Syllabus
Course Program

Dynamics of hydropneumatic systems

Specialty
131 – Applied Mechanics

Institute
Educational-scientific Institute of Mechanical Engineering and Transport

Educational program
Applied Mechanics

Department
Hydraulic Machines (150)

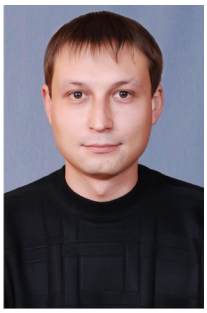
Level of education
Master's level

Course type
Optimal (profile)

Semester
1

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".

Oleksandr Hasiuk

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

Work experience is 18 years.
Author and co-author of more than 50 scientific and educational works.
Courses: " Dynamics of hydropneumatic systems", "Manufacturing technology of hydraulic pneumatic actuators", "Operation and diagnostics of hydraulic pneumatic systems".

General information

Summary

The Dynamics of Hydropneumatic Systems course offers students an in-depth study of the dynamics of complex hydropneumatic systems used in mechanical engineering. Starting with the basic concepts of dynamics, the course looks at examples of real-world systems and teaches students how to analyze, model, and optimize their performance. This course will provide students with the knowledge and practical skills to analyze, model and improve the dynamics of hydropneumatic systems in mechanical engineering, contributing to the development of their professional competencies in this area

Course objectives and goals

The aim of this course is to provide students with a deep understanding of the dynamics of hydraulic pneumatic systems used in mechanical engineering. The course is aimed at studying the principles of operation, mathematical modeling and analysis of system dynamics, as well as developing skills in solving engineering problems related to the design and control of hydraulic pneumatic systems in the industrial sector. As a result of the course, students will be able to develop effective solutions to optimize equipment performance and improve equipment safety and reliability.

Format of classes

Lectures, self-study, report. Final control in the form of a test.

Competencies

GC1. Ability to identify, formulate and solve engineering, technical and scientific problems.
PC3. Application of appropriate methods and resources of modern engineering based on information technology to solve a wide range of engineering problems using the latest approaches, forecasting methods with awareness of the invariance of solutions.
PC6. Ability to apply appropriate mathematical, scientific and technical methods, information technology and applied computer software to solve engineering and scientific problems in applied mechanics

Learning outcomes

LA1 Apply specialized conceptual knowledge of the latest methods and techniques for design, analysis and research of structures, machines and/or processes in mechanical engineering and related fields
LA3 Apply automation systems to perform research, design and development work, technological training and engineering analysis in mechanical engineering.
LA12 Demonstrate the ability to perform modeling, static and dynamic analysis of structures, mechanisms, materials and processes at the design stage using modern computer systems.

Student workload

The total volume of the course is 180 hours (6 ECTS credits): lectures - 48 hours, practical work - 16 hours, laboratory work - 16 hours, self-study - 100 hours.

Course prerequisites

Bachelor's degree

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

In the lectures, various methods of oral presentation of information are used: maintaining attention for a long time, activating the listeners' thinking; techniques that ensure logical memorization: persuasion, argumentation, evidence, classification, systematization, generalization, etc.
The method of discussion of educational material and discussion is used in lectures. The discussion makes it possible to significantly deepen and systematize knowledge and understanding of a particular problem, to check the basis of the conclusions reached by students during the study of a specific topic. The discussion method develops students' ability to defend their views and beliefs. The discussion helps to identify, logically and critically consider different points of view, scientific concepts and approaches to the issues under consideration. The organization and support of the discussion is achieved by using the

following methods: asking questions (main, additional, leading, etc.), discussing the answers and opinions of students, correcting the answers and formulating conclusions.
Visual and practical teaching methods. Among the visual methods of learning, illustration and demonstration are used. Illustration - showing students posters, maps, graphs, sketches on the board.
During distance education, lecture material is presented in the form of presentations with pictures and videos.
The material is available on the Microsoft 365 resource and on the Moodle platform.

