Syllabus
Course Program

Proportional hydraulics

Specialty
131 – Applied Mechanics

Institute
Educational-scientific Institute of Mechanical Engineering and Transport

Educational program
Applied Mechanics

Department
Hydraulic Machines (150)

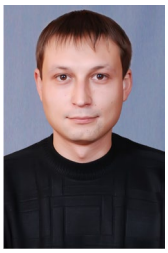
Level of education
Master's level

Course type
Optional course

Semester
2

Language of instruction
English

Lecturers and course developers



Andrii Rogovyi

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Doctor of Technical Sciences, Professor, Head of the Department

Author of more than 200 scientific and educational works. Leading lecturer in the courses: "Modeling and calculation of viscous fluid flows", "Mathematical modeling of work processes in hydraulic machines", "Numerical study of spatial flow in hydraulic machine channels". He defended his dissertation on "Development of the theory and methods of calculation of vortex chamber superchargers".
More about the lecturer on the department's website

Oleksandr Fatyeyev

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Candidate of Technical Sciences, Assistant Professor of the Department of Hydraulic machines named after G. F. Proskura

Author and co-author of more than 30 scientific and methodological publications.
Courses: "Proportional Hydraulics", "Modern Technologies in Applied Mechanics", "Workflows of modern industries", "Certification and Metrological Quality Assurance", "Theory of Automatic Control".
More about the lecturer on the department's website

General information

Summary

The Proportional Hydraulics course studies the principles of construction of hydraulic systems with proportional devices and the laws of processes occurring in them, which it investigates on dynamic

models of systems, taking into account the operating conditions, specific purpose and design features of the controlled object in order to build efficient and accurate control systems.

Course objectives and goals

The course aims to form and develop students' scientific and practical outlook, modern forms of theoretical thinking, and to provide students with knowledge in the field of control and dynamics of systems with proportional hydraulic devices, which are necessary for further mastering special disciplines and practical activities in the specialty.

Format of classes

Lectures, laboratory work, consultations. Final control - test

Competencies

GC1. Ability to identify, formulate and solve engineering, technical and scientific problems.
GC4. Ability to develop and manage projects.
GC5. Ability to communicate with representatives of other professional groups of different levels.
GC6. Ability to learn and master modern knowledge.
GC8. Ability to conduct research at the appropriate level.
PC1. Ability to apply appropriate methods and resources of modern engineering to find optimal solutions to a wide range of engineering problems using modern approaches, forecasting methods, information technology and considering existing constraints in conditions of incomplete information and conflicting requirements.
PC2. Ability to describe, classify and model a wide range of technical objects and processes based on a deep knowledge and understanding of theories and practices of mechanical engineering, as well as knowledge of related sciences.
PC5. Ability to plan and carry out experimental and theoretical research in applied mechanics and related interdisciplinary problems, to process and summarize research results.

Learning outcomes

LO1 Apply specialized conceptual knowledge of the latest methods and techniques for designing, analyzing and researching structures, machines and/or processes in mechanical engineering and related fields.
LO3 Apply automation systems to perform research, design and development work, technological training and engineering analysis in mechanical engineering.
LO4 Use modern methods of optimizing the parameters of technical systems by means of system analysis, mathematical and computer modeling, in particular in conditions of incomplete and contradictory information.
LO8 Master modern knowledge, technologies, tools and methods, in particular through independent study of professional literature, participation in scientific, technical and educational events;
LO12 Plan and carry out experimental and theoretical research in the field of applied mechanics, analyze their results, and justify conclusions.

Student workload

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

Course prerequisites

Bachelor's degree

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

The lectures use video materials, interactive techniques, logical methods, work with scientific literature, and the preparation of graphic diagrams and tables. Laboratory installations, models of devices, and posters are used in the organization of classes. In order to acquire skills of independent work in laboratory work, each student performs creative tasks in the course of study.

