TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School
Oleg Yu. Dolmatov
"25" 06 2020

Course Name: Thermal Hydraulics in Nuclear Reactors

Field of Study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear Power Engineering

Level of Study: Master Degree Programme

Year of admission: 2019

Semester, year: semester 1, year 1

ECTS: 4

Total Hours: 144

Contact Hours: 48

- **Lectures:** 24
- **Practical experience:** 24

Self-study: 96

Assessment: Credit-test

Division: Nuclear Fuel Cycle

Director of Programme Vera V. Verkhoturova

Professor Alexander G. Korotkikh

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Course name: Thermal Hydraulics in Nuclear Reactors

Course Overview

Course Objectives	The objective of the course is to form a set of competences (learning outcomes) which will enable graduates to carry out their professional activity in the field of thermal physics and operation of nuclear reactors at nuclear power plants.
Learning Outcomes	Upon completion of the course, a graduate **will obtain the knowledge of:** – basics of structuring a report and preparing presentations using foreign language, accepted in the international environmentж – goals and objectives of scientific research in the field of professional activity, basic principles and methods of their organization; – thermohydraulic calculations of nuclear power plants; – heat exchange equipment using modern methods; – calculation programs and information sources, Upon completion of the course, graduates are also expected to develop the following **skills:** – to develop a project taking into account the analysis of alternative options for its implementation, determine the target stages, the main directions of work; – to explain goals and formulate tasks related to the preparation and implementation of the project, determine the main stages and directions of work; – to compile and present technical and scientific information used in professional activities in the form of a presentation; – to perceive authentic audio and video materials related to training direction; – to compose a general plan of work on a given topic, suggest research methods and methods of result processing; – to perform thermohydraulic calculations of nuclear power plants, heat exchange equipment using modern methods; – to use calculation programs and information sources; – to search and analyze information related to structures and operating experience of nuclear power plants, fuel elements, structural materials using scientific citation databases. Upon completion of the course, graduates should acquire **the practical experience in**: – applying methods of development and project management; – applying methods for assessing resource requirements and project effectiveness; – applying skills of monologue speech in a foreign language according to the profile of specialty, reasonably expressing his position and using auxiliary means (tables, graphs, charts, etc.); – applying acquired knowledge of a foreign language at a sufficient level in his future professional activities; – applying systematic knowledge in the field of future professional activity;

	– applying in-depth knowledge on the chosen direction of training, basic skills for conducting research on the proposed topic; – performing thermohydraulic calculations of nuclear power plants, heat exchange equipment using modern methods.
Course Outline	The target course is taught using a variety of teaching forms such as: – 12 lectures; – 12 practical experiences; – 3 individual homework assignments; – 2 reviews; – 2 tests; – 1 colloquium. The course consists of four sections, which are given below. Section 1. Heat release in a nuclear reactor. Section 2. Thermal conductivity in a nuclear reactor. Section 3. Convective heat transfer in a nuclear reactor. Section 4. Heat transfer by radiation in a gas cooled nuclear reactor. Each section includes several lectures and practical experiences. During the course, students perform practical tasks and 2 tests. The course ends with a colloquium. Learners'self-study is arranged in a form of individual research of the topics and individual homework assignments. During the course of study, learners are expected to complete three individual homework assignments and two reviews. *Individual homework assignment* is a set of tasks each containing unique set parameters. It is obligatory for each student to present the results of individual homework assignment completion in a form of a report. The report must have a title page, initial data, task solution, conclusions, and final statement. The report must be defended in a class. This suggests students answering from 3 to 5 questions related to the topic of the assignment. *Review* is given to the student by the teacher with an indication of the databases and the deadlines for the assignment. The topic of review must be thoroughly researched. The materials of the review work must be presented in paper. Review includes the literature overview on the given topic and shall have the following parts: a title page, outline, introduction, main body sections, conclusion and reference list.
Course Structure	The content of the course covers four main sections. Each section is studied through lectures and practical experiences. **Section 1. Heat release in a nuclear reactor** Lecture 1. The nuclear reactors. Processes of heat release in the core of nuclear reactor. Lecture 2. The distribution of the heat release in a nuclear reactor. Practical experience 1. Designs and characteristics of nuclear reactors. Practical experience 2. Calculation of the heat generated in the core of nuclear reactor. **Section 2. Thermal conductivity in a nuclear reactor.** Lecture 3. Conductive heat flux. Fourier law. Thermal conductivity coefficient. Lecture 4. Steady-state conduction in a nuclear reactor design. Lecture 5. Heat conduction with the heat release in a fuel rod. Lecture 6. Unsteady heat conduction during cooling (heating) of body. Practical experience 3. Calculation of the heat flux and the temperature distribution in bodies of various shapes.

	Practical experience 4. Calculation of the heat flux on the surface of the nuclear reactor design. Practical experience 5. Calculation of the heat flux and the temperature distribution in the fuel element. Practical experience 6. Calculation of the heat release during shutdown of a nuclear reactor and temperatures in structures during their cooling (heating). **Section 3. Convective heat transfer in a nuclear reactor.** Lecture 7. Newton-Richman Law. Similarity and modeling of the convective heat transfer. Lecture 8. Heat transfer in a single-phase medium with free and forced flow of the coolant. Lecture 9. Heat transfer at the forced longitudinal and cross-washing tubes, tube and rod bundles. Heat transfer of liquid metal coolant. Lecture 10. Heat transfer during boiling and condensation. Critical heat flux. Lecture 11. The principle of thermohydraulic calculation of the nuclear reactor core cooled by single-phase and two-phase flows. Practical experience 7. Calculation of heat transfer in natural circulation of the coolant. Practical experience 8. Calculation of heat transfer in forced circulation of the coolant. Practical experience 9. Calculation of heat transfer in the forced longitudinal and cross-washing tubes, tube and rod bundles. Practical experience 10. Calculation of heat transfer during boiling liquid, heat transfer crisis in fuel assemblies. Practical experience 11. Thermohydraulic calculation of the nuclear reactor core. Thermal calculation of heat exchange equipment. **Section 4. Heat transfer by radiation in a gas cooled nuclear reactor.** Lecture 12. Heat transfer by radiation in a gas cooled nuclear reactor. Practical experience 12. Calculation of complex heat transfer in power plants.
Facilities and Equipment	1. Lecture hall with multimedia equipment and computers: Tomsk, Lenin ave. 30a, build. 4, room 31.
Grading Policy	In accordance with TPU rating system we use: – Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities (performance control questions, practical problems). Max score for current assessment is 100 points, min – 55 points. – Course final assessment (credit test) is performed at the end of the semester according to the results of the current rating.
Course Policy	Attendance at lectures and practical experience are compulsory.
Teaching Aids and Resources	**Compulsory reading:** 1. Прибытков И. А. Thermophysics = Теплофизика : учебное пособие / И. А. Прибытков. — Москва : МИСИС, 2019. — 97 с. — Текст : электронный // Лань : электронно-библиотечная система. — URL: https://e.lanbook.com/book/129050 (дата обращения: 17.12.2020). — Режим доступа: из корпоративной сети ТПУ. **Additional reading:** 1. Breeze, P. Combined Heat and Power [Электронный ресурс] / P. Breeze. — Электрон. дан. — Elsevier Ltd.: Academic press, 2018. — 95 p. — Режим

	доступа: https://ezproxy.ha.tpu.ru:2056/book/9780128129081/combined-heat-and-power. — Загл. с экрана.
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