TESTING, DIAGNOSIS OF DEFECTS AND SERVICE OF ELECTRICAL MACHINES
Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	*Second*
Branch of knowledge	*14 "Electrical Engineering"*
Specialty	*141 "Electric power, electrical engineering and electromechanics"*
Educational program	*ELECTRIC POWER ENGINEERING, ELECTRICAL ENGINEERING AND ELECTROMECHANICS*
Discipline status	*Normative*
Form of study	*Eye (day)*
Year of preparation, semester	*2nd year, spring semester*
The scope of discipline	*120 hours / 4 ECTS credits*
Semester control / control measures	*Offset / MCR*
Timetable	*http://rozklad.kpi.ua*
Language of instruction	*Ukrainian / English*
Information about the course leader / teachers	Lecturer: Ph.D. Chumak Vadim Vladimirovich, tel. 0502083843
Course placement	*Distance course in the Moodle system* *https://do.ipo.kpi.ua/login/index.php*

Curriculum

1. Description of the discipline, its purpose, subject of study and learning outcomes

The program of the discipline "Testing, diagnostics of defects and service of electric machines»Compiled in accordance with the educational program" Electric Power, Electrical Engineering and Electromechanics "training of masters majoring in 141 - Power Engineering, Electrical Engineering and Electromechanics.

The purpose of studying the discipline "Testing, diagnostics of defects and service of electric machines" is to form in students a system of abilities and skills to perform duties, production functions and typical tasks of the educational qualification level (EQF) master of science and master of professional. provided for primary positions in a particular type of economic activity. The system of abilities and skills that must be mastered by a specialist, meet the standard of higher education master's degree in specialty 141. In particular, the purpose of studying the discipline is to form a system of competencies and skills in diagnosing and monitoring the technical condition of electrical machines, methods of technical calculations, experimental research, operation electric machines.

The subject of the discipline - *there is a branch of diagnostics of electric machines - methods, means, devices, methodologies of diagnostics and control of electric machines.*

Program learning outcomes:

_Competences:_on the choice of methods, schemes, equipment of experimental researches of a technical condition of EM. On processing, analysis and generalization of results of experimental researches.

_Knowledge:_awareness of the place and role of electric machines in modern technical and technological complexes; methods and means of control and diagnostics of technical condition of electric machines; principles of operation of diagnostic equipment of electric machines; place and role of diagnostic systems for electric machines in modern technical and technological complexes; principles of operation of diagnostic equipment of electric machines; on service and control of a technical condition of electric cars; mathematical methods of research and modeling, development of knowledge bases of test and functional diagnostics of electric machines.

_Skills:_apply the acquired knowledge in practice in the control and diagnosis of the technical condition of wide-ranging electric machines; to master the specifics and skills of experimental research of EM, practical skills of testing and certification of electrical machines and devices based on improving general testing issues, state regulations for issuing a certificate of conformity, analysis of known literature sources to individual tasks, performing individual tasks.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

Elective course "Testing, diagnostics of defects and service of electric machines" in the training of specialists of educational qualification level (EQF) master of science and master of professional knowledge 14 Electrical Engineering specialty 141 Electrical Engineering, Electrical Engineering and Electromechanics specialization "Electrical Machines and Apparatus".

The discipline belongs to the cycle of professional training, Educational disciplines of professional and practical training.

The subject of the discipline "Testing, defect diagnostics and service of electric machines" is the field of diagnostics of electric machines - methods, tools, devices, methodologies for diagnosing and controlling electric machines.

Interdisciplinary connections. Disciplines that precede the study of the discipline "Electric machines of automation systems" and constitute its theoretical basis are: "Higher Mathematics", "Physics", "Theoretical Foundations of Electrical Engineering", "Engineering Graphics", "Electrical Materials", "Applied Mechanics", " Fundamentals of metrology and measuring equipment "," Electric machines 1 "," Electric machines 2 ". In addition, the study of this credit module is directly related to the preparation of students for the conscious perception of further courses such as "Special electric machines", "Fundamentals of automated design of electric machines" and others.

3. The content of the discipline

The discipline structurally consists of 9 meaningful subdivisions, namely:

1. General questions of tests of electric machines and devices

Topic 1.1 Introduction. Technical requirements for quality indicators of electric machines. Standardization of test methods for electric machines.
Topic 1.2 Basic requirements for measuring equipment. Basic methods of measurements in tests of electric machines.

2. Determination of efficiency. Testing of machines at high speed and short-term current overload

Topic 2.1. Methods of direct and indirect determination of losses and efficiency.
Topic 2.2. Testing of electric machines at high speed and short-term current overload.

3. Heating test
Topic 3.1. Heating test conditions and operating modes of electric machines. Direct and indirect methods for determining the heating of electric machines.
Topic 3.2. Means for measuring the temperature of individual parts of electrical machines and cooling media.

4. Measurement of winding resistance and insulation
Topic 4.1. Measurement of winding resistance and insulation. Test of electrical insulation strength of windings

5. Testing of certain types of electric machines
Topic 5.1. Tests of power transformers. Testing of asynchronous machines
Topic 5.2. Testing of synchronous machines. Testing of DC machines
Topic 5.3. Testing of low-voltage and high-voltage electrical devices

6. Certification of electrical machines
Topic 6.1. Normative documents on standardization and requirements to them. Categories of normative documents on standardization.
Topic 6.2. Product certification for electrical machines and devices. Drawing up of the certificate of conformity of separate types of electric cars.

7. Diagnosis of active parts of electrical machines (insulation strength of windings and the state of magnetic circuits)
Topic 7.1. Classification of diagnostic models. Properties of mathematical models. Hierarchy of mathematical models and forms of their representation
Topic 7.2. Deterministic and stochastic models. Forecasting the technical condition of electric machines

8. Diagnosis of passive parts of electric machines (bearings, ventilation systems)
Topic 8.1. Identification of components and parts to be diagnosed. Economic efficiency of diagnostics of an electric machine or device.
Topic 8.2. Selection and development of tools for diagnosing electrical machines. Troubleshooting of electric machines. Wear and damage to bearings of electric machines.

9. Service of electric machines (determination of quality of the basic knots on an actual condition, definition of necessity of preventive, average or capital repairs)
Topic 9.1. Aging insulation of electrical machines. Defects and damage to the insulation of the windings of electrical machines and devices
Topic 9.2. Determining the service life of insulation. Damage and defects of rotor and armature windings of electric machines. Wear and damage of active steel of electric machines
Topic 9.3. Wear and damage of collectors, contact rings and brush mechanism of electric machines. Diagnosing the windings of electrical machines

4. Training materials and resources

Main information resources:

1. Vyatkin VE, Chegolin PM Automated control station for electric motors // Sb. Electrical industry. Ser. "Technology of production of electric machines". - M .: Informelectro, issue. 2 (165), 1983. - NTB.
2. Goldberg OD, Gurin JS, Sviridenko IS / Ed. OD Goldberg. Design of electrical machines. - Moscow: Higher School, 1984. - NTB.
3. Goldberg OD Scientific bases of diagnostics and quality control of asynchronous motors // Electricity, 1986. № 1. - NTB.
4. Gurevich EI Thermal testing and research of electric machines. - L .: Energy, 1987. - NTB.
5. Gervais GK Industrial testing of electrical machines. - L .: Energoatamizdat, 1984. - NTB.
6. Kopylov IP Electric machines. - M .: Energoatomizdat, 1986. - NTB.
7. Kotelenets NF, Kuznetsov NL Tests and reliability of electric machines. - M .: Higher. Shk., 1988. - 232 p. - method office of the department. Electromechanics. INTRANET website
8. Loginov VN Electrical measurements of mechanical quantities. - M .: Energy, 1986. - NTB.
9. Methodical instructions for laboratory classes in the discipline "Electric Machines". Sections: "Transformers", "Asynchronous machines" for students of electromechanical and electric power specialties / Incl .: VMAndrienko, MGAnpilogov, VFShinkarenko. - K .: КПІ, 2001. - 53 c. method office office Electromechanics. INTRANET website.
10. Methodical instructions for laboratory classes in the discipline "Electric Machines". Sections: "Synchronous machines", "DC machines" for students of electromechanical and electric power specialties / Incl .: MO Reutsky, OM Davydov, MG Anpilogov, EM Dubchak. - K .: KPI, 2007. method office of the department. Electromechanics. INTRANET website.
11. DECREE OF THE CABINET OF MINISTERS OF UKRAINE (On standardization and certification). With changes and additions made by the Laws of Ukraine. of June 11, 1997 N 333/97-VR.
12. Tests, operation and repair of electric machines: Textbook for universities / NF Kotelenets, NA Akimova, MV Antonov. - M .: Publishing Center - "Academy", 2003. - 384 p.
13. Taran VP Diagnosis of electrical equipment. - K .: Техніка, 1983. - 200 c.
14. Taran VP, Evlantiev VA Methodical instructions for diagnosing asynchronous short-circuited electric motors. M., GOSNITI, 1981. 44p.
15. Umantsev RB Design and repair of short-circuited rotors of large engines. - M .: Энергия, 1976. - 77 c.
16. Volume and standards of tests of electrical equipment. RD 34.45-51.300-97 Production and practical edition. M .: Izdatelstvo NC ENAS, 2006. - 255 p.

