



PROSPECTIVE DIRECTIONS FOR THE DEVELOPMENT OF ENERGY- AND RESOURCE-EFFICIENT PROCESSES, EQUIPMENT AND TECHNOLOGIES

Work program of the educational component (Syllabus)

Educational component details

Level of higher education	<i>Third (educational and scientific)</i>
Discipline	<i>13 Mechanical Engineering</i>
Specialty	<i>133 Industrial mechanical engineering</i>
Educational program	<i>Industrial mechanical engineering</i>
Status of the educational component	<i>Required</i>
Form of study	<i>full-time (day)</i>
Year of training, semester	<i>2nd year, spring semester</i>
Status of the educational component	<i>5 (150)</i>
Semester control/control measures	<i>Exam</i>
Class schedule	<i>3 hours per week (1 hour of lectures and 2 hours of practical classes)</i>
Language of instruction	<i>Ukrainian</i>
Information about the course leader /teachers	Lecturer: Prof., Doctor of Technical Sciences, Valeriy Yuriyovych Shcherbina, https://cpsm.kpi.ua/shcherbina-valeriy-yurijovich.html?tmpl=component ; Practical / Seminar: Prof., Doctor of Engineering, Valeriy Yuriyovych Shcherbina, https://cpsm.kpi.ua/shcherbina-valeriy-yurijovich.html?tmpl=component ;
Course placement	<i>Sikorsky Platform</i>

Educational component program

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

One of the key tasks of modern mechanical engineering is the research and implementation of innovative approaches to the design of highly efficient technological equipment. This is an extremely relevant issue in the context of constantly increasing requirements for energy efficiency and resource conservation in the field of mechanical engineering.

Effective design of production equipment is of critical importance for increasing productivity, reducing operating costs and minimizing the environmental impact of machine-building enterprises. The application of modern modeling methods, optimization and the use of advanced materials allows creating technological solutions that meet the highest standards of energy efficiency and resource conservation.

In the course "Prospective directions of development of energy and resource-efficient processes, equipment and technologies", considerable attention is paid to the identification and use of the relationship between individual educational components. This is possible with the systematic application of certain branches of knowledge, which include specific research methods and solutions to the problems of the design process itself, its improvement and increase in efficiency. This includes such sections as technological design, morphological models, a systems approach and others, which are of great interest to a modern specialist.

Research in this area is aimed at developing innovative designs, improving energy and resource saving systems, introducing new technological processes and materials that ensure sustainable production and minimal environmental impact. The implementation of these areas is crucial for increasing the competitiveness of the engineering industry and ensuring its sustainable development in the long term.

Subject of the educational component "Prospective directions of development of energy and resource-efficient processes, equipment and technologies" - implementation of approaches that provide the study of the latest design systems and special methods for improving, increasing efficiency, ensuring high quality of design and development with the implementation of the most effective design solutions, which orients students to the modern world level of scientific and technical developments.

Expected learning outcomes include the ability to apply a systematic approach to development and design, use morphological models and mathematical modeling methods to solve current problems of increasing the efficiency of technological processes and equipment. This will allow graduates to be competent specialists capable of developing and implementing promising energy- and resource-efficient solutions in the mechanical engineering industry.

Purpose of the educational component « Promising directions for the development of energy and resource-efficient processes, equipment and technologies »

The main goal of the educational component - to teach postgraduate students methods of technological forecasting of parameters of machines and equipment taking into account the requirements of their operation and manufacturing. Special attention is paid to a systematic approach to design, the use of morphological models and the integration of various educational components , such as technological design, systems theory, mathematical modeling, etc. This allows for a comprehensive approach to solving the problems of increasing the efficiency of technological equipment.

In accordance with the goal, the training of postgraduate students in this specialty requires strengthening the competencies formed in students:

Integral competence:

The ability to solve complex problems in the field of professional and/or research and innovation activities, which involves a deep rethinking of existing and the creation of new holistic knowledge and/or professional practice.

ZK1 Ability for abstract thinking, analysis and synthesis

ZK2 Ability to search, process and analyze information from various sources, generate new ideas and solve complex industry problems engineering.

CK3 Ability to work in an international context.

ZK4 Ability to solve problems in the field of industrial mechanical engineering on based on a systematic scientific worldview and a general cultural outlook, in compliance with the principles of academic integrity.

FC 2 Ability to present and discuss the results of scientific research orally and in writing research and/or innovative developments in Ukrainian and English (or other) languages, a deep understanding of English-speaking (or other foreign-speaking) scientific texts in the mechanical engineering industry.

FC 3 Ability to critically analyze, evaluate, and synthesize new and complex ideas in the field of industrial mechanical engineering and related interdisciplinary issues.

FC 4 Ability for continuous self-development and self-improvement.

FC 6 Ability to generate new ideas for the development of theory and practice of industry mechanical engineering, identify, pose and solve research problems nature, evaluate and ensure the quality of the research performed.

FC 7 The ability to take into account promising areas of energy and resource-efficient processes, equipment and technologies for scientific research and solving engineering problems in industrial mechanical engineering, effective quantitative methods in mathematics, physics, engineering sciences, and appropriate computer software for solving engineering problems and research tasks of industrial mechanical engineering.

knowledge:

PR H 01 Have conceptual and methodological knowledge in mechanical engineering and at the border of subject areas, as well as research skills sufficient to conduct scientific and applied research at the level of the latest world achievements in the relevant field, obtain new knowledge and/or implement innovations

PR H 11 Know the fundamental principles of the theory of hydrodynamics, heat and mass transfer and modern methods and techniques of hydrodynamic activation of technological environments

skills :

PR H 06 Develop and implement scientific and/or innovative engineering projects that provide an opportunity to rethink existing and create new holistic knowledge and/or professional practice and solve significant scientific and technological problems in mechanical engineering while adhering to the norms of academic ethics and taking into account social, economic, environmental and legal aspects.

