Syllabus
Course Program

Work processes of modern production

Specialty
G4 Energy Production (by specialization)

Institute
Institute of mechanical engineering and transport

Specialization
Renewable Energy Sources and Hydropower

Department
Hydraulic Machines (150)

Educational program

Course type
Educational components of free choice of professional training of the general institutional catalog

Level of education
second (master's) level

Form of study
Full-time, part-time, distance learning

Semester

Language of instruction
English

Lecturers and course developers

Kseniia Riezva
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Candidate of Technical Sciences, Associate Professor of the Department of Hydraulic Machines of NTU "KhPI"

Work experience is 12 years.
Author and co-author of more than 70 scientific and educational works.

Courses: "Technical equipment and technology of well repair", "Introduction to the specialty. Introductory practice", "Hydrogasdynamics", "Hydraulics", "Basics of scientific research", "Fountain and gas safety in the oil and gas industry", "Machines and equipment for wells drilling, equipment for oil and gas production".

Yevhenii Krupa

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Candidate of Technical Sciences, Associate Professor of the Department of Hydraulic Machines named after G.F. Proscura of NTU "KhPI"

The author of more than 80 scientific and educational works (articles, manuals, monographs, patents on a useful model). Courses: "Fundamentals of bladed hydraulic machines theory", "Hydraulic turbines and reversible hydraulic machines", "Fundamentals of CAD for bladed hydraulic machines", "Design of bladed hydraulic machines"

General information

Summary

The course Work Processes of Modern Production provides graduate students in Hydropower Engineering with advanced knowledge of the physical, technological, and operational processes that govern modern industrial production systems. The discipline focuses on the principles of energy conversion, fluid flow, hydraulic machinery operation, automation, efficiency improvement, reliability assessment, and sustainable production practices. Special attention is given to work processes occurring in hydroelectric power plants and related energy facilities, including turbine operation, hydraulic transport systems, power generation processes, and modern monitoring and control technologies. The course combines theoretical foundations with engineering analysis and practical applications, enabling students to evaluate, model, optimize, and manage production processes in complex hydropower and energy systems.

Course objectives and goals

The aim of the course is to develop in students an advanced understanding of the work processes occurring in modern production systems, particularly within hydropower and energy facilities, and to foster the ability to analyze, model, optimize, and manage technological processes using contemporary engineering approaches, digital technologies, and sustainability principles.

Format of classes

Lectures, practical classes, individual tasks, consultations, self-study. Final control in the form of a test

Competencies

Ability to analyze the physical principles underlying production and energy conversion processes.
Ability to evaluate the operational performance of hydraulic and energy equipment.
Ability to model work processes in hydropower systems using engineering and computational methods.
Ability to assess the efficiency, reliability, and safety of production processes.
Ability to optimize technological processes and operating modes of hydropower facilities.
Ability to apply modern monitoring, diagnostics, automation, and control systems in production environments.
Ability to develop technical solutions aimed at improving productivity, energy efficiency, and operational sustainability.

Learning outcomes

Analyze operational processes occurring in hydraulic structures, turbines, pumps, pipelines, and auxiliary equipment.
Evaluate the performance and efficiency of production systems using engineering calculations and analytical methods.

Assess the influence of operating parameters on equipment productivity, reliability, and service life.
Conduct energy and technological analyses of modern production facilities.
Develop mathematical and computational models of production processes.
Select appropriate engineering methods and technological solutions for process improvement.
Optimize operating conditions of hydropower equipment and production systems.
Propose measures for increasing efficiency, reliability, safety, and sustainability.
Apply modern software tools for simulation, monitoring, and process analysis.
Interpret operational data and diagnostic information from production systems.
Conduct technical assessments and prepare engineering recommendations.
Present and justify engineering decisions using scientific and technical arguments.
Perform independent research and apply innovative approaches to solving production-related engineering problems.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures – 32 hours, practical classes – 16 hours, self-study – 72 hours.

Course prerequisites

The study of this discipline is directly based on general physics, hydraulic and pneumatic drives, CAD and powerengineering.

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

Lectures are conducted using multimedia technologies. Practical classes use a project-based approach to learning, game methods. Educational materials are available to students via Microsoft Teams and Microsoft Office 365 and an electronic course on the educational platform of NTU "KhPI" https://dlc.kpi.kharkov.ua/course/view.php?id=532.