Educational content

5. Methods of mastering the discipline (educational component)

Lectures

№ s / n	The title of the lecture topic and a list of key issues (list of teaching aids, links to information sources)
1	***Introduction. General questions of tests of electric machines and devices.*** *Technical*

	requirements for quality indicators of electric machines. Standardization of test methods for electric machines. *Literature: [1], p. 21- 42; [3], pp.24-27; [8], pp.41-47*
2	**Basic requirements for measuring equipment.** *General provisions on the operation, design, characteristics and properties of measuring equipment. Basic methods of measurements in tests of electric machines.* *Literature: [1], p. 43- 47; [3], pp.27-31; [7], pp.71-73*
3	**Determination of efficiency.** *Testing of machines at high speed and short-term current overload. General information about the efficiency of the electric machine, the nature of the efficiency, the factors influencing the efficiency, the types of waste in the electric machine. Methods of direct and indirect determination of losses and efficiency.* *Literature: [2], p. 23- 29; [4], pp.17-21; [7], pp.75-78.*
4	**Heating test.** *Heating test conditions and operating modes of electric machines. Means for measuring the temperature of individual parts of electrical machines and cooling media. Devices for heating of structural parts of EM at test diagnostics.* *Literature: [2], p. 31- 39; [4], pp.27-35; [7], pp.79-83*
5	**Measurement of winding resistance and insulation.** *Methods, tools and devices that implement them are designed to measure the resistance of windings. Measuring bridges. Methods for determining the insulation state of windings.* *Literature: [2], p. 101- 119; [4], p.72-85 [8] p. 131-145*
6	**Testing of asynchronous machines.** *Classification of methods and tools for testing asynchronous machines. Functional diagnostics. Test diagnostics of separate constructive elements of electric machines.* *Literature: [3], p. 21- 39; [5], p.12-76 [8], p. 120-131; [9], p. 5- 19.*
7	**Testing of DC machines.** *Classification of methods and means for testing DC machines. Functional diagnostics. Test diagnostics of separate constructive elements of electric machines of a direct current.* *Literature: [1], p. 131- 149; [5], pp.42-65 [8]; with. 131-145*
8	**Certification of electrical machines.** *Normative documents on standardization and requirements to them. Equipment used for monitoring and diagnostics.* *Literature: [1], p. 151- 174; [3], pp.71-125; [9] p. 13-28; [10] p. 10-18; [11] p. 12-21*
9	**Features of certification of electric machines.** *Categories of normative documents on standardization. Automation of certification of eclectic machines.* *Literature: [1], p. 175- 187; [3], pp.126-143; [9] p. 28-34; [10] p. 19-28; [11] p. 22-34*
10	**Classification of models. Properties of mathematical models. Hierarchy of mathematical models and forms of their representation. Deterministic and stochastic models.** *Classification of models. Properties of mathematical models. Hierarchy of mathematical models and forms of their representation.* *Literature: [1], p. 21- 42; [3], pp.24-27; [5], pp.41-47.*
11	**Basic definitions and probabilistic characteristics of stochastic models.** *Random processes as models of signals in objects of technical nature. Random processes. Basic definitions. Classification of random processes. Stationary random processes. Ergodic random processes. The main probabilistic characteristics of random processes.* *Literature: [1], p. 43- 47; [3], pp.27-31; [4], pp.71-73*
12	**Identification of components and parts to be diagnosed.** *Selection of parameters and development of diagnostic methods for electric machines.* *Literature: [2], p. 23- 29; [2], pp.17-21; [5], pp.75-78.*

