes. Start and stop SG on the power plant unit (hydraulic lifting, shaft-rotating device).

Topic 4.6. Regulation of active and reactive power of SG at parallel work. Static and dynamic stability of SG. Suddenly KZ SG. Bearing currents: causes, protection of SG from bearing currents.

Topic 4.7. The principle of operation of a synchronous motor (SD). Design and principle of operation of SD. Problems and ways to start diabetes. Speed control SD.

Topic 4.8. Voltage equation and vector diagram of SD. Performance characteristics of diabetes. U-shaped characteristics of diabetes. Synchronous compensator.

Topic 5. DC machines

Topic 5.1. Design and principle of operation of direct current machines (DC). Schemes of inclusion of windings of excitation of DC machines. EMF DC machines anchor winding. Electromagnetic moment of the DC machines.

Topic 5.2. Switching in the DC machines. Means to improve switching. The reaction of the anchor in the DC machines. Means of combating the reaction of the anchor. Anchor windings of DC machines.

Topic 5.3. The principle of operation of the DC generator (GDC). GDC characteristics. Basic equation of GDC. Features of GDC parallel excitation operation, self-excitation conditions.

Topic 5.4. Characteristics of DC motors (DC). The basic equation of the State Tax Service. Problems and ways to start the DC motors. Performance characteristics of DC motors taking into account the scheme of excitation winding. Means of speed control of DC motors. Methods of braking DC engines.

Topics of the workshops

Topic 1. Electrical materials that are used for electrical machines.

Topic 2. Use of transformers with different number of windings per phase. Cooling systems for transformers. Transformer marking.

Topic 3. Determination of schemes and groups of connection of transformer windings.

Topic 4. Construction of stator winding circuits for AC machines. The calculation of the winding factor.

Topic 5. Building an energy diagram of an asynchronous motor. Calculation of starting rheostats of an asynchronous motor with a phase rotor.

Topic 6. Analysis of the angular and *U*-shaped characteristics of a synchronous generator with explicit and implicit pole rotor.

Topic 7. Working characteristics of synchronous generator. Characteristics of the synchronous compensator.

Topic 8. Construction of speed characteristics of DC motors, taking into account the scheme of switching on the field winding.

Topics of the laboratory classes

Topic 1. Study of a single-phase transformer.

Topic 2. Study of a three-phase two-winding transformer.

Topic 3. Determining the polarity of the winding of the three-phase transformer.

Topic 4. Analysis of parallel operation of three-phase two-winding transformer.

Topic 5. Mechanical characteristics of asynchronous machine.

Topic 6. Analysis of the synchronous generator, which works on autonomous load.
Topic 7. Analysis of the synchronous generator in parallel work with the electrical network.
Topic 8. Analysis of the DC generator characteristics.

ISelf-study

Individual tasks. «Calculation of characteristics of transformers and electric machines».
Calculation task according to methodical instructions [15]

