Syllabus

Course Program

Modeling of fluid flow in the flow part of hydraulic machines

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".

General information

Summary

The discipline provides the ability to independently apply methods of modeling and calculating the flow of viscous fluid, apply correct turbulence models, navigate and choose rational mathematical models of viscous fluid flow

Course objectives and goals

To learn the basics of the turbulent flow theory of viscous fluid and modern methods of flow mathematical modeling in hydraulic machine channels.

Format of classes

Lectures, laboratory work, consultations. Final control - exam

Competencies

GC2. Ability to make informed decisions
PC1. Ability to apply specialized conceptual knowledge of the latest methods and techniques for designing and researching structures, machines and/or processes in the field of mechanical engineering.
PC2. Ability to critically analyze and predict the performance parameters of new and existing mechanical structures, machines, materials and production processes of mechanical engineering based on knowledge and use of modern analytical and/or computerized methods and techniques.
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

LO1. Apply specialized conceptual knowledge of the latest methods and techniques of design, analysis and research of structures, machines and/or processes in mechanical engineering and related fields.
LO3. Demonstrate the ability to perform modeling, static and dynamic analysis of structures, mechanisms, materials and processes at the design stage using modern computer systems
LO4. Demonstrate theoretical knowledge and practical skills in using modern methods of finding optimal parameters of technical systems by means of system analysis, mathematical, simulation and computer modeling, including under conditions of incomplete and contradictory information.
LO5 Independently set and solve innovative tasks, argue and defend the results and decisions made.
LO12 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 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: Classification of flows. Methods of applied problems research.
Topic 2. Navier-Stokes equation.
Topic 3. Fundamentals of the hydromechanical processes similarity theory.
Topic 4. Turbulent motion of a viscous fluid.
Topic 5. Boundary layer.
Topic 6. Mathematical formulation of the most common approaches to turbulence modeling.
Topic 7. LES and DES methods.

Topics of the workshops

Practical classes are not provided within the course

Topics of the laboratory classes

Laboratory work 1. Calculation of flow in a channel
Laboratory work 2. Calculation of minor losses
Laboratory work 3. Sensitivity analysis
Laboratory work 4. Calculation of heat transfer from gas to water through solid pipe walls
Laboratory work 5. Features of mesh construction in the boundary layer and features of boundary layer modeling
Laboratory work 6. Comparison of calculation results for different turbulence models
Laboratory work 7. DES modeling
Laboratory work 8. Performing a coupled analysis of the temperature and structural strength of the mixer walls

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. Tu, J., Yeoh, G. H., & Liu, C. (2018). Computational fluid dynamics: a practical approach. Butterworth-Heinemann.
2. Sharma, A. (2021). Introduction to computational fluid dynamics: development, application and analysis. Springer Nature.
3. Papanastasiou, T., Georgiou, G., & Alexandrou, A. N. (2021). Viscous fluid flow. CRC press.
4. Patankar, S. (2018). Numerical heat transfer and fluid flow. CRC press.
5. Nakayama, Y. (2018). Introduction to fluid mechanics. Butterworth-Heinemann.
6. Janna, W. S. (2020). Introduction to fluid mechanics. CRC press.
7. Pepper, D. W., & Heinrich, J. C. (2017). The intermediate finite element method: Fluid flow and heat transfer applications. Routledge.
8. Kajishima, T., & Taira, K. (2016). Computational fluid dynamics: incompressible turbulent flows. Springer.
9. Ferziger, J. H., Perić, M., & Street, R. L. (2019). Computational methods for fluid dynamics. springer.
10. Wu, Y. S. (2015). Multiphase fluid flow in porous and fractured reservoirs. Gulf professional publishing.

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