PRN 07 Be able to plan and carry out experimental and/or theoretical research in the field of mechanical engineering and related interdisciplinary areas using modern tools and adhering to the norms of professional and academic ethics, critically analyze the results of one's own research and the results of other researchers in the context of the entire complex of modern knowledge regarding the problem under study.

PR H 09 To deeply understand the general principles and methods of mechanical engineering as well as the methodology of scientific research, to apply them in one's own research in the field of industrial mechanical engineering and in teaching practice.

PR H 12 Be able to use innovative methods of activity to implement scientific research

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

Studying the educational component " Prospective directions of development of energy and resource-efficient processes, equipment and technologies " is based on the principles of integration of various knowledge obtained by postgraduate students during their bachelor's and master's studies. educational component natural science and engineering, in particular: "Mathematics", "Engineering and computer graphics", "Resistance of materials", "Machine parts", "Theoretical foundations of heat engineering", "Mechanics of a solid deformed body", "Technological foundations of mechanical engineering", "Modern methods of calculating processes and devices", "Design methodology", "Processes, devices and machines of the industry".

3. Content of the educational component

Topic 1. Energy and resource conservation in industry. General issues and definitions

Topic 2. Discoveries, inventions, innovations in solving problems of increasing energy and resource conservation

Topic 3. Identification of possible directions for increasing energy efficiency using artificial intelligence technologies

Topic 4. Intensification of technological processes due to pulsed energy impact

Topic 5. Methods for intensification of extraction processes
Topic 6. Waste-free technological schemes of chemical production
Topic 7. Alternative energy

4. Educational materials and resources

Basic literature

1. Shcherbyna V.Yu., Gondlyakh O.V., Sivetsky V.I. Engineering of innovative technologies and equipment. Mechanical equipment for the production of binding building materials [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2022. – 147 p. URL: <https://ela.kpi.ua/handle/123456789/45720>
- 2Kazak I.O., Shcherbyna V.Yu., Leleka S.V., Methodological recommendations "Modern design methods" (Part 1) [Electronic resource] / NTUU "KPI", Kyiv, 2017. – 58 p.
- 3Shcherbyna V.Yu., Leleka S.V., Bezverkhyy I.O. Design methodology. Laboratory practical [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2024. 119 p. URL: <https://ela.kpi.ua/handle/123456789/67997>
- 4Sivetsky V.I., Shcherbyna V.Yu., Gondlyakh O.V. Engineering of innovative technologies and equipment. Lines for the production of sheet and profile polymer products [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2022. – 113 p. URL: <https://ela.kpi.ua/handle/123456789/45732>
- 5on the academic discipline [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2018. – 67 p. URL : <http://ela.kpi.ua/handle/123456789/25671>
- 6Sivetskyi V. I., Sidorov D. E., Panov E. M., Prystaylov S. O. Resource- and energy-saving mixing processes in polymer processing - K.: Publishing house "EKMO", 2006. – 174p.
7. Shcherbyna V.Yu., Design Methodology. Lecture notes [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2020 . – 77 p. URL: <http://ela.kpi. u a/handle/123456789/25673>
- 8Vorfolomeyev A.V. Fundamentals of resource efficiency of enterprises. Textbook. – K.: 2018. – 52 p.
- 9Electrical technologies: a textbook. / I. V. Batsurovska. Mykolaiv: MNAU, 2021. – 258 p.
- 10Vragov A. P. Mass exchange processes and equipment of chemical and petroleum refining industries: a textbook / A. P. Vragov. – Sumy: VTD "University Book", 2007. – 284 p.
- 11Integrated use of renewable energy sources: Lecture course [Electronic resource]: teaching aid for students of specialty 141 "Electrical power engineering, electrical engineering and electromechanics" / Igor Sikorsky Kyiv Polytechnic Institute; Compiled by: M.P. Kuznetsov, O.A. Melnyk – Electronic text data (1 file: 7.93 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2022. – 304 p.

Additional literature

12. Shcherbyna V.Yu., Stepanyuk A.R. Shell-and-tube heat exchangers. Design design of equipment [Electronic resource] / Igor Sikorsky Kyiv Polytechnic Institute. Kyiv, 2024. 117 p. URL: <https://ela.kpi.ua/handle/123456789/67996>
13. CAD. Application of the VESNA software complex in calculations of processes and equipment taking into account thermal power loads. / V.Yu. Shcherbyna, O.S. Sakharov, V.I. Sivetsky, O.V. Gondlyakh Textbook Kyiv, Publishing House "EKMO", 2014. – 218 p.
- 14Policy on the use of artificial intelligence for academic activities at Igor Sikorsky Kyiv Polytechnic Institute. <https://ela.kpi.ua/server/api/core/bitstreams/70b895b5-1339-4d51-975b-a6114035c950/content>
- 15Kushlyk R. V., Nazarenko I. P., Kushlyk R. R. Electrical technologies and thermal processes. Melitopol: Tavri. State Agrotechnological University named after Dmitry Motorov, 2021. 105 p.
- 16Vlasenko V.V., Bandura V.M., Kolyanovska L.M. Intensification of extraction in the technology of vegetable oil production. – Vinnytsia, RVV VNAU, 2016. – 203 p.
- 17Renewable energy sources / Edited by S.O. Kudri. – Kyiv: Institute of Renewable Energy of the National Academy of Sciences of Ukraine, 2020. – 392 p .

Information resources on the Internet

- 18Law of Ukraine "On Energy Efficiency" URL: <https://www.sae.gov.ua/uk/content/energy-efficiency>
- 19National Energy Efficiency Action Plan for the period until 2030 URL: https://ecoaction.org.ua/wp-content/uploads/2021/10/brief_zp_4507_pro-energoefektyvnist-s.pdf
- 20Sustainable and Renewable Energy. Fundamentals. https://prometheus.org.ua/course/course-v1:Prometheus+ENERG101+2023_T1

- 21Interactive seminar "Modern technologies of energy efficiency and resource conservation"
<https://sd4ua.org/interaktyvnyj-seminar-suchasni-tehnologiyi-energoefektyvnosti-ta-resursozberezhennya/>
- 22Energy saving seminars from a lecturer at the Romstal Academy <https://romstal.ua/uk/info/108-seminar-eco>
- 23Home page of the SolidWorks software product [Electronic resource]: [Website]. – Electronic data. – Access mode <https://www.solidworks.com/ru> (access date 10.06.2024) – Screen name.
24. 3D Solid Modelling Videos : [Website]. – Electronic data. – Access mode <https://nisheeth-inventortalks.blogspot.com/> (access date 10.06.2024) – Screen name.
25. Solidworks Flow Simulation. Flow velocity calculation. [Website]. – Electronic data. – Access mode <https://www.solidworks.com/ru/product/solidworks-flow-simulation> (access date 10.06.2024) – Screen title.

Educational content

5. Methodology for mastering the educational component

Lectures are aimed at:

- providing modern, holistic, interdependent knowledge with educational components , the level of which is determined by the target setting for each specific topic;
- ensuring creative work of postgraduate students together with the teacher during the lecture;
- fostering professional and business qualities in postgraduate students and developing their independent creative thinking;
- formation of postgraduate students the necessary interest and direction for independent work;
- determination of the current level of development of science and technology in the field of numerical calculation methods;
- reflection of the methodological processing of the material (highlighting the main ideas and provisions, underlining conclusions, repeating them in different formulations);
- acquisition of visual, combining if possible with the demonstration of audiovisual materials, models, models and samples;
- teaching in clear and concise language, explaining all newly introduced terms and concepts;
- accessibility for audience perception.

No. of the company	Title of the lecture topic and list of main questions (list of didactic aids, references to literature and tasks for the SRS)	Number of listening hours
1.	Topic 1. Energy and resource conservation in industry. General issues and definitions Introduction. General provisions. Promising directions for the development of energy and resource-efficient processes in industrial sectors. Traditional and progressive technological processes. The concept of “energy efficiency”. Heat recovery systems. Energy recovery in energy processes. Efficiency indicators of energy-saving technologies. Methods of increasing energy efficiency in industrial processes. References: [1], p. 13-16; [6], p. 21-45; [8], p. 3-15 ; [21] Tasks for the VTS. Use of cogeneration units. Energy recovery in energy processes. Definition of the terms “energy audit” and “carbon footprint”. Features of the use of thermal accumulators. Methods of controlling energy consumption at industrial enterprises	2
2.	Current problems and prospects for the development of energy and resource-efficient technologies. Main tasks for increasing energy efficiency. New technologies used to increase energy efficiency. Technologies with the greatest potential for implementation in Ukraine. State programs of Ukraine supporting the implementation of energy-efficient technologies References [1], pp. 11-15; [6], pp. 48-56; [18]; [19]	2

	<i>Tasks for the SRS. The role of intelligent energy systems (Smart Grid). Methods for increasing the energy efficiency of industrial furnaces and dryers. Trends in the development of energy-efficient technologies in the chemical industry. Main methods of energy storage. Main sources of energy losses in industrial processes. Examples of modern energy-efficient equipment. State programs of Ukraine supporting the implementation of energy-efficient technologies.</i>	
3.	Topic 2. Discoveries, inventions, innovations in solving problems of increasing energy and resource conservation <i>Discoveries and inventions in design. Repeated and simultaneous discoveries. Anticipated discoveries. Unexpected (accidental) discoveries. Precursor events. Premature, late discoveries. False discoveries. Invention. Accidental (erroneous) inventions. Repeated and simultaneous inventions. Unexpected inventions. Late inventions. Innovations in design</i> <i>References: [4], pp. 32-40 ; [7], pp. 17-18, 23-27</i> <i>Tasks on the VTS. Search systems. Systems for searching patents Ukrpatent and EPO. Search mechanisms. Agents, crawlers , robots . International patent classification. Patent structure: descriptive part, section, class, subclass, group, subgroup. Agents, crawlers, robots. Descriptive part, section, class, subclass, group, subgroup.</i>	2
4.	Topic 3. Identification of possible directions for increasing energy efficiency using artificial intelligence technologies <i>General information on the use of artificial intelligence (AI) technologies. Examples of AI application in mechanical engineering. AI algorithms. Search for technical solutions. Generating and correcting text documentation. Analysis of the quality of drawing work. Risks and limitations of AI implementation.</i> <i>References: [3], pp. 62 - 72 , [14], pp. 3-10</i> <i>Tasks for the SRS. The concept of AI and its main types. History of development. AI algorithm for searching for technical solutions, text generation. Methods for checking the quality and reliability of information obtained using AI. Ethical and legal aspects when using AI.</i>	2
5.	Topic 4. Intensification of technological processes due to pulsed energy impact <i>Basic concepts. Types of energy influences: acoustic, electrical, magnetic, thermal, mechanical, radiation, chemical. Activation of raw material. Mechanical activation.</i> <i>References [1], pp. 1 1 6-1 2 5; [9], pp. 7 8- 9 5; [15], pp. 1 38- 1 53</i> <i>Tasks for the SRS. Energy impact on raw materials. Types of energy impacts: acoustic, electrical, magnetic, thermal, mechanical, radiation, chemical.</i>	2
6.	<i>Mechanical activation. Energy impact on raw materials. Grinding mechanisms. Fine and ultrafine grinding, mixing and activation of solid particles.</i> <i>References [1], pp. 1 19 -1 21 ; [9], pp. 8 1 - 92 ; [15], pp. 140 - 147</i> <i>Tasks for the SRS. Grinding mechanisms. Activation of raw materials. Mechanical activation. Fine and ultrafine grinding, mixing and activation of solid particles.</i>	2
7.	Topic 5. Methods for intensification of extraction processes <i>Extraction of a substance from a solution or mixture. Increasing the efficiency of processes through rational organization of phase movement. Contacting solid and liquid phases in the apparatus. Separation of the solid phase - solution system. The influence of various technological and physical factors affecting the efficiency of extraction (temperature, pressure, degree of grinding, mechanical and sound vibrations, electric and magnetic fields, ionizing radiation). Methods for analyzing the efficiency of extraction. Practical examples of the extraction process. Development prospects.</i>	2

	References: [8], pp. 23 - 58; [10], pp. 185 - 201 , [16], pp. 142 -150 Tasks on the SRS. Extraction in a planetary apparatus. Sorption and extractive extraction. Thermodynamic equilibrium in extraction processes. Methods for increasing the selectivity of extraction. Principles of extraction using enzymes. Carrying out extraction under high pressure conditions. Partition coefficient in extraction.. Use of membrane technologies in extraction. Use of combined extraction methods.	
8.	Topic 6. Waste-free technological schemes of chemical production The importance of waste-free technologies (WT) for modern production. Definition of waste-free and low-waste technologies. Principles of waste-free production. Types of waste-free technologies . Comprehensive direction of use. Criterion of waste-free production. Absolute economic efficiency coefficient. Impact of WT on product quality. Examples of waste-free technologies . Prospects for the development of waste-free technologies. References: [8], p. 23 - 38; [11]. p. 180 - 204 , [17] . pp. 220 - 246 Tasks for the VTS. The main stages of the implementation of BT. The concept of “secondary raw materials”. The process of processing waste into secondary raw materials. The main principles and tasks of BT. Methods of reducing waste in production. The economic feasibility of implementing BT. The concept of “ecological footprint of production”. The main technological processes used in waste-free schemes. Problems arising when implementing BT.	2
9.	Topic 7. Alternative energy The relevance of using alternative energy sources. Principles of operation, advantages and disadvantages of using solar, wind, geothermal, aerothermal, hydrothermal, wave and tidal energy, hydropower, biomass energy and others. Potential for use in Ukraine. Prospects for the development of alternative energy sources. References: [8], pp. 40 - 46; [11], pp. 111-128; [17], pp. 156- 173; [20] Tasks for the VTS. The main challenges of the development of renewable energy . The process of biogas production. The main principles of green energy. Advantages and disadvantages of hydroelectric power plants. Examples of the use of geothermal energy. Advantages of using alternative sources. Application of geothermal energy in energy and heat supply. The feasibility of using heat pumps. Energy production using geothermal stations. The principle of operation of cogeneration plants.	2
	Total hours	18

Practical classes

The purpose of the cycle of practical classes in the educational component is to consolidate theoretical knowledge and develop skills in working with modern systems for calculating elements of chemical production equipment.

Practical work is carried out in a computer classroom using didactic tools and modern software from the Department of Computer Science and Engineering.

The main tasks of the practical training cycle :

- help postgraduate students to systematize , consolidate and deepen knowledge theoretical character in the field of modern methods of calculating processes and devices;
- to teach postgraduate admissions solving practical problems , contributing to mastery skills and skills performing calculations , graphics and others types of tasks ;
- to teach them to work with scientific and reference literature , documentation and diagrams ;
- to form skills to study independently , that is master methods , ways and techniques self-study , self-development and self-control.

No. of the company	Title of the lesson topic and list of main questions (list of didactic resources, references to literature and tasks for the CTS)	Number of listening hours
1.	Topic 1. Energy and resource conservation in industry. General issues and definitions Practical lesson 1. Search for promising design solutions in the direction of energy and resource-efficient technologies Literature: [2], pp. 5-18; [7], c. 72-87] Tasks for the CTS: Identify possible promising design solutions in the direction of energy and resource-efficient technologies using various search engines.	2
2.	Topic 2. Discoveries, inventions, innovations in solving problems of increasing energy and resource conservation Practical lesson 2. Selection of technical solutions in the direction of energy and resource-saving equipment in the information and search system UkrPatent Literature: [2], pp. 19-23; [7] Task for the CRC. Find patents for equipment modernization in the UkrPatent system.	2
3.	Practical lesson 3. Selection of patents for technical solutions in the direction of energy and resource-saving equipment in the European information and search system EPO. Literature: [2], pp. 24-32; [7] Tasks for the CPC: To conduct patents for equipment modernization in the EPO system.	2
4.	Topic 3 . Using artificial intelligence technology in design Practical lesson 4. Assessing the relevance and determining the methodology of research towards the development of energy and resource-efficient processes References: [3], pp. 76-78, 101-106 Tasks on the SRS. Using the chatbots ChatGPT, Copilot, Gemini and Poe, determine the relevance and directions of possible scientific research. Analyze the results obtained and provide a conclusion indicating possible research in the direction of developing energy and resource-efficient processes	4
5.	Practical lesson 5. Search for literary references on the development of energy and resource-efficient processes, equipment and technologies References: [3], pp. 79-81 , 107-111 Tasks on the SRS. Using the chatbot ELIot chatbots, Copilot (ChatGPT-4) and Gemini (ChatGPT-4) perform a search for literature references. Analyze the results and provide a conclusion, which indicates the valid literary sources that reflect the development directions of energy and resource efficient processes, equipment and technologies.	2
6.	Practical lesson 6*. Analysis and description of graphs and illustrations using AI. References: [3], pp. 82-89 , 112-116 Tasks on the CTS. Using the chatbots Copilot (ChatGPT-4), Gemini (ChatGPT-4) and Poe, analyze and describe graphs and illustrations. Analyze the responses received by the AI and draw a conclusion, indicating which of the chatbots were the most effective, providing complete and meaningful answers; which answers had shortcomings, what they consist of.	2
7.	Practical lesson 7*. Checking and correcting text documentation using AI. References: [3], pp.92-94, 117-119 Tasks on the CTS. Using the chatbots ChatGPT, Gemini, Aria and Perplexity, analyze the text, check and correct the text documentation. Analyze the results and provide a conclusion, indicating which of the chatbots provided	2

	complete and meaningful answers. Also indicate which answers had shortcomings and what they consist of.	
8.	Topic 4. Intensification of technological processes due to pulsed energy impact Practical lesson 8. Calculation of the strength of a rotary kiln section References: [13], pp. 62-68, pp. 172-173 Tasks on the SRS. Using the numerical complex "VESNA", determine the stress-strain state (SS) of the furnace body, reduced, permissible stresses. Make graphs of stresses and displacements. Make a conclusion about the operability of the structure. Determine the safety margin and possible zones of destruction.	4
9.	Practical lesson 9. Calculation of the support station of a rotary kiln with determination of the optimal location of the support rollers References: [13], pp. 87-92, pp. 190-194 Task on the SRS. Using the numerical complex "VESNA" taking into account cyclic loads, determine the NDS and reduced stresses. Determine the optimal location of the support rollers to increase the service life of the furnace. Make a comparison with the base design.	2
10.	Practical lesson 10. Calculation of a rotary kiln 4.5x80m with determination of the optimal casing thickness References: [13], pp. 142-143, pp. 199-214 Tasks on the SRS. Using the numerical complex "VESNA", determine the NDS of the rotary kiln. By changing the thickness of the casing according to the energy zones, determine the optimal thickness to reduce the metal content. Determine the operability and safety margin of the casing of the rotary kiln. Compare with the base design, determining resource efficiency.	4
11.	Practical lesson 11. Calculation of shaped refractory with determination of the effective size of the thermal insulation cell References: [13], pp. 177-178, pp. 197-198 Task on the SRS. Using the numerical complex "VESNA", determine the thermal state of a refractory with a thermal insulation cell. Specify the refractory design with the optimal size of the thermal insulation cell taking into account thermal efficiency and permissible stresses. Compare the reduction in energy consumption depending on the refractory design.	4
12.	Practical lesson 12 * . Calculation of the movement and heat transfer of the coolant in a horizontal heat exchanger of the TKG type References: [12], pp. 17-18, 59 ; [24] ; [25] Tasks on the CRC. Using the capabilities of the AutoCAD program to build the design area of the heat exchanger. Using SW Flow Simulation programs, simulate the movement of the coolant flow, heat exchange and the action of hydrodynamic forces. To analyze the behavior of the coolant in different conditions, with an assessment of the efficiency of the device. To indicate the possibility of using the obtained results to optimize the design and increase the energy efficiency of the heat exchanger.	4
13.	Modular test work.	2
	Total hours	36

* - additional or optional work.

6. Laboratory classes (computer lab)

According to the working curriculum, laboratory classes are not provided.

7. Student's independent work

Independent work of students takes 64% of the time of studying the course, also includes

preparation for the exam. The main task of independent work of postgraduate students is to master scientific knowledge in the field of modern methods of calculating machines and devices of chemical production, which are not included or not fully disclosed in the list of lecture questions, through personal search for information, the formation of active interest in a creative approach in educational work. In the process of independent work within the framework of the educational component, the postgraduate student must learn to deeply analyze the problem of choosing effective calculation methods and come to his own well-founded conclusions.

No. of the company	Title of the topic to be studied independently	Number of hours of CTC
1.	Topic 1. Energy and resource conservation in industry. General issues and definitions Use of cogeneration plants. Energy recovery in energy processes. Definition of the terms “energy audit” and “carbon footprint”. Features of the use of thermal accumulators. Methods of controlling energy consumption at industrial enterprises References: [1], p. 13-16; [6], p. 21-45; [8], p. 3-15 ; [21]	8
2.	The role of intelligent energy systems (Smart Grid). Methods for increasing the energy efficiency of industrial furnaces and dryers. Trends in the development of energy-efficient technologies in the chemical industry. Main methods of energy storage. Main sources of energy losses in industrial processes. Examples of modern energy-efficient equipment. State programs of Ukraine supporting the implementation of energy-efficient technologies. References [1], pp. 11-15; [6], pp. 48-56; [18]; [19]	8
3.	Topic 2. Discoveries, inventions, innovations in solving problems of increasing energy and resource conservation Search systems. Patent search systems Ukrpatent and EPO. Search mechanisms. Agents, crawlers , robots . International patent classification. Patent structure: descriptive part, section, class, subclass, group, subgroup. Agents, crawlers, robots. Descriptive part, section, class, subclass, group, subgroup. References: [4], pp. 32-40 ; [7], pp. 17-18, 23-27	6
4.	Topic 3. Identification of possible directions for increasing energy efficiency using artificial intelligence technologies The concept of artificial intelligence AI and its main types. History of development. AI algorithm for searching for technical solutions, text generation. Methods for checking the quality and reliability of information obtained using AI. Ethical and legal aspects of using AI. References: [3], pp. 62 - 72 , [14], pp. 3-10	12
5.	Topic 4. Intensification of technological processes due to pulsed energy impact Energy impact on raw materials. Types of energy impacts: acoustic, electrical, magnetic, thermal, mechanical, radiation, chemical. References [1], pp. 1 1 6-1 2 5; [9], pp. 7 8- 9 5; [15], pp. 1 38- 1 53	6
6.	Grinding mechanisms. Activation of raw materials. Mechanical activation. Fine and ultrafine grinding, mixing and activation of solid particles. References [1], pp. 1 19 -1 21 ; [9], pp. 8 1 - 92 ; [15], pp. 140 - 147	4
7.	Topic 5. Methods for intensification of extraction processes Extraction in a planetary apparatus. Sorption and extractive extraction. Thermodynamic equilibrium in extraction processes. Methods for increasing	6

	the selectivity of extraction. Principles of extraction using enzymes. Carrying out extraction under high pressure conditions. Partition coefficient in extraction.. Use of membrane technologies in extraction. Use of combined extraction methods. References: [8], pp. 23 - 58; [10], pp. 1 8 5 - 201 , [16], pp. 142 -1 50	
8.	Topic 6. Waste-free technological schemes of chemical production The main stages of BT implementation. The concept of “secondary raw materials”. The process of processing waste into secondary raw materials. The main principles and objectives of BT. Methods of reducing waste in production. The economic feasibility of BT implementation. The concept of “ecological footprint of production”. The main technological processes used in waste-free schemes. Problems arising during BT implementation. References: [8], p. 23 - 38; [11]. p. 1 8 0 - 204 , [17] . pp. 220 - 246	6
9.	Topic 7. Alternative energy The main challenges of renewable energy development . The process of biogas production. The main principles of green energy. Advantages and disadvantages of hydroelectric power plants. Examples of the use of geothermal energy. Advantages of using alternative sources. Application of geothermal energy in energy and heat supply. The feasibility of using heat pumps. Energy production using geothermal plants. The principle of operation of cogeneration plants. References: [8], pp. 4 0 - 4 6; [11], pp. 1 1 1-1 2 8; [17], pp. 1 56- 1 73; [20]	6
10.	Preparation for the modular test	4
11.	Exam	30
	Total hours 96	96

Policy and control

8. Policy of the educational component of the curriculum

Rules for class attendance and behavior in class

Attendance at classes is a mandatory component of assessment. Postgraduate students are required to actively participate in the educational process, not be late for classes or miss them without a good reason, not interfere with the teacher conducting classes, and not be distracted by activities unrelated to the educational process.

Rules for assigning incentive and penalty points

- Incentive points can be awarded by the teacher exclusively for performing creative works that correspond to the work program or for additional completion of online specialized courses with the receipt of the corresponding certificate:
- https://prometheus.org.ua/course/course-v1:Prometheus+ENERG101+2023_T1
- <https://sd4ua.org/interaktyvnyj-seminar-suchasni-tehnologiyi-energoefektyvnosti-ta-resursozberezhennya/>
- <https://romstal.ua/uk/info/108-seminar-eco>

But their sum cannot exceed 25% of the rating scale.

- penalty points within the educational component are not provided.

Deadline and rescheduling policy

In case of arrears on the educational component or any force majeure circumstances, students must contact the teacher via available (provided by the teacher) communication channels to resolve problematic issues and agree on an algorithm of actions for practice.

Academic Integrity Policy

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the lack of references when using printed and electronic materials, quotes, opinions of other authors. Hints and copying when writing tests, conducting classes are unacceptable; taking credit for another student ; copying materials protected by the copyright system without the permission of the author of the work.

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: <https://kpi.ua/code>

Academic Conduct and Ethics Policy

Students should be tolerant, respect the opinions of others, formulate objections in a correct form, and provide constructive feedback in class.

The norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More information: <https://kpi.ua/code>

9. Types of control and rating system for assessing learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the educational component according to the working curriculum:

Semester	Study time		Distribution of teaching hours				Control measures		
	Loans	academic year	Lectures	Practical	Lab work	CRC	MKR	RR	Semester control
4	5	150	18	36	–	96	1	–	exam

Student rating for the educational component consists of the points he receives for:

A student's rating for the educational component consists of the points he receives for his work in practical classes, module tests, and the exam.

Rating (weighting) points system and evaluation criteria

1. Performing practical work.

Weighted score – 3.0. The maximum number of points for all practical work is:

3.0 points x 12 credits/year = 36 points

Criteria for assessing student knowledge

Mark	Completeness of the answer
2.5-3	Timely and complete completion of the task, preparation of all programs, calculations, registration and protection without flaws
1-2.5	Minor flaws in the programs that do not affect the calculation results
0.5-1	Untimely completion of the task, shortcomings in programs, calculations and design
0	Failure to complete the task

2. Completion of modular test work.

Weighted score – 9. The maximum number of points on the current test is:

9 points x 1 MCR = 9 points

Criteria for assessing student knowledge

Mark	Completeness of the answer
9	Timely and complete completion of the task, preparation of all programs, calculations, registration and protection without flaws

8-4	Minor flaws in the programs that do not affect the calculation results
3-2	Untimely completion of the task, shortcomings in programs, calculations and design
1-0	Failure to complete the task

Incentive points:

1. modernization of practical base (+2...+5) points
2. development of didactic course material (+2...+5) points

Thus, the semester rating scale for a credit module is:

$$RC = R_{pz} + R_{kr} + R_{zaokh} = 36 + 9 + (+2...+5) = 50 \text{ points}$$

The exam component is 50% of R:

$$Rekz = 50 \text{ points}$$

Thus, the rating scale for the credit module is:

$$R = RC + Rekz = 50 + 50 = 100 \text{ points}$$

The maximum sum of points for the starting component is 50 points. A prerequisite for admission to the exam is the completion of all practical classes and a starting rating of at least 34 points.

According to the results of the academic work in the first 7 weeks, the "ideal student" should score 29 points. At the first certification (8th week), the student receives "passed" if his current rating is at least 14 points.

According to the results of the academic work in the first 7 weeks, the "ideal student" should score 29 points. At the first certification (8th week), the student receives "passed" if his current rating is at least 14 points.

According to the results of the academic work, the "ideal student" should score 50 points in 13 weeks of study. At the second certification (week 14), the student receives a "pass" if his current rating is at least 25 points.

At the exam, students complete a written exam paper. Each task contains 4 questions. Each question is rated 12, 5 points. Question scoring system:

- "excellent", complete answer (at least 90% of the required information) – 12, 5-10 points;
- "good", sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 9 - 7 points;
- "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 6 - 4 points;
- "unsatisfactory", unsatisfactory answer – 0 points.

The condition for admission to the exam is a minimum rating of R_c , 34 points ($R_c = 34$ points). The sum of the starting points and exam points is converted into the exam score according to the table.

Number of points	Rating
95 ... 100	perfectly
85 ... 94	very good
75 ... 84	good
65 ... 74	satisfactorily
60 ... 64	enough
$RD < 60$	unsatisfactorily
Admission conditions not met	not allowed

10. Additional information on the educational component

Approximate list of questions that are put forward for the modular test

1. Formulate the main problems that arise when implementing waste-free technologies.

2. Name the main types of renewable energy sources.
3. List the main methods of saving energy in everyday life.
4. List the basic principles of waste-free technologies.
5. Indicate how particle size affects extraction efficiency.
6. Name the advantages and disadvantages of hydroelectric power plants.
7. Justify the feasibility of using heat pumps for space heating.
8. Name the main promising areas of development of energy processes.
9. List the main benefits of waste-free technologies for the environment.
10. Name the main methods of intensification of extraction processes.
11. List the main advantages and disadvantages of biofuels as an alternative energy source.
12. Define the concept of "energy audit" and explain its importance.
13. What is needed to implement Smart Grids in modern power systems?
14. Name the main types of waste generated in production.
15. List the factors that affect extraction efficiency.
16. Name the main directions of development of energy technologies.
17. State the key advantages and disadvantages of using solar energy.
18. Justify the importance of switching to renewable energy sources.
19. Formulate approaches to assessing the energy efficiency of industrial facilities.
20. List the main technological processes used in waste-free schemes.
21. State the main steps of the extraction process.
22. Specify the main indicators of the efficiency of energy-saving technologies.
23. What is needed for the successful implementation of waste-free technologies in production?
24. State the basic principles of extraction using enzymes.
25. Formulate the main objectives of waste-free technologies.
26. What should be considered when designing waste-free technological schemes?
27. Name the main types of renewable energy sources.
28. Justify the importance of using energy-efficient household appliances.
29. State the advantages and disadvantages of using electric vehicles.
30. Formulate the main problems that arise when implementing waste-free technologies.

Approximate list of questions submitted for semester control

1. Give examples of energy-efficient technologies in industry.
2. State the advantages of using solar panels.
3. Explain the principle of operation of a heat pump.
4. Justify the need to use wind power plants.
5. Define the term "energy audit".
6. Give examples of the use of ultrasound in extraction.
7. Indicate the main stages of implementing waste-free technologies at the enterprise.
8. Describe the biogas production process.
9. Formulate the basic principles of green energy.
10. Give examples of the use of geothermal energy.
11. Identify the main components of a biomass heating system.
12. Explain how a heat recovery system works.
13. Define the extraction process.
14. What is needed to implement energy-efficient technologies in transport?
15. Define the term "carbon footprint".
16. Justify the need to use waste-free technologies in modern industry.
17. Formulate the main challenges for the development of renewable energy.
18. Name the main types of energy-efficient materials for construction.
19. Give examples of the use of cogeneration plants.
20. What is needed to reduce energy consumption in industry?
21. Define the term "energy efficiency".
22. State the advantages and disadvantages of using microwave heating in extraction.
23. Define the concept of "secondary raw materials".
24. Describe the process of utilizing waste for energy production.

25. *Formulate the main strategies for reducing greenhouse gas emissions.*
26. *What is needed to perform solvent extraction?*
27. *Give examples of resource-efficient technologies in different industries.*
28. *State the advantages of using alternative energy sources compared to traditional ones.*
29. *Describe the process of recycling waste into secondary raw materials.*
30. *Explain the principle of operation of solar panels and their use in energy.*
31. *List the main areas for improving the energy efficiency of industrial equipment.*
32. *Define the concept of "cogeneration" and give examples of its use.*
33. *Describe the design and operating principle of wind power plants.*
34. *Name the main types of extractors used in industry.*
35. *Name modern technologies for waste utilization to produce energy.*
36. *Formulate the main objectives of waste-free technologies.*
37. *Give examples of the use of geothermal energy in energy and heat supply.*
38. *Explain the principle of operation and areas of application of fuel cells.*
39. *Describe methods for increasing mass transfer in extraction processes.*
40. *What should be considered when designing energy-efficient industrial processes?*
41. *List methods for increasing the energy efficiency of lighting systems.*
42. *Justify the feasibility of using combined heating, ventilation and air conditioning systems.*
43. *Give examples of successful implementation of waste-free technologies in various industries.*
44. *Explain how temperature affects the extraction process.*
45. *Describe the features of using thermal accumulators to increase energy efficiency.*
46. *Give examples of the application of energy recovery in energy processes.*
47. *Indicate the main sources of energy losses at enterprises and ways to reduce them.*
48. *List the methods for increasing the selectivity of extraction.*
49. *Explain the role of intelligent energy systems (Smart Grid) in increasing energy efficiency.*
50. *Define thermodynamic equilibrium in extraction processes.*
51. *What should be considered when designing energy-efficient water supply and drainage systems?*
52. *List methods for improving the energy efficiency of industrial ovens and dryers.*
53. *Define the concept of "energy conservation" and give examples of its implementation.*
54. *Describe current trends in the development of energy-efficient technologies in the chemical industry.*
55. *What should be considered when designing waste-free technological schemes?*
56. *Name the main methods for increasing energy efficiency in industrial processes.*
57. *What should be considered when choosing energy-efficient equipment?*
58. *Give examples of modern energy-efficient technologies.*
59. *Describe methods for intensifying extraction using electromagnetic fields.*
60. *Give examples of alternative energy sources and their applications.*
61. *List the main types of renewable energy sources.*
62. *Explain the basic principles of wind power plants.*
63. *Define the partition coefficient in extraction.*
64. *What is needed to implement resource-efficient technologies in production?*
65. *List the main advantages of using bioenergy technologies.*
66. *Describe methods for analyzing extraction efficiency.*
67. *Explain the meaning of the term "closed production cycle".*
68. *Define the concept of "resource efficiency".*
69. *Define the concept of "environmentally friendly technologies".*
70. *Describe the main methods of storing energy.*
71. *Explain how surfactants are used in extraction.*
72. *Describe the process of energy production using geothermal plants.*
73. *Name the most important trends in the development of the energy sector for the next 10 years.*
74. *Name the main sources of energy loss in industrial processes.*
75. *Justify the economic feasibility of implementing waste-free technologies.*
76. *Give examples of successful implementation of energy-efficient technologies in world practice.*
77. *Specify the main methods of controlling energy consumption at industrial enterprises.*
78. *Justify the use of combined extraction methods.*
79. *Explain the principle of operation of cogeneration plants.*

80. List the basic principles of waste-free technologies.
81. Describe the impact of waste-free technologies on product quality.
82. Indicate the main stages of implementing waste-free technologies at the enterprise.
83. Explain the meaning of the term "closed production cycle".
84. List the main benefits of waste-free technologies for the environment.
85. Justify the need to use waste-free technologies in modern industry.
86. Define the concept of "secondary raw materials".
87. What is needed to perform high-pressure extraction?
88. Describe the process of recycling waste into secondary raw materials.
89. State the basic principles of extraction using enzymes.
90. Name the main types of waste generated in production.
91. Give examples of successful implementation of waste-free technologies in various industries.
92. List methods for increasing the extraction rate.
93. Define the concept of "ecological footprint of production".
94. Indicate the main methods of reducing waste in production.
95. Explain the role of government support in the implementation of waste-free technologies.
96. List the main technological processes used in waste-free schemes.
97. Justify the economic feasibility of implementing waste-free technologies.
98. Define the concept of "ecological footprint of production".
99. Describe the impact of waste-free technologies on product quality.
100. Formulate the basic requirements for extraction equipment.

Work program of the educational component (syllabus):

Compiled by Prof., Doctor of Engineering Sciences, Shcherbina V.Yu.

Approved by the department CPSM (protocol no. 1 7 from 04.06.202 5)

Approved by the Methodological Commission of the Faculty of Chemical Engineering (Minutes No. 11 from 2 7 .06.202 5)