Program of the course

Topics of the lectures

Topic 1: Dynamics of tracking HPS with throttle control.
Scope, classification, quality indicators of the transient process.
Topic 2. Linear model of the tracking HPS.
The initial system of equations, their linearization, transfer functions of the links of the HPS, structural diagrams.
Topic 3. Dynamics of a tracking hydraulic system (THS) with a four-stroke spool.
Schematic diagram, design features, initial system of equations and assumptions.
Topic 4. Linear model.
Linear model, transfer functions, structural diagrams, frequency of undamped oscillations, damping coefficient, speed gain.
Topic 5. Nonlinear model.
Nonlinear model, structural and functional diagrams of system elements and the system as a whole. Features of the construction of the structural and functional scheme of the equation of motion of the executive body under passive load.
Topic 6. Determination of dynamic processes in the system by simulation modeling on a computer.
Comparison of modeling results based on linear and nonlinear models of the HPS.
Topic 7. Dynamics of programmable HPS with throttle control.
Dynamics of programmable throttle-controlled GCS designed for CNC equipment. Field of application, classification, features of HPS. The design of two-stage hydraulic amplifiers of the "nozzle-flapper" type - electrically controlled spool, electro-hydraulic amplifier (EHA). Mathematical model of the EHA.
Topic 8. Dynamics of the hydraulic system of moving the slider of a CNC sheet bending press.
Dynamics of the hydraulic system for moving the slider of a CNC sheet bending press for the manufacture of boxes and other bent profiles used in mechanical engineering.
Topic 9: Schematic and functional diagrams of the hydraulic system.
Non-linear model of the software hydraulic system of the sheet bending press, closed by the position of the slider.
Topic 10. Drawing up a structural and functional diagram.
Drawing up a structural-functional diagram according to the equations of the mathematical model for the simulation package.
Topic 10. Determination of dynamic processes in the system by simulation modeling on a computer.
Dynamics of a nonlinear HPS with regard to viscous friction. The mathematical model of the HPS in the switching mode and its structural and functional diagram for a set in a computer simulation package.
Dynamics of a nonlinear HPS under input harmonic influence.
Topic 12: Dynamics of HPS with volumetric control.
The field of application, advantages and disadvantages in comparison with throttle control, possible schemes of combinations of regulated and unregulated pumps and hydraulic motors with volumetric control, speed and mechanical characteristics.
Topic 13. Dynamics of the hydraulic system of a hydraulic drilling pump with volumetric control.

Topics of the workshops

1. Dynamics of a nonlinear THS under input step action with a harmonic load component.
2. Dynamics of a nonlinear path-closed THS under a step input without taking into account viscous friction.
3. Dynamics of a path-closed nonlinear THS under input stepwise impact with viscous friction.

5. Dynamics of a closed-loop nonlinear THS under input stepwise action with rigid and flexible negative velocity feedback.
6. Dynamic characteristics of a hydraulic drilling pump with volumetric control. Dynamics of a nonlinear hydraulic drilling system under input step influence with a harmonic load component.
7. Dynamics of a nonlinear path-closed THS under a step input without taking into account viscous friction.
8. Dynamics of a closed-path nonlinear THS under input stepwise impact with viscous friction.
9. Dynamics of a closed-loop nonlinear THS under input stepwise action with rigid and flexible negative velocity feedback.
10. Dynamic characteristics of a hydraulic drilling pump with volumetric control.

Topics of the laboratory classes

1. The dynamics of the THS, represented by the transfer functions by the increment of speed and displacement. The dynamics of the THS, represented by the transfer function by the increase in load pressure.
2. The dynamics of the THS represented by the transfer function by the increase in flow rate. The dynamics of the THS represented by a linear model in increments.
3. The dynamics of the hydraulic system represented by a nonlinear model with generalized characteristics of the hydraulic distributor and hydraulic cylinder.
4. Dynamics of a nonlinear THS with a linearly increasing controlling influence with a limitation.
5. Dynamics of a nonlinear THS taking into account viscous friction.

Self-study

The individual task is presented in the form of a course project on the topic "Dynamics of the tracking hydraulic system" according to the options

Course materials and recommended reading

1. Mathias, L. (2023). Fluid Power Systems in Mechanical Engineering: Hydraulics and Pneumatics.
2. Parr, A. (2011). Hydraulics and pneumatics: a technician's and engineer's guide. Elsevier.
3. Ilango, S., & Soundararajan, V. (2011). Introduction to hydraulics and pneumatics. PHI Learning Pvt. Ltd..
4. Sivaraman, I. (2017). NTRODUCTION TO HYDRAULICS AND PNEUMATICS. PHI Learning Pvt. Ltd..
5. Pawar, P. B. (2020). Industrial Hydraulics and Pneumatics. Sankalp Publication.

Assessment and grading

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

The overall course grade consists of the following components:
Course project - 40 points,
Exam (in the form of a test task) - 60 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

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