Syllabus
Course Program

Modeling of Electromechanical Systems

Specialty
141 – Electric Power Engineering, Electrical Engineering and Electromechanics

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

Educational program
Electromechanics

Department
Electrical Machines (126)

Level of education
Master's level

Course type
Special (professional),

Semester
1

Language of instruction
English,

Lecturers and course developers

Yurieva Olena

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candidate of technical sciences, associate professor, docent of the Department of Electrical Machines

Author and co-author of more than 80 scientific and methodical publications. Teaches disciplines: General Theory of Electrical Machines, Simulation of Electrical Machines, Design and Manufacturing Technology of High-Power Synchronous Machines, Organization of Technological Preparation for Production
More about the lecturer on the department's website

General information

Summary

The discipline studies the principles of designing and manufacturing technology of high-power synchronous machines, namely, turbo and hydro generators, medium and high-power synchronous motors.

Course objectives and goals

The purpose of studying the discipline is to acquire knowledge of modern methods of designing synchronous machines, the production technology of turbo- and hydro generators and powerful synchronous motors, as well as acquiring practical skills in making reasonable independent engineering decisions, which are obtained during the implementation of a course project on synchronous clear-pole machines of general or special purpose and laboratory classes at a specialized enterprise..

Format of classes

Lectures, laboratory classes, practical classes, consultations, self-study. Final control in the form of an exam.

Competencies

Ability to abstract thinking, analysis and synthesis.

Ability to search, process and analyze information from various sources.
Ability to use information and communication technologies.
Ability to apply knowledge in practical situations, work independently and in a team.
Ability to generate new ideas, make informed decisions, show creativity and system thinking, identify and assess risks.
Ability to manage projects and critically evaluate their results.
Awareness of the need to constantly expand one's own knowledge about new technologies in electric power, electrical engineering and electromechanics.
Knowledge and understanding of modern technological processes and systems of technological preparation of production, technical characteristics, design features, purpose and rules of operation of electric power, electrotechnical and electromechanical equipment and equipment.
Ability to apply acquired theoretical knowledge, scientific and technical methods and appropriate software to solve scientific and technical problems and conduct scientific research in the field of electric power, electrical engineering and electromechanics.
The ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks, in particular, in the design and operation of power engineering, electrical engineering and electromechanics facilities.
The ability to apply analytical methods of analysis, mathematical modeling and perform physical, mathematical and computational experiments to solve engineering problems and when conducting scientific research.
Ability to apply information and communication technologies and programming skills to solve typical tasks of engineering and scientific activities in electric power, electrical engineering and electromechanics.
The ability to use laws and engineering principles, high-level mathematical apparatus for design, modeling, construction, production, installation, operation, maintenance and disposal of objects, in the field of electric machines, electric devices, electrical household appliances and electric transport.
The ability to research, analyze, apply, and scientifically substantiate the choice of materials, equipment, and the application of technological measures for the implementation of the latest technologies in the field of electric machines, electric devices, electrical household appliances, and electric transport.

Learning outcomes

Find options for increasing energy efficiency and reliability of electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems.
Reproduce processes in electric power, electrotechnical and electromechanical systems during their computer simulation.
Master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems.
Determine a plan of measures to increase the reliability, safety of operation and prolong the resource of electric power, electrotechnical and electromechanical equipment and relevant complexes and systems.
Analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems.
To have the methods of mathematical and physical modeling of objects and processes in electric power, electrotechnical and electromechanical systems.
Adhere to the principles and rules of academic integrity in educational and scientific activities.
Communicate freely orally and in writing in national and foreign languages on modern scientific and technical problems of electric power, electrical engineering and electromechanics.
Plan and carry out scientific research and innovative projects in the field of electric power, electrical engineering and electromechanics.
Solve professional tasks related to the design, installation and operation of electric power, electrotechnical, electromechanical complexes and systems.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, practical classes - 16 hours, self-study - 86 hours.

Course prerequisites

The discipline is based on the bachelor's educational program.

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

Lectures are conducted interactively using multimedia technologies. Active forms of classes are used: lecture, lecture-dialogue, lecture survey, laboratory classes, practical classes, engineering seminar, interview, consultation.
Laboratory works involve familiarization with modern technological methods used at enterprises manufacturing synchronous machines.
Practical classes use a project-based approach to learning, game methods, and focus on the application of information technologies in the design of synchronous machines.