Program of the course

Academic classes

Lectures

Topics of the lectures	Hours
Topic 1. Evolution of Production Technologies in the Energy Sector Historical development of industrial production systems and energy technologies. Industrial revolutions from Industry 1.0 to Industry 5.0. Transformation of hydropower technologies and the role of innovation in modern energy production.	4
Topic 2. Industry 5.0 and Human-Centric Production in Hydropower Engineering Principles of Industry 5.0. Human-machine collaboration, resilience, sustainability, and digital transformation. Application of Industry 5.0 concepts in hydropower plants, smart energy systems, and sustainable infrastructure.	4
Topic 3. Digital Twins and Smart Hydropower Facilities Fundamentals of digital twin technology. Modeling and simulation of hydraulic turbines, dams, pipelines, and auxiliary equipment. Real-time monitoring, predictive maintenance, and optimization of hydropower operations.	4
Topic 4 Agile Methodologies and Project Portfolio Management in Hydropower Projects Principles of Agile, Scrum, and Kanban in engineering environments. Portfolio management approaches for energy projects. Planning, prioritization, risk management, and implementation of innovation programs in hydropower enterprises.	4
Topic 5 Additive Manufacturing and 3D Printing Technologies for Hydropower Equipment Principles of additive manufacturing. Materials and technologies used in 3D printing.	4

Applications for turbine components, hydraulic equipment, spare parts production, rapid prototyping, and maintenance of hydropower facilities.	
Topic 6 Artificial Intelligence, Big Data, and Machine Learning in Hydropower Systems Data-driven production processes. Intelligent monitoring and diagnostics of hydraulic machinery. Predictive analytics, fault detection, performance forecasting, and decision-support systems for hydropower operations.	4
Topic 7 Advanced Automation, Robotics, and Industrial Internet of Things (IIoT) Modern automation architectures in energy production. Smart sensors, cyber-physical systems, industrial communication networks, and robotic inspection technologies for dams, turbines, and power stations.	4
Topic 8 Sustainable Production Processes and Green Technologies in Hydropower Engineering Energy efficiency, circular economy principles, low-carbon production technologies, environmental impact reduction, resource optimization, and sustainable development strategies for modern hydropower facilities.	4
Total hours	**32**

Workshops

Topics for workshops/seminars	Hours	Weighting coefficients *a*
Topic 1. Analysis of Technological Evolution in the Energy Sector. Content: Students analyze the development stages of industrial production systems from Industry 1.0 to Industry 5.0. The practical includes comparison of traditional and modern hydropower technologies, preparation of technology roadmaps, and assessment of the impact of technological innovations on hydropower plant productivity and efficiency.	4	1
Topic 2. Evaluation of Industry 5.0 Solutions for Hydropower Facilities Content: Students assess the implementation of Industry 5.0 principles in existing hydropower plants. The practical includes analysis of human-machine interaction, sustainability indicators, resilience metrics, and identification of opportunities for digital transformation and smart operation of hydropower facilities.	4	1
Topic 3 Development of a Digital Twin Concept for a Hydropower Unit Content: Students create a simplified digital twin model of a turbine, pumping station, or hydropower unit. The practical includes identification of system parameters, sensor requirements, operating variables, and performance indicators. Students evaluate how digital twins can improve maintenance, monitoring, and operational efficiency.	4	1
Topic 4 Agile Project Planning and Portfolio Management for Hydropower Projects Content: Students develop a project implementation plan using Agile methodologies (Scrum or Kanban). The practical includes defining project goals, creating backlogs, prioritizing activities, allocating	4	1

resources, analyzing risks, and managing a portfolio of innovation projects for hydropower enterprises.		
Total hours	**24**	$\sum_{i=1}^{n} a_i = 4$

Laboratory classes

Topics for laboratory classes	Hours	Weighting coefficients *a*
Total hours		$\sum_{i=1}^{n} a_i$

Control works

If applicable

Topics for control works	Weighting coefficients *b*
Total	$\sum_{i=1}^{m} b_i$

Self-study

Self-study includes independent work on theoretical materials and completion of individual assignments (if any).

Work on theoretical materials

Topics for self-study	Hours
Topic 1. Digital Oilfield Technologies and Smart Production Systems Principles of digital oilfield concepts. Application of sensors, real-time monitoring systems, industrial Internet of Things (IIoT), and digital twins in hydrocarbon production. Intelligent optimization of well operation, predictive maintenance, and data-driven decision-making in oil and gas production systems.	18
Topic 2. Emerging Trends in Artificial Lift Technologies Recent developments in sucker rod pumping systems, electric submersible pumps, gas lift systems, and progressing cavity pumps. Energy-efficient production technologies, automation of artificial lift systems, and challenges associated with unconventional hydrocarbon reservoirs.	18
Topic 3. Reliability and Failure Analysis of Production Equipment Common failure mechanisms of surface and downhole equipment. Corrosion, wear, fatigue, scaling, and paraffin deposition. Modern diagnostic approaches, condition monitoring, and reliability improvement strategies for hydrocarbon production systems.	18
Topic 4 Sustainable and Environmentally Responsible Hydrocarbon Production Environmental aspects of oil and gas extraction. Energy-efficient equipment, emission reduction technologies, produced water management, and sustainable development principles in hydrocarbon production operations.	18

Total hours	**72**

Topics for individual assignments

Information about individual assignments (if any): individual work. Deadline is 10 academic week