13	***Forecasting the technical condition of electric machines.*** *Selection and development of tools for diagnosing electrical machines. Classification of diagnostic tools.* *Literature: [2], p. 31- 39; [4], pp.27-35; [5], pp.79-83*
14	***Identification of components and parts to be diagnosed.*** *Economic efficiency of diagnostics of an electric machine or device. Troubleshooting of electric machines. Wear and damage of parts and components of the EM during operation is a natural process of wear of parts and components of electrical machines.* *Literature: [2], p. 101- 119; [4], p.72-85 [5] p. 131-145* ***Modular control work*** *- 2 hours*
15	***Selection and development of tools for diagnosing electrical machines.*** *Troubleshooting of electric machines. Aging. Defects and damage to the insulation of the windings of electrical machines and devices.* *Literature: [1], p. 21- 39; [2], p.12-76 [4], p. 120-131; [5], p. 5- 19.* *Literature: [1], p.55-64; [2], p. 125-133; [5] p. 186-193*
16	***Troubleshooting of electric machines.*** *Analysis of methods for troubleshooting electrical machines. Effective methods for determining the technical condition of eclectic machines. Diagnostic methods based on the application of several characteristics of one diagnostic parameter.* *Literature: [1], p. 131- 149; [3], pp.42-65 [5]; with. 131-145*
17	***Wear and damage to bearings of electric machines.*** *Analysis of statistics on bearing failures. Regularity between dimensions and reliability of bearings.* *Literature: [1], p. 131- 149; [3], pp.42-65 [5]; with. 131-14*
18	***Aging insulation of electrical machines. Determining the service life of insulation.*** *Analysis of factors influencing the service life of electrical machine insulation. Causes of insulation defects of electrical machines. Types of insulation of electric machines. Values of constants in determining the service life of insulation* *Literature: [1], p. 175- 187; [2], pp.126-143; [4] p. 28-34*

Laboratory work

The main purpose of laboratory work is for students to acquire practical skills in monitoring and diagnosing the technical condition of electric machines of direct and alternating currents.

№ s / n	Name of laboratory work	Number of aud. hours
	Carrying out safety briefing and acquaintance with the equipment	1
1	Testing and diagnosing an induction motor with a short-circuited rotor by the test method	2
2	Testing and diagnostics of windings of general purpose electric machines of 0.4 kV voltage class	2
3	Diagnosing a short-circuited rotor of an induction motor	2
4	Condition monitoring and diagnostics of charged magnetic circuits of electric machines	2

6. Independent work of student

Distribution of hours for independent work by students:

№з / п	Type of independent work	Number hours of CPC
1	Preparation for classroom classes	13
2	Execution of RGR	22
3	Preparation for MCR	8
4	Exam preparation	14
	Total	58

Policy and control

7. Course policy (educational component)

The system of requirements that the teacher puts before the student:

• *rules of attendance: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and practical classes.*

• *rules of conduct in the classroom: the student has the opportunity to receive points for the relevant types of educational activities in lectures and practical classes provided by the RSO discipline. The use of means of communication to search for information on the teacher's Google drive, on the Internet, in a distance course on the Sikorsky platform is carried out under the guidance of the teacher;*

• *policy of deadlines and rearrangements: if the student did not pass or did not appear at the MCR (without good reason), his result is evaluated at 0 points. Interpretation of MCR results is not provided;*

• *Academic Integrity Policy: Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical conduct of individuals and provides a policy of academic integrity for people who work and study at the university, which they should be guided in their activities, including the study and preparation of control measures in this discipline;*

• *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.) it is necessary to adhere to generally accepted ethical norms, in particular to be polite and limit communication during the teacher's working hours.*

8. Types of control and rating system for evaluation of learning outcomes (RSO)

1. Work on lectures
*Weight score - 1.5. The maximum number of points in all lectures is: 1.5 points * 1 = 1.5 points.*
Evaluation criteria:
1.5 points - a complete reasonable answer,
1 point - insufficiently substantiated answer,
0 points - no or incorrect answer.
2. Answers in laboratory classes
*Weight score - 1.5. The maximum number of points in all laboratory work - 1.5 points * 1 = 1.5 points.*

3. Abstract

Weight point - 30 points.

Evaluation criteria:

30 points - the report is completed in compliance with all design requirements, the topic of the task is disclosed in full using both domestic and foreign literary sources with an extensive list of references, free possession of the material, reasonable conclusions;

20… 29 points - the presence of a properly designed report with an average depth of literary search, mastery of the material at the level of the report, reasonable conclusions;

10… 19 points - the presence of a report and a literary search performed at an average level, satisfactory conclusions.

0… 9 points - unsatisfactory design of the report, the list of literature consists only of Internet resources without foreign links, the lack of sound conclusions and analysis of the work.

4. Laboratory work

Weight score - 3.

The maximum number of points for all laboratory work is 9 × 3 = 27 points.

For each laboratory you can get points according to the following rating:

Execution of the experimental part of the work, high-quality processing of experimental data, registration of the protocol in accordance with the standards and a complete, reasonable answer in the defense of the work - 3 points.

Processing of experimental data with minor errors or poor design of the protocol - 2 points.

Significant errors in experimental data but a full understanding of the topic and material of laboratory work - 1 point.

Laboratory work is generally unprotected - 0 points.

The sum of weight points of control measures during the semester (starting rating) is:

RC = 1.5 + 1.5 + 30 + 27 = 60 points.

The credit component of the scale Rc is:

Rs = 40 points

The total weight score of the credit module is:

R = Rc + Rc = 60 + 40 = 100 points.

A necessary condition for admission to the test is the completion of all laboratory classes, as well as a starting rating of at least 50% of the RC, ie 30 points.

Form of semester control - credit

The final evaluation of learning outcomes is carried out according to the stobal rating scale.The credit component of the scale is equal to 40% of the overall rating scale, ie RZ = 40 points. A necessary condition for admission to the exam is a complete syllabus of lectures, completed and defended laboratory work and MCR.

Exam work consists of two theoretical questions

<div align="center">Credit evaluation criteria</div>

− complete answer (complete, error-free problem solving) Rs = 39 - 40 points;

- answer with some insignificant errors Rз = 30 - 38 points;

- answer without significant errors, but not with the full amount of information required Rs = 20 - 29 points;

- incomplete answer with certain errors Rз = 12-19 points;

- incomplete answer with a significant number of errors, but which are not fundamental Rz = 8-11 points;

- completely incorrect answer or no answer - 0 points.

The total number of rating points is defined as RP = RC + Rз

The table of correspondence of total rating points to estimations on the following scale:

Total number of points R_P	Rating
95-100	*Perfectly*
85-94	*Very good*
75-84	*Fine*
65-74	*Satisfactorily*
60-64	*Enough*
Less than 60	*Unsatisfactorily*
Less than 30	*Not allowed*

Work program of the discipline (syllabus):

FoldedAssociate Professor of Electromechanics FEA, Ph.D. Chumakom VV

ApprovedDepartment of Electromechanics FEA (protocol № 11 from 24.06.2021)

AgreedFEA Methodological Commission (Minutes № 11 of 25.06.2021)