The material is available on the Microsoft 365 resource and on the Moodle platform

Program of the course

Topics of the lectures

Topic 1: Introduction to proportional hydraulics.
Overview of types of hydraulic actuator control. Advantages of proportional hydraulics
Topic 2. Electromagnetic control
Design and principle of operation of a proportional electromagnet.
Topic 3. Design and principle of operation of proportional pressure valves.
Pressure valves of direct and indirect action. Pressure limiting valves (safety valves). Pressure control valves (pressure reducing valves).
Topic 4. Design and principle of operation of the proportional throttles and distributors.
Direct-acting proportional valves. Proportional distributors with pilot control.
Topic 5. Design and principle of proportional valves of flow controllers.
Direct-acting proportional flow control valves without spool position control. Direct-acting proportional flow control valves with spool position control.
Topic 6. Control electronics for proportional valves.
Presentation of the characteristic curve. Hysteresis, inverse range and threshold.
Topic 7. Criteria for determining control parameters using proportional valves.
Criteria for determining control parameters using proportional valves. Graphs of pressure valve characteristics. Charts of characteristics of throttles and distributors. Dynamic parameters of a proportional valve.
Topic 8. Proportional valves, instrumentation.
Amplifier and setting the settings. Design and principle of the amplifier. Setting up the amplifier. Setting.
Topic 9. Digital hydraulics. Servo valves.
General information.

Topics of the workshops

Practical classes are not provided within the course

Topics of the laboratory classes

Topic 1: Familiarization with the general hydraulic ratios in hydraulic units.
Manual control. Electromagnetic control. Proportional control.
Topic 2. Determination of hydraulic parameters on the example of extending / retracting a differential hydraulic cylinder with a positive load.
Calculation of the required pressures and flow rates in a proportional distributor.
Topic 3: Determination of hydraulic parameters on the example of extending / retracting a differential hydraulic cylinder with a negative load.
Topic 4. Determination of hydraulic parameters on the example of extending / retracting a differential cylinder on an inclined plane with a positive load.
Topic 5. Determination of hydraulic parameters on the example of extending / retracting a differential cylinder on an inclined plane with a negative load.
Topic 6: Determination of hydraulic parameters on the example of using a hydraulic motor with a positive load.
Topic 7. Determination of hydraulic parameters on the example of using a hydraulic motor with a negative load.
Topic 8. Influence of the maximum force on the piston on the process of acceleration and deceleration.

Self-study

Study the lecture material. Preparation for practical classes. Independent study of topics and issues that are not covered in lectures

Course materials and recommended reading

1. Smith, P. D. (2013). BASIC hydraulics. Butterworth-Heinemann.
2. Ružarovský, R., Holubek, R., Janíček, M., Velíšek, K., & Tirian, G. O. (2021, February). Analysis of the Industry 4.0 key elements and technologies implementation in the Festo Didactic educational systems MPS 203 I4. 0. In Journal of Physics: Conference Series (Vol. 1781, No. 1, p. 012030). IOP Publishing.
3. Hamill, L. (2001). Understanding hydraulics (Vol. 2). Basingstoke, UK: Palgrave.
4. Ilango, S., & Soundararajan, V. (2011). Introduction to hydraulics and pneumatics. PHI Learning Pvt. Ltd..
5. Khalil, M. K. B., & CFPHS, C. (2017). Electro-Hydraulic Components and Systems. CompuDraulic LLC.
6. Manring, N. D., & Fales, R. C. (2019). Hydraulic control systems. John Wiley & Sons.

Assessment and grading

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

100% of the final grade consists of the results of the current assessment

Current assessment: quizzes, online test, defense of laboratory work (10% each), defense of individual work (20%).

Grading scale

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

Norms of academic integrity and course policy

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

Approval

Approved by	Date, signature	Head of the department Andrii ROGOVYI
	Date, signature	Guarantor of the educational program Volodymyr Rubashka