Topics for individual assignments

Topic Create a Presentation on the Agile Process at a Hydroelectric Power Plant (HPP)
Prepare a presentation that explains the application of the Agile project management methodology in the operation, maintenance, and modernization of a hydroelectric power plant (HPP). The presentation should describe the key Agile principles, roles, events, and artifacts, and demonstrate how Agile practices can improve project execution, equipment reliability, operational efficiency, and teamwork in a hydropower facility. The presentation should include: Introduction to Agile methodology and its core principles. Challenges of project management at a hydroelectric power plant. Agile roles and responsibilities in HPP projects. Creation and management of the project backlog. Sprint planning and task prioritization. Daily coordination meetings and progress tracking. Sprint review and retrospective processes. Benefits of Agile implementation for HPP operation and modernization. Examples of Agile applications in maintenance, automation, and infrastructure improvement projects. Conclusions and recommendations for Agile adoption in the hydropower sector. Expected outcome: A clear and well-structured presentation demonstrating how Agile methodologies can support efficient management of engineering and operational projects at a hydroelectric power plant.
Total hours

Non-formal education

Non-formal education includes professional courses/training, civic education, online education, professional internships, etc. The recognition of learning outcomes acquired in non-formal education applies to both mandatory and elective academic courses/educational components. The elements of non-formal education recommended in the syllabus can be recognized through a simplified procedure without additional validation of the results (without creation of a subject committee).
Provide a list of recommended professional courses/training, internships, etc. (if available).

Recommended training courses, internships

1.

Literature, training materials, and information resources

A list of sources of information and materials formatted in accordance with the standards. It's possible to split the list into sections, e.g. Main literature and Additional materials, etc.

Main literature

1. Schaefer D. (Ed.). Industry 4.0 and Advanced Manufacturing. Springer, 2020.
2. Nahavandi S. Industry 5.0: Human-Centric Solutions for a Sustainable Future. Springer, 2022.

3. Liu D., Xie L. Hydropower Engineering Handbook. CRC Press, 2021.
4. Koutsoyiannis D. Hydrology and Hydraulic Systems. CRC Press, 2021.
5. IEC. Hydroelectric Power Plants: Operation, Monitoring and Maintenance. International
6. Electrotechnical Commission Publications, 2020.
7. Montgomery D.C. Design and Analysis of Experiments. John Wiley & Sons, 2019.
8. Kerzner H. Project Management: A Systems Approach to Planning, Scheduling, and Controlling. Wiley, 2022.
9. Schwaber K., Sutherland J. The Scrum Guide. Scrum.org, latest edition.
10. Cadden T., Humphreys P. Innovation Management in Engineering and Technology. Routledge, 2021.
11. International Energy Agency (IEA). Hydropower Special Market Report. Paris: IEA, latest edition.

Additional materials

1. European Commission. Industry 5.0: Towards a Sustainable, Human-Centric and Resilient European Industry. Brussels, 2021.
2. Nahavandi S. Industry 5.0: A Human-Centric Solution. Sustainability, 2022.
3. Longo F., Padovano A., Umbrello S. Value-Oriented and Ethical Technology Engineering in Industry 5.0. Springer, 2023.
4. Kumar R. Industry 5.0 Applications in the Energy Sector. Elsevier, 2023.
5. Russell S., Norvig P. Artificial Intelligence: A Modern Approach. Pearson, 2021.
6. Géron A. Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow. O'Reilly, 2023.
7. Aggarwal C.C. Artificial Intelligence: A Textbook. Springer, 2021.
8. Ahmed M., Karray F. Machine Learning Applications in Energy Systems. Wiley, 2022.

Information resources

1.

Grading system

The final grade for the educational component is determined by the lecturer and is based on topics, types of activities, etc., in accordance with the syllabus. It is an integrated assessment of the results of all types of student learning activities. The final grade should reflect all the grades for the different parts of the educational process, taking into account their weighting coefficients *k*:

Continuous assessment (during workshops, seminars, laboratory classes) k_1	Control works (if any), k_2	Individual assignment (if any), k_3	Final assessment (for courses with exams), k_4
0,5		0,2	0,3

The sum of the coefficients must be equal to one: $k_1 + k_2 + k_3 + k_4 = 1$. The weighting coefficients for the final assessment are decided by the course developer..
The final grade is calculated using the following formula:

$$G = C \cdot k_1 + K \cdot k_2 + I \cdot k_3 + E \cdot k_4$$

where: C – weighted average score for the continuous assessment
I – individual assignment grade
K – weighted average score for the continuous assessment
E – final assessment (exam) grade

$$C = \frac{C_1 \cdot a_1 + C_2 \cdot a_2 + \ldots + C_n \cdot a_n}{\sum_{i=1}^{n} a_i}$$

де: a_i - weighting coefficient for each workshop (seminar) or laboratory class.

$$K = \frac{K_1 \cdot b_1 + K_2 \cdot b_2 + \ldots + K_m \cdot b_m}{\sum_{i=1}^{m} b_i}$$

де: b_i - weighting coefficient for each control work.

Description of the final score structure:
Exam (test) - 30 points
Laboratory works and workshops - 40 points
Individual assignment - 30 points

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

Students must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by

Head of the department

Guarantor of the educational program