TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

Course Name: Special Materials for Nuclear Power Facilities

Field of Study: Nuclear Physics and Technology

Programme name: Nuclear Physics and Technology

Specialization: Nuclear Power Engineering

Level of Study: Master Degree Programme

Year of admission: 2020

Semester, year: semester 1, year 1

ECTS: 4

Total Hours: 144

Contact Hours: 48

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

Self-study: 96

Assessment: Exam

Division: Nuclear Fuel Cycle

Director of Programme _____ / Vera V. Verkhoturova

Instructors _____ / Oleg Yu. Dolmatov

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Course name: Special Materials for Nuclear Power Facilities

Course Overview

Course Objectives	The course aims at preparation of students for scientific-research work and innovative activity in the areas of nuclear reactors and power installations operation. The practical objective of the course is to prepare the students for engineering and manufacturing activity, which provides the implementation and application of novel products, science-driven products, and technologies in the area of nuclear reactors and power installations operation.
Learning Outcomes	**Upon completion of the course, a graduate is expected to acquire the knowledge of:** – the features of professional etiquette of Western and domestic culturesж – the basics of structuring a report and preparing presentations in a foreign language, accepted in the international environment; – the goals and objectives of scientific research in the field of professional activity, basic principles and methods of their organization; – the main sources of scientific information and the requirements for the presentation of information materials; – modern methods of research, evaluation and presentation of the results of work performed; – the basics of formatting research results in the form of articles, proceedings, scientific reports and presentations using computer typesetting systems and office software packages; **Graduates are also expected to develop the following skills**: – 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; – to draw up a general plan of work on a given topic, suggest research methods and methods of processing the results; – to conduct research according to the plan agreed with the manager, to present the results; – to format the results of research activities in the form of articles, proceedings, scientific reports and presentations using computer typesetting systems and office software packages; – to use the basic terminology in the field of nuclear physics and technology in English, to present and defend the results of innovative engineering work; – to apply the deep mathematical, natural-science, social, economic and professional knowledge for theoretical and experimental research in the area of nuclear science and technology; – to define, formulate and solve interdisciplinary engineering tasks in the nuclear field using professional knowledge and modern research methods; – to use basic and special approaches, skills and methods for identification, