National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute

Department of Automation of Electrical and Mechatronic Complexes

Management of the efficiency of energy use of electrical engineering complexes

Working program of the academic discipline (syllabi)

Details of the academic discipline	
Level of higher education	*Second (master's)*
Branch of knowledge	*14 Electrical engineering*
Specialty	*141 Electric Power Engineering, Electrotechnics and Electromechanics*
Educational program	*Engineering of Intellectual Electrotechnical and Mechatronic Complexes*
Discipline status	*Selective*
Form of education	*Full-time (full-time), part-time*
Year of training, semester	*5th year, spring semester*
Scope of the discipline	*5 credits / 150 hours*
Semester control/ control measures	*Exam*
Lessons schedule	*http://rozklad.kpi.ua/*
Language of teaching	*Ukrainian*
Information about head of the course / teachers	Lecturer and practical classes: senior teacher *Volodymyr Dubovyk; e-mail: processor-wl@ukr.net; tel. +380 44-204-8225 (08:00 – 16:00)*
Placement of the course	Available on the Sikorsky platform. The access code is provided by the teacher at the first lesson.

Program of educational discipline

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

The purpose of the discipline "Management of the efficiency of energy use of electrical engineering complexes" is the formation of students' theoretical and practical knowledge about the main types of electromechanical energy converters, increasing their energy efficiency, the principles and systems of electric drive control, the main trends in the development and direction of energy saving in electric drives. At the same time, students acquire specific knowledge, abilities and skills of calculation, design and selection of an automated electric drive for technological machines and mechanisms with different modes of operation, taking into account energy saving issues.

The subject of the educational discipline is the electromechanical properties of the electric drive, the processes of electromechanical energy conversion, the processes of energy consumption and energy use of electromechanical systems, regulation of torque and speed, static and dynamic modes, the issue of energy saving by means of an electric drive. The discipline is designed to form in students a systematic approach to solving the current problems of choosing electrical equipment and managing a technological process with an increased level of use of energy resources. The discipline provides the student with the knowledge and skills necessary for designing and setting up automatic control systems, solving problems of intellectual decision-making in the systems of the electrotechnical complex, and is designed to form in students a systematic approach to solving the actual problems of making certain decisions regarding the management and control of the technological process and optimizing the use of energy resources.

Program learning outcomes:

After mastering the academic discipline, according to the requirements of the educational and professional program, students must demonstrate the following learning outcomes:

KNOWLEDGE:

- the main trends in the development of the electric drive, schemes and technical characteristics of the modern electric drive, typical devices and principles of electric drive control, taking into account energy saving issues, energy properties and characteristics of the electric drive and semiconductor converters.

- laws of development of complex electrotechnical complexes;

– methods of calculating stable and transient processes in electromechanical systems (EMCs);

– methods of calculating energy processes in EMC;

– methods of calculating thermal processes in EMC;

– methods of modeling electric drive systems and their separate components;

- fundamentals of electromagnetic compatibility of electrical equipment;

– methods of research of electromechanical properties of EMC;

- peculiarities of the interaction of material, energy, information, financial and intellectual flows of electrical engineering complexes;

- methods of assessing the energy efficiency of the components of electrical engineering complexes;

- methods of managing the level of energy efficiency of typical technological installations as complexes of energy flow, load node, semiconductor converter, electromechanical converter, mechanical converter, executive body, material flow;

- calculations of the main modes of operation of rotating electric machines, using passport and catalog data;

- methods of increasing the degree of ideality of complex technical systems due to increasing the degree of utility of equipment and intellectualization of control systems of typical electrotechnical installations.

SKILLS:

- analyze and describe the processes of electromechanical energy transformation of industrial facilities, choose measures and means of energy saving and analyze them;

- evaluate the energy efficiency of the complex from the power supply network, load node, semiconductor converter, electromechanical converter, mechanical converter, executive body, material flow network;

- compose verbal algorithms for improving the efficiency of typical installations of electrical engineering complexes, formulate goal functions, formalize verbal algorithms;

- choose methods of increasing the energy efficiency of typical installations of electrical engineering complexes;

– analyze the obtained results;

- search, process and analyze information from various sources, produce new ideas for increasing the energy efficiency of typical installations of electrical engineering complexes:

- be able to work independently with educational and methodological and reference literature in the field of development and operation of automation systems;

- be able to make functional and structural diagrams with different types of power converters and electric motors;

– calculate the established modes of the electric drive;

- calculate transient processes in the electric drive by analytical, grapho-analytical or graphic methods;

– calculate the parameters of energy modes of EMC operation;

- calculate the parameters of the thermal modes of operation of the electric drive;

- form and calculate models for electrical equipment;

– construction, electromechanical and mechanical characteristics of the electric drive;
– selection of rational modes of operation and operation of EMC;
– calculation and design of an automated electric drive;
– selection of a rational type of electric drive for a specific technological installation, power of the power equipment of the electric drive.
– choosing the necessary electromechanical devices when solving specific problems, taking into account their specifics and fields of application;
– conduct the necessary tests of electric machines to obtain their real parameters and operating characteristics;
– practical application of methods of modeling and calculation of thermal processes of the electric drive;
– conducting experimental studies and summarizing their results;
– use of electrical measuring equipment;
– independent work with educational, methodological and reference literature in the field of electrical engineering and related disciplines;
– to be able to take into account socio-political processes of Ukraine, legal, democratic principles and ethical norms in industrial or social activities.

2. Pre-requisites and post-requisites of the discipline (place in the structural-logical scheme of learning according to the relevant educational program)

The study of the discipline is based on the knowledge acquired by students in the fundamental and professionally oriented disciplines "Higher mathematics", "Theoretical foundations of electrical engineering", "Electric machines", "Electric drive", "Automated electric drive".

3. Content of the academic discipline

150 hours / 5 credits are allotted for studying the credit module

Names of sections, topics	Number of hours				
	In total	including			
		Lectures	Practical (seminar)	Laboratory (computer workshop)	Independent work of students
Chapter 1. Energy properties of electromechanical systems and complexes					
Topic 1.1. Energy channel of electromechanical systems	8	2	0	0	6
Topic 1.2. Energy characteristics of electromechanical systems	9	2	0	0	7
Topic 1.3. Energy conservation in electromechanical systems by means of an electric drive	16	4	2	0	8
Topic 1.4. Thermal modes of electric drive operation in electromechanical systems.	10	2	2	0	8
Topic 1.5. The influence of the quality of the energy flow on the efficiency of energy use of electrical engineering complexes.	11	2	2	0	7
Topic 1.6. Measurement of energy flow parameters	13	4	2	0	7
Chapter 2. Industrial electromechanical systems and complexes					
Topic 2.1. Electromechanical systems with alternating current electric drive	16	4	2	0	8

Topic 2.2. Electromechanical systems with a direct current electric drive	9	2	0	0	7
Topic 2.3. Electromechanical systems with an adjustable electric drive	14	4	2	0	6
Chapter 3. Management of the efficiency of energy use of electrical engineering complexes					
Topic 3.1. Management of the energy efficiency of regulated electric drives of electrical engineering complexes	14	4	2	0	8
Topic 3.2. Management of energy efficiency of typical installations of electrical engineering complexes	10	4	2	0	6
Topic 3.3. Electromechanical systems and complexes of continuous action	10	2	2	0	8
Calculation and graphic work	10				10
In total	150	36	18	0	96

Chapter 1. Energy properties of electromechanical systems and complexes

Topic 1.1. Energy channel of electromechanical systems

The structure of the energy channel of the electromechanical system. Power balance of energy flows of the energy channel. An example of the physical implementation of a power channel of an electromechanical system.

Topic 1.2. Energy characteristics of electromechanical systems

Power losses in an unregulated electric drive. Power losses in a regulated electric drive. Coefficient of performance. Power factor in the electric drive. Power losses in electromechanical systems in dynamic modes.

Topic 1.3. Energy conservation in electromechanical systems by means of an electric drive

Improvement of the engine selection procedure for a specific installation. Using an energy-saving electric drive. Elimination of intermediate gears. The choice of a rational type of electric drive for a specific technological installation. Selection of rational modes of operation and operation of electric drives. Transition from an unregulated electric drive to an adjustable one. Energy-saving aspects of the use of a regulated electric drive in electromechanical systems.

Topic 1.4. Thermal modes of electric drive operation in electromechanical systems.

Loss of power. Method of average losses. Engine heating. Heat balance equation and engine heating. Thermal modes of operation of engines of electromechanical systems. Choice of engine power. Criteria for choosing engine power. Methods of equivalent current, power and moment. Refinement of equivalent values with variable heat transfer. Choice of engine power for long-term, short-term and repeatedly short-term operation modes. Checking the selected engine. Load diagrams of the electric drive of electromechanical systems.

Topic 1.5. The influence of the quality of the energy flow on the efficiency of energy use of electrical engineering complexes.

Voltage deviation. Voltage fluctuations. Voltage asymmetry. Non-sinusoidality of the strip. Losses of electricity due to deviation of voltage quality from normalized values.

Topic 1.6. Measurement of energy flow parameters.

Measurement of deflection, span, interval, Flicker dose. Measurement of the coef. sinusoidal distortion coefficient. of harmonic components, asymmetry coefficient of reverse and zero sequence voltages, overvoltage coefficient, impulse overloads. Measurement and registration of current and power parameters. Measurement of electrical parameters of electric drives.

Chapter 2. Industrial electromechanical systems and complexes

Topic 2.1. Electromechanical systems with alternating current electric drive.

Electric drive with asynchronous motors. Schematic diagram of asynchronous motors with a phase and short-circuited rotor, principle of operation. Electromechanical characteristic equation. Creation of special circuit solutions of non-regulated electric drives with AD to increase energy performance. Features of asynchronous drive. Electric drive with synchronous motors. Circuit diagram and principle of operation. Angular characteristic and overload capacity of SD. Using a synchronous machine as a reactive power compensator to increase energy performance. Features of the synchronous electric drive.

Topic 2.2. Electromechanical systems with a direct current electric drive.

Electric drive with DC motors. Principle, functional-logical and structural schemes of DPS. Principle of operation. General differential equation. DPS speed regulation. Schematic diagram of sequential and mixed excitation motors. Universal characteristics - high-speed and electromagnetic. Natural characteristics. Regulatory properties. Features of the direct current drive.

Topic 2.3. Electromechanical systems with an adjustable electric drive.

Electromechanical systems with an adjustable alternating current electric drive. Frequency-regulated electric drive. Functional and principle diagrams of a frequency-regulated electric drive. Principles of pulse width (PWM) modulation and output voltage generation. Vector control of an asynchronous electric drive. Asynchronous electric drive with the realization of sliding energy. Asynchronous valve-machine and valve cascades. Phase control of an asynchronous motor. Schemes and principle of operation. DC and AC valve motors. Comparative analysis of schemes. Schemes and means of controlling valve engines. Electromechanical systems with adjustable direct current electric drive. Thyristor converter-motor system. Basic and structural diagrams. Principle of operation. Increasing energy performance and reducing the impact on the network of electric drives with semiconductor converters.

Chapter 3. Management of the efficiency of energy use of electrical engineering complexes

Topic 3.1. Energy efficiency management of regulated electric drives of electrical engineering complexes.

Directions for increasing the energy efficiency of regulated electric drives. Indicators of energy efficiency of regulated electric drives. Methodology for assessing the energy efficiency of regulated electric drives. Management of energy efficiency with the help of the magnetic flux of electric motors. Control according to the minimum of electromagnetic losses, total losses, the minimum of stator currents, the minimum of the generalized quality indicator.

Topic 3.2. Energy efficiency management of typical installations of electrical engineering complexes.

Electric drive of lifting mechanisms. Crane mechanisms. Kinematic schemes. Modes of operation. Electric drive systems of lifting cranes. Crane electric drive control schemes using cam and magnetic controllers. Non-contact control schemes. Lifting installations. Kinematic schemes. Modes of operation. Functional schemes of SAR by lifting. Management principles. Elevator installations. Kinematic diagrams of elevator installations with the upper and lower arrangement of the electric drive. Schemes of the electric drive. Schemes of low-speed and high-speed elevators. Management principles. Scheme of a passenger elevator with a selector control system. Scheme of a passenger elevator with a selector control system.

Topic 3.3. Electromechanical systems and complexes of continuous action.

Electric drive of transport mechanisms of continuous action. Conveyors. Kinematic schemes and characteristics of transport mechanisms of continuous action. Requirements for the electric drive. Conveyor electric drive and control schemes. Choice of engine power. Principles of controlling the speed of conveyor belts. Escalators. Electric drive and control. Electric drive of rope yards. Schemes of the electric drive. Electric drive of turbomechanisms. Fans (centrifugal and axial), compressors and pumps. Modes of operation. Electric drive systems. Selection of electric motor power. Principles of performance regulation. Typical schemes for controlling the electric drive of fans, compressors and pumps.

4. Educational materials and resources

Basic literature

1. Capehart, Barney L., Wayne C. Turner, and William J. Kennedy. Guide to energy management. River Publishers, 2020.
2. Krarti, Moncef. Energy audit of building systems: an engineering approach. CRC press, 2020.
3. Abu-Rub, Haitham, Atif Iqbal, and Jaroslaw Guzinski. High performance control of AC drives with Matlab/Simulink. John Wiley & Sons, 2021.
4. Lyakhomskii, Aleksandr, et al. "Conceptual design and engineering strategies to increase energy efficiency at enterprises: Research, technologies and personnel." 2015 IV Forum Strategic Partnership of Universities and Enterprises of Hi-Tech Branches (Science. Education. Innovations). IEEE, 2015.
5. Rana, Md Juel, and Mohammad Ali Abido. "Energy management in DC microgrid with energy storage and model predictive controlled AC–DC converter." IET Generation, Transmission & Distribution 11.15 (2017)
6. Sumper, Andreas, and Angelo Baggini. Electrical energy efficiency: technologies and applications. John Wiley & Sons, 2012.
7. Gilbert M. Masters. Renewable and Efficient Electric Power Systems. IEEE PRESS. Wiley. 2013
8. Zhong, Qing-Chang, and Tomas Hornik. Control of power inverters in renewable energy and smart grid integration. John Wiley & Sons, 2012.

Additional

9. Arianyan, Ehsan, Hassan Taheri, and Saeed Sharifian. "Novel energy and SLA efficient resource management heuristics for consolidation of virtual machines in cloud data centers." Computers & Electrical Engineering 47 (2015): 222-240.
10. Nur Najihah Abu Bakar, Mohammad Yusri Hassan, Hayati Abdullah, Hasimah Abdul Rahman, Md Pauzi Abdullah, Faridah Hussin and Masilah Bandi. Sustainable Energy Management Practices and Its Effect on EEI: A Study on University Buildings. Journal of Modern Science and Technology Vol.2 No.1 February 2014. Pp. 39-48
11. Beaty, H. Wayne, and Donald G. Fink. Standard handbook for electrical engineers. McGraw-Hill Education, 2013.
12. Agrawal, K. C. Industrial power engineering handbook. Elsevier, 2001.
13.Motapon, Souleman Njoya, Louis-A. Dessaint, and Kamal Al-Haddad. "A comparative study of energy management schemes for a fuel-cell hybrid emergency power system of more-electric aircraft." IEEE transactions on industrial electronics 61.3 (2013): 1320-1334.
14. Iris, Çağatay, and Jasmine Siu Lee Lam. "A review of energy efficiency in ports: Operational strategies, technologies and energy management systems." Renewable and Sustainable Energy Reviews 112 (2019): 170-182.
15. Lozano, Francisco J., et al. "New perspectives for green and sustainable chemistry and engineering: Approaches from sustainable resource and energy use, management, and transformation." Journal of Cleaner Production 172 (2018): 227-232.
16. Shahidehpour, Mohammad, and Yaoyu Wang. Communication and control in electric power systems: applications of parallel and distributed processing. John Wiley & Sons, 2004.
17. Ukil, Abhisek. Intelligent systems and signal processing in power engineering. Springer Science & Business Media, 2007.

Literature, the bibliography of which is provided with a link, can be found on the Internet. Literature, the bibliography of which does not contain references, can be found in the library of KPI named after Igor Sikorsky.

Certain sections of the basic literature [1]-[6] are mandatory for study. Sections of basic literature that are mandatory for reading, as well as the connection of these resources with specific topics of the discipline, are given below, in the methodology of mastering the academic discipline. All other literary sources are optional, it is recommended to familiarize yourself with them.

Teaching methods and forms include not only traditional university lectures and seminar activities, but also elements of teamwork and group discussions. Active learning strategies are used, which are determined by the following methods and technologies: problem-based learning methods (research method); personal-oriented technologies based on such forms and methods of learning as case technology and project technology; visualization and information and communication technologies, including electronic presentations for lectures. Communication with the teacher is built using the "Electronic Campus" information system, the "Sikorsky" distance learning platform based on G Suite for Education, as well as such communication tools as e-mail and Telegram. During training and for interaction with students, modern information and communication and network technologies are used to solve educational tasks.

Educational content

5. Methods of mastering an educational discipline (educational component)

Week	**The name of the topic of the lecture and a list of main questions (references to the literature)**
1	**Lecture 1. Energy channel of electromechanical systems.** The structure of the energy channel of the electromechanical system. Power balance of energy flows of the energy channel. **Literature: [1]**
2	**Lecture 2. Energy characteristics of electromechanical systems Power losses in an unregulated electric drive**. Power losses in a regulated electric drive. Coefficient of performance. Power factor in the electric drive. Power losses in electromechanical systems in dynamic modes. **Literature: [1]**
3	**Lecture 3. Energy conservation in electromechanical systems by means of an electric drive. Using an energy-saving electric drive**. Elimination of intermediate gears. The choice of a rational type of electric drive for a specific technological installation. **Literature: [1]**
4	**Lecture 4. Energy conservation in electromechanical systems by means of an electric drive.** Selection of rational modes of operation and operation of electric drives. Energy-saving aspects of using a regulated electric drive in electro-mechanical systems. **Literature: [1]**
5	**Lecture 5. Thermal modes of electric drive operation in electromechanical systems.** Loss of power. Engine heating. Heat balance equation and engine heating. Thermal modes of operation of engines of electromechanical systems. Choice of engine power. Methods of equivalent current, power and moment. Load diagrams of the electric drive of electromechanical systems. **Literature: [2]**
6	**Lecture 6. The influence of the quality of energy flow on the efficiency of energy use of electrical engineering complexes.** Voltage deviation. Voltage fluctuations. Voltage asymmetry. Non-sinusoidal voltage. Losses of electricity due to deviation of voltage quality from normalized values. **Literature: [2]**

7	**Lecture 7. Measurement of energy flow parameters** Measurement of the coefficient of sinusoidal distortion, the coefficient of harmonic components, the coefficient of asymmetry of the reverse and zero sequence voltages, the overvoltage coefficient, impulse overloads. **Literature: [3]**
8	**Lecture 8. Measurement of energy flow parameters** Measurement of electrical parameters of electric drives. Measurement of deflection, span, interval, Flicker dose. **Literature: [3].** Modular control work 1
9	**Lecture 9. Electromechanical systems with alternating current electric drive.** Electric drive with asynchronous motors. Schematic diagram of asynchronous motors with a phase and short-circuited rotor, principle of operation. Equation of electro-mechanical characteristic. Creation of special schematic solutions of non-regulated electric drives with AD to increase energy performance. **Literature: [3]**
10	**Lecture 10. Electromechanical systems with alternating current electric drive.** Features of asynchronous drive. Electric drive with synchronous motors. Circuit diagram and principle of operation. Angular characteristic and overload capacity of SD. Using a synchronous machine as a reactive power compensator to increase energy performance. Features of the synchronous electric drive**. Literature: [3]**
11	**Lecture 11. Electromechanical systems with a direct current electric drive.** Electric drive with direct current motors (DC). Principle, functional-logical and structural schemes of DPS. Principle of operation. DPS speed regulation. Schematic diagram of sequential and mixed excitation motors. Universal characteristics - high-speed and electromagnetic. Natural characteristics. Regulatory properties**. Literature: [4]**
12	**Lecture 12. Electromechanical systems with an adjustable electric drive.** Electromechanical systems with an adjustable alternating current electric drive. Frequency-regulated electric drive. Principles of pulse width (PWM) modulation and output voltage formation. Vector control of an asynchronous electric drive. Asynchronous electric drive with the realization of sliding energy. Phase control of an asynchronous motor. DC and AC valve motors. Comparative analysis of schemes. **Literature: [4]**
13	**Lecture 13. Electromechanical systems with an adjustable electric drive.** Schemes and means of controlling valve engines. Electromechanical systems with adjustable direct current electric drive. Thyristor-converter-motor system. Increasing energy performance and reducing the impact on the network of electric drives with semiconductor converters. **Literature: [5]**
14	**Lecture 14. Management of the energy efficiency of regulated electric drives of electrical engineering complexes.** Directions for increasing the energy efficiency of regulated electric drives. Indicators of energy efficiency of regulated electric drives. . Methodology for assessing the energy efficiency of regulated electric drives. Energy efficiency management using the magnetic flux of electric motors. Control according to the minimum of electromagnetic losses, total losses, the minimum of stator currents, the minimum of the generalized quality indicator. **Literature: [6].** Modular control work 2
15	**Lecture 15. Management of the energy efficiency of regulated electric drives of electrical engineering complexes.** Directions for increasing the energy efficiency of regulated electric drives. Indicators of energy efficiency of regulated electric drives. . Methodology for assessing the energy efficiency of regulated electric drives. Energy efficiency management using the magnetic flux of electric motors. Control according to the minimum of electromagnetic losses, total losses, the minimum of stator currents, the minimum of the generalized quality indicator**. Literature: [6]**
16	**Lecture 16. Energy efficiency management of typical installations of electrotechnical complexes** Electric drive of lifting mechanisms. Crane mechanisms. Kinematic schemes. Modes of operation. Electric drive systems of lifting cranes. Crane electric drive control schemes using cam and magnetic controllers. Non-contact control schemes. Lifting in-

	stallations. Kinematic schemes. Modes of operation**. Literature: [7]**
17	**Lecture 17. Energy efficiency management of typical installations of electrotechnical complexes** Functional schemes of SAR by lifting. Management principles. Elevator installations. Kinematic diagrams of elevator installations with the upper and lower arrangement of the electric drive. Schemes of the electric drive. Schemes of low-speed and high-speed elevators. Management principles. Scheme of a passenger elevator with a selector control system. Scheme of a passenger elevator with a selector control system. **Literature: [8]**
18	**Lecture 18. Electromechanical systems and complexes of continuous action** Electric drive of transport mechanisms of continuous action. Conveyors. Requirements for the electric drive. Conveyor electric drive and control schemes. Choice of engine power. Principles of controlling the speed of conveyor belts. Escalators. Electric drive and control. Electric drive of turbomechanisms. Fans (centrifugal and axial), compressors and pumps. Principles of performance regulation. Typical schemes for controlling the electric drive of fans, compressors and pumps**. Literature: [9]**

6. Practical classes

Practical classes provide an opportunity to master calculation methods, to develop independence in the application of theoretical knowledge. The success of classes is ensured by setting problems that require the use of both standard methods and the search for non-standard approaches to the solution, analysis of the obtained results. The problems that are solved in the practical classes illustrate the general physics and calculation-theoretical provisions of the course and are selected taking into account the specifics of the students' future profession. The main emphasis during practical classes is on the development of the student's independent logical thinking and skills in using calculation methods. Practical classes in the discipline are conducted by the teacher according to the curriculum. The main goal of practical classes is to consolidate the theoretical provisions of the discipline "Management of the efficiency of energy use of electrical engineering complexes" and to acquire the ability to apply them in practice by performing certain tasks formulated accordingly.

№ P/l	**Tasks that are assigned to practical classes**
Practical lesson 1	The choice of a rational type of electric drive for a specific technological installation. Selection of rational modes of operation and operation of electric drives. Transition from an unregulated electric drive to an adjustable one.
Practical lesson 2	Criteria for choosing engine power. Methods of equivalent current, power and moment. Choice of engine power for long-term, short-term and repeatedly short-term operation modes. Checking the selected engine.
Practical lesson 3	Voltage asymmetry. Non-sinusoidal voltage. Losses of electricity due to deviation of voltage quality from normalized values.
Practical lesson 4	Measurement and registration of current and power parameters. Measurement of electrical parameters of electric drives.
Practical lesson 5	Electric drive with asynchronous motors. Electromechanical characteristic equation. Electric drive with synchronous motors (SD). Angular characteristic and overload capacity of SD.
Practical lesson 6	Functional and principle diagrams of a frequency-regulated electric drive. Principles of pulse width (PWM). Schemes and principle of operation. Increasing energy performance and reducing the impact on the network of electric drives with semiconductor converters.
Practical lesson 7	Indicators and methods of evaluating the energy efficiency of regulated electric drives. Management of energy efficiency by the minimum of electromagnetic losses,

	total losses, the minimum of stator currents, the minimum of the generalized voltage quality indicator.
Practical lesson 8	Electric drive of lifting mechanisms. Kinematic schemes. Modes of operation. Functional schemes of lifting SAR. Management principles.
Practical lesson 9	Principles of controlling the speed of conveyor belts. Schemes of the electric drive. Principles of regulating the performance of fans, compressors and pumps by electric drive.

7. Independent work of the student

The student's independent work involves:

- preparation for classroom classes - 58 hours;

- preparation for the modular control work - 4 hours;

- implementation of RGR - 10 hours;

- exam preparation - 24 hours

8. Individual tasks

Topics of calculation works:

1. Calculation and selection of an electric drive with an asynchronous motor.
2. Calculation and selection of an electric drive with a direct current motor.
3. Calculation and selection of an electric drive with a valve engine. Optimization of electrical equipment parameters.

Content of calculation works:

• according to the specified technical data, determine the calculated power of the drive and choose an electric motor;

• calculate and build load diagrams, determine the operation modes of the electric drive;

• check the selected engine;

• build the natural characteristic of the engine, determine the start time;

• determine energy losses in the engine during the work cycle, during start-up and braking;

• compare the energy losses in the engine when it starts idling from the network and from the controlled converter;

• calculate the efficiency of the engine during its operation in a given cycle;

• check the suitability of the selected engine for short-term operation with a load;

• propose ways of energy saving in the electric drive.

Policy and control

9. Policy of academic discipline (educational component)

The policy of the educational discipline "Management of the efficiency of energy use of electrotechnical complexes" is based on the corporate policy of KPI named after Igor Sikorsky.

KPI named after Igor Sikorskyi is a free and autonomous center of education, which is called to give adequate answers to the challenges of modern times, to nurture and protect the spiritual freedom of a person, which makes him able to act according to his own conscience; its civil freedom, which is the basis of the formation of a socially responsible personality, and academic freedom and integrity, which are the main driving factors of scientific progress. The internal atmosphere of the University is built on the principles of openness, transparency, hospitality, and respect for the individual.

The study of the educational discipline "Management of the efficiency of energy use of electrotechnical complexes" requires: preparation for practical classes; preparation for laboratory classes; performance of an individual task according to the curriculum; elaboration of the recommended basic and additional literature.

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

• rules for attending classes: in accordance with Order 1-273 dated 14.09.2020, it is forbidden to evaluate the presence or absence of the applicant at the classroom class, including the award of incentive or penalty points for this. According to the RSO of this discipline, points are awarded for the appropriate types of educational activity in lectures, practical and laboratory classes.

Rules of behavior in classes: the student has the opportunity to receive points for the appropriate types of educational activity in lectures, laboratory and practical classes, provided for by the RSO of the discipline. Using communication tools to search for information on the teacher's Google Drive, on the Internet/

At the time of each lesson, both lecture and practical, the student must have the Zoom application installed on the device from which he works (in the case of distance learning), and the course "Energy Efficiency Management of Electrical Engineering Complexes" must be opened on the Sikorsky platform » (the access code to the course is provided at the first lesson according to the schedule). Syllabus; lecture material; tasks for each practical session; variants of modular control work; tests to be completed after lectures; methodical recommendations for practical work and calculation and graphic work; variants of the credit test are posted on the "Sikorsky" platform and in the "KPI Electronic Campus" system.

During the course "Managing the efficiency of energy use of electro-technical complexes", students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

The deadlines for the completion of each task are specified in the course "Managing the efficiency of energy use of electrical engineering complexes" on the "Sikorsky" platform.

Policy of deadlines and rescheduling: each student is obliged to adhere to the deadlines for the completion of tasks within the schedule of conducting classroom classes in the discipline. Completion of MKR, completion of tasks for practical classes and defense of laboratory works are a mandatory assessment control measure for admission to credit. exam consists of MKR and performance of tasks for practical classes. A student who for a good reason (hospital, academic mobility, etc.) did not write the MKR, has the right to do so during regular consultations of the teacher according to the schedule. The procedure for rescheduling semester control is determined by the general rules of the university.

All students, without exception, are obliged to comply with the requirements of the Regulations on the Academic Plagiarism Prevention System at the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

Academic Integrity Policy:

The 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 behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities. Teachers and students studying this discipline are obliged to comply with the provisions of the Code of Honor adopted at the university;

When using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to observe generally accepted ethical norms, in particular, to be polite and limit communication to the free working time of the teacher (with 16-00 to 19-00 hours on working days).

Inclusive education. The acquisition of knowledge and skills in the course of learning a discipline can be accessible to most individuals with special educational needs, except for learners with severe visual impairments that do not allow them to complete tasks with the help of personal computers, laptops and/or other technical means.

Studying in a foreign language. In the course of the tasks, students may be recommended to refer to English-language sources.

For participation in the All-Ukrainian Olympiad (competition of scientific works), a student is awarded 5 (I round) or 10 (II round) points. For writing an article and its publication, the student is awarded 10 points (a publication included in Scopus or WebofScience) or 6 points (a specialized publication of Ukraine). 3 points for publication of report abstracts at a scientific conference. The total amount of incentive points cannot exceed 10 points.

10. Types of control and rating evaluation system (RSO) of training results

Current control: tasks within the framework of a practical lesson (9 practical lessons × 5 point = 45 points), MKR (conducted directly in a practical session, in the presence of a teacher, 15 points). MKR is performed in the form of a test. The student takes the test directly on lecture, 5-10 minutes before its end. At the end of the lesson, the test is closed and cannot be rewritten or completed at home. The test contains 15 questions and several answers to each of them, one of which is correct. Each correct answer is valued at 1 point.

Tasks within the framework of a practical lesson are evaluated in 5 points according to the following criteria:

- "excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 5 points;
- "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 4-3 points;
- "satisfactory" - incomplete answer (at least 60% of the required information), completed according to the requirements for the "stereotype" level and contains some errors - 2-1 points;
- "unsatisfactory" - unsatisfactory answer - 0 points.

Calendar control: conducted twice a semester as a monitoring of the status of meeting the syllabus requirements. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

Semester control: Exam. Conditions for admission to the semester control: fulfilled and enrolled practical, MKR.

Calculation of the rating scale (RS):

RC(max) = 45 + 15 = 60 points

RC(min) = 25 + 5 = 30 points.

The exam paper is valued at 40 points. The control task of this work consists of two theoretical questions from the list provided in the appendix to the syllabus and a task.

A theoretical question is evaluated in 12 points according to the following criteria:

- "excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 12 - 10 points;
- "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies -9 - 7 points;
- "satisfactory" - incomplete answer (at least 60% of the required information), completed according to the requirements for the "stereotype" level and contains some errors - 6 - 5 points;
- "unsatisfactory" - unsatisfactory answer - 0 points.