Course materials and recommended reading

1. Turowski Janusz, Turowski Marek. Engineering Electrodynamics: Electric Machine, Trans-former, and Power Equipment Design 1st Edition. [Electronic resource]. URL: https://www.amazon.com/Engineering-Electrodynamics-Electric-Transformer-Equipment/dp/1466589310
2. Sahdev S. K. Electrical Machines. - Cambridge University Press, 2018. – 980 p. [Electronic resource]. URL: https://referenceglobe.com/CollegeLibrary/library_books/20200125041045198204Electrical%20Machines%20by%20Mr.%20S.%20K.%20Sahdev.pdf
3. Shevchenko VV. Basics of electric power engineering. Beginning. Training manual. Kharkiv, 2022. 256 p. [Electronic resource]. https://zenodo.org/record/6465750
4. James Cale. Control of Wind Turbine Generators. – Colorado State University? 2014/ - 57 p. [Electronic resource]. URL: https://www.engr.colostate.edu/ECE566/Slides/ECE566_Week5_LectureSlides_Cale.pdf
5. Jacek F. Gieras. Electrical Machines. Fundamentals of Electromechanical Energy Conversion. – Published 2020 by CRC Press. – 450 p. [Electronic resource]. URL: https://www.routledge.com/Electrical-Machines-Fundamentals-of-Electromechanical-Energy-Conversion/Gieras/p/book/9780367736941.
6. Official site of the NTU "KhPI» Electric Machines department. [Electronic resource]. URL: http://web.kpi.kharkov.ua/elmash.
7. Kothari D. P., Nagrath I. J. Electric Machines, 4/e. - Published by the Tata McGraw Hill Education Private Limited, 2010. – 777 p. [Electronic resource]. URL: https://electrovolt.ir/wp-content/uploads/2019/04/Electric-Machines-Kothari-Nagrath-4th-ElectroVolt.ir_.pdf
8. Elements of Electrical Machines. Lecture Notes. Subject Code: BEE 1301. For 3rd Semester Mechanical Engineering and Production Engineering students. VEER Surendra SAI university of technology burla, Odisha, India. – Department of Electrical Engineering. [Electronic resource]. URL: https://www.vssut.ac.in/lecture_notes/lecture1423454727.pdf
9. Lecture Notes of Electric Machines-II. – VEER Surendra SAI University of Technology. [Electronic resource]. URL: https://www.vssut.ac.in/lecture_notes/lecture1424353332.pdf
10. Adneli Consultant, S.L. Electrical Machines – Basic Theory. – License: CC-BY-SA 4.0 International - Creative Commons, Attribution Share-alike, 2021. – 124 p. [Electronic resource]. URL: https://www.researchgate.net/publication/358046144_Book_on_Electrical_Machines_Basic_Theory
11. Kumar S. Ratna. Lecture Notes on Electrical Machines – I. – 2019-2020. II B. Tech II Semester. – Electrical and Electronics Engineering. JB Institute of Engineering and Technology. – 142 p. [Electronic resource]. URL: https://www.jbiet.edu.in/pdffls/EEE-Coursematerial/electrical-machines-1-notes.pdf
12. Electrical Machines and their Applications Fourth Edition. – Pergamon Press, 2016. – 693 p. https://handoutset.com/wp-content/uploads/2022/02/Electrical-Machines-and-their-Applications-by-John-Hindmarsh.pdf
13. Electricity quality and its provision – Balance of active and reactive power. [Electronic resource]. URL: https://forca.ru/knigi/arhivy/kachestvo-elektroenergii-i-ego-obespechenie-7.html
14. Lessons in Electric Circuits. Vol. I – Direct Current (DC). Vol. II – Alternating Current (AC). [Electronic resource]. URL: https://www.allaboutcircuits.com/textbook/
15. Calculation of characteristics of transformers and electric machines. Methodical instructions for performing calculation tasks on the discipline "Electric machines" for full-time foreign students of specialty 141 – Power engineering, electrical engineering and electromechanics / Compilers: Shevchenko V. V., Domochka L. V. – Kharkiv: NTU "KhPI", 2021. – 28 p. [Electronic resource]. URL:

https://repository.kpi.kharkov.ua/server/api/core/bitstreams/62610150-349d-4ca3-961f-c907795edc69/content

Evaluation system

Criteria for evaluating student performance and distribution of points

100% of the final grade consists of the results of the exam assessment (40 %) and the current assessment (60 %). The exam is conducted according to exam tickets in oral form. The current evaluation consists of evaluations for surveying in lectures (15 points), laboratory work (10 points), practical works (10 points), execution of an individual task (30 points), interviews on the topics of independent work student (5 points).
Total 100 points.

Rating scale

Total points	National assessment	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 ethics and policy of the course

TThe 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

The syllabus has been agreed

31.08.2023 — Head of Department
Volodymyr MILYKH

31.08.2023 — Guarantor of the educational program
Olena Yurieva