Program of the course

Topics of the lectures

Topic 1. Basic principles of designing high-power synchronous machines
Classification of synchronous machines. Nominal data of synchronous machines. Machine constant. Selection of main dimensions and electromagnetic loads of synchronous machines
Topic 2. Design of the stator core of a synchronous machine
Selection of the number of stator grooves. Selection of stator slot geometry. Filling the stator groove
Topic 3. Design of the stator winding of a synchronous machine
Loop and wave windings of the stator with an integer and fractional number of slots per pole and phase. The efficiency of using stator windings with a small number of grooves per pole and phase. Transposition of conductors in the stator winding rods
Topic 4. Designing the rotor of a synchronous machine
Selection of the length and shape of the air gap in synchronous machines. Short circuit ratio. Design of the rotor core of synchronous machines. Calculation of EMF of the excitation at idle speed and load.
Topic 5. Checking the electromagnetic calculation of a synchronous machine
Analysis of the correctness of the choice of electromagnetic loads, main dimensions, active and insulating materials, structural and electrical parameters of the stator and excitation windings, manufacturability of the windings
Topic 6. Losses and efficiency of a synchronous machine
Design of the damper (starting) winding. Basic and additional losses of a synchronous machine. efficiency Cooling of synchronous machines. Determination of active and inductive resistances of the windings of a synchronous machine
Topic 7. Calculation of characteristics of synchronous machines
Calculation of the characteristics of synchronous generators during autonomous operation and parallel operation with an infinite power network. Calculation of the characteristics of a synchronous motor.
Topic 8. Construction of synchronous machines
Mechanical calculations and construction of synchronous machines. Design features of turbo- and hydrogen generators, synchronous motors and compensators. Basics of designing a series of synchronous machines.
Topic 9. Technology of assembling the turbogenerator housing
Features of the production technology of turbo and hydro generators. The design of the turbogenerator. The sequence of technological operations of assembly and welding of the constituent parts of the hull. Annealing of welded structures. Testing the turbogenerator housing for strength and tightness. Technology of mechanical processing of parts and assemblies of the turbogenerator body.
Topic 10. Manufacturing technology of the turbogenerator stator core
Manufacturing technology of turbogenerator stator parts and assemblies (body blades, pressure rings, brackets and tire holders, banding rings). The technology of assembling the turbogenerator stator core (stamping and processing of segments, acceleration of the stator blades, assembly and pressing of the core, testing of the core).
Topic 11. Manufacturing technology of the turbogenerator stator winding

Manufacturing technology of turbogenerator stator winding rods (fabrication, weaving, insulation, soldering of tips, testing of conductors and rods). The technology of laying the rod windings of the turbine generator stator (fastening the rods, soldering the tips and testing).

Topic 12. Designing the rotor of a synchronous machine

Technology of mechanical processing of the rotor of the turbogenerator (processing of the rotor shaft and barrel, slotted blades, banding rings and current outlets). The technology of manufacturing the winding of the turbogenerator rotor (features of the winding design, the technology of manufacturing and stacking coil turns and their testing). Turbogenerator rotor assembly technology).

Topic 13. Assembly, transportation, installation of a turbo generator

Turbogenerator assembly technology (stand equipment, stator and rotor transportation, winding the rotor into the stator, control assembly and testing). Packaging for transportation of turbogenerator units to the customer and installation of the turbogenerator at the customer.

Topic 14. Manufacturing technology of the stator core of the hydro generator

Design features of the main types of hydrogen generators (suspended, umbrella and capsule). Manufacturing technology of the stator housing of the hydro generator (dividing into sectors, assembling a sector, manufacturing joint plates, assembling sectors into a ring, dispersing prisms). Production technology of the hydrogen generator stator core (types of segments, their assembly and pressing, laying of banding rings).

Topic 15. Production technology of hydro generator windings

Technology of production and laying of the stator winding of the hydrogen generator (coil and rod winding, laying of the lower and upper layers of the winding, fastening and connection of the rods and their testing). Hydro generator rotor manufacturing technology (design features of the rotor components, manufacturing of the shaft, disc, drum and spoke cores). Production technology of the hydro generator rotor rim (production of segments and their assembly). Technology of manufacturing rotor poles of a hydro generator (manufacturing cores, coils and damper windings).

Topic 16. Assembly, transportation, installation of a hydro generator

The technology of the installation of the hydrogen generator at the customer (organization of the installation, assembly of the stator, laying of the contact parts of the winding, assembly of the rotor, features of the assembly of hanging and umbrella hydro generators).

Topics of the workshops

Topic 1. Selection of main dimensions and electromagnetic loads of synchronous machines
Topic 2. Design of the groove-tooth zone of the stator of a synchronous machine. Filling the stator groove
Topic 3. Construction of the stator winding scheme
Topic 4. Magnetic calculation of synchronous machines
Topic 5. Filling the interpole window of a synchronous clear-pole machine
Topic 6. Calculation of characteristics of synchronous machines
Topic 7. Control work #1
Topic 8. Control work #2.

Topics of the laboratory classes

Laboratory work 1. Technology of mechanical processing of parts and assemblies of the turbogenerator body
Laboratory work 2. Manufacturing technology of turbine generator stator parts and assemblies
Laboratory work 3. Manufacturing technology of turbogenerator stator winding rods
Laboratory work 4. Protection of laboratory work
Laboratory work 5. The technology of winding the stator winding of the hydro generator
Laboratory work 6. Hydro generator rotor manufacturing technology
Laboratory work 7. Manufacturing technology of the hydro generator rotor rim
Laboratory work 8. Protection of laboratory work

Self-study

The discipline involves the implementation of the course project "Design of a Synchronous Salient Pole Machine". The course project contains an explanatory note and drawings of the designed synchronous

machine according to the chosen version of nominal data. The successful defense of the course project is valued at 25 points and is included in the examination grade.
Students are recommended additional materials (videos, articles) for independent study.

Course materials and recommended reading

1. Boldea I. Synchronous Generators / I. Boldea. – CRC Press, 2015.
2. Yuryeva O. Yu. Design of a Synchronous Salient Pole Machine: educational and methodological guide on course design for students of electrical engineering specialties / O.Yuryeva. - Kh.: NTU "KhPI", 2024. - 76 p.

Assessment and grading

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

100% of the final grade consists of the results of the exam assessment (30%) and the current assessment (70%). The exam is conducted according to exam tickets in oral form. The current evaluation consists of evaluations for control works (2 to 10 points), defense of laboratory works (5 to 5 points), defense of the course project (25 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	28.08.2024	Head of the department Andrii YEHOROV
	28.08.2024	Guarantor of the educational program Yevhen BAIDA