The task is evaluated in 16 points according to the following criteria:

- "excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 16 - 14 points;
- "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 13 - 10 points;
- "satisfactory" - incomplete answer (at least 60% of the required information), completed according to the requirements for the "stereotype" level and contains some errors - 9 - 6 points;
- "unsatisfactory" - unsatisfactory answer - 0 points.

Table of correspondence of rating points to grades on the university scale:

Scores	Rating

100-95	Perfectly
94-85	Very good
84-75	Fine
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

11. Additional information on the discipline (educational component)

The list of questions submitted for semester control is given in Appendix A to the syllabus. A student of higher education could take an online course(s) on one or more topics provided by the work program of the academic discipline. The applicant can choose an online course independently or on the recommendation of a teacher. One hour of listening to the course is valued at 0.83 points. The maximum number of hours that can be credited for the results of non-formal education is 12 hours, accordingly the maximum number of points for such results is 10 points.

Working program of the academic discipline (syllabus):

Compiled by senior teacher Volodymyr Dubovyk

Adopted at a meeting of the Department of Automation of Electrotechnical and Mechatronic Complexes (protocol № 17 from May 31, 2023)

Agreed by the methodological commission Educational and Research Institute of Energy Saving and Energy Management (protocol №9 from June 22, 2023)

Appendix A to the syllabus of the educational component of the course "Energy efficiency management of electrical engineering complexes"

The list of tasks submitted for semester control

APPENDIX A EXAMINATION QUESTIONS FROM THE COURSE

1. Voltage deviation, voltage fluctuations, voltage asymmetry, voltage non-sinusoidality.
2. Losses of electricity due to deviation of voltage quality from normalized values.
3. Measurement of the coefficient. sinusoidal distortion. coefficient of harmonic components, coef. asymmetry of reverse and zero sequence voltages, coef. overvoltage, impulse overload.
4. Measurement of electrical parameters of electric drives.
5. Determination of loading of electrical network elements.
6. Control of transient resistances and leakage currents.
7. Basics of choosing the power of the electric drive
8. Energy losses in constant modes of operation of a direct current electric drive.
9. Energy losses in constant modes of operation of an alternating current electric drive.
10. Energy losses in the transient processes of operation of a direct current electric drive.
11. Energy losses in the transient processes of operation of an alternating current electric drive.
12. Energy losses in the process of starting a direct current electric drive.
13. Energy losses in the process of starting an AC electric drive.
14. Dependence of the compensating effect on the level of non-sinusoidality.
15. Directions and tasks of increasing the energy efficiency of regulated electric drives.

16. Indicators of energy efficiency of regulated electric drives.
17. Methodology for evaluating the energy efficiency of regulated electric drives.
18. Management of the energy efficiency of electromechanical converters using the magnetic flux of electric motors.
19. Control of minimum electromagnetic losses.
20. Management by minimum total losses.
21. Management by minimum stator currents.
22. Management according to the minimum of the generalized quality indicator.
23. Energy efficiency management of conveyor installations.
24. Energy efficiency management of ventilation units.
25. Energy efficiency management of pumping installations.
26. Energy efficiency management of lifting installations.
27. Nominal losses in an electric motor.
28. Saving electricity in lifting installations.
29. Saving electricity in fan installations.
30. Saving electricity in pumping installations.
31. Saving electricity in compressor installations.
32. Saving electricity in conveyor installations.
33. The main indicators of the efficiency of energy use in specific sectors of the economy.
34. Efficiency of use and converted energy of natural energy resources.
35. Energy efficiency due to organizational, technical and economic measures.
effective ways of implementing energy-saving strategies.
36. Increasing energy efficiency within a single complex: energy, economy, ecology.
37. Effectiveness of energy use due to the implementation of energy saving programs and energy consumption management.
38. Basic information and sources for energy survey.
39. Purpose of the Project Expert program?
40. What tasks are solved when using the Project Expert program?
41. Management of energy use modes thanks to digital processing of information for heating, ventilation, air conditioning, lighting, etc. systems.
42. The main ways of reducing specific energy consumption and saving fuel and energy resources, the cost of production and increasing its competitiveness.
43. Peculiarities of managing energy use due to the effective strategy and tactics of active electricity conservation by the structure of generating capacities.
44. Management of energy use due to integral, multi-criteria and two-stage optimization of electric network modes.
45. Load management to reduce the cost of services and increase the efficiency and reliability of the system.
46. Management of energy use modes with the ability to adapt to changes in the operation of the enterprise, equipment and weather conditions.
48. Peculiarities of the use of non-traditional energy to meet the household and production needs of people and enterprises.
49. Features of hydrogen-based storage systems for obtaining thermal and electrical energy with optimal characteristics, stable energy supply

50. The task of energy saving and technical and economic analysis for the selection of new priorities and setting the task of reducing the consumption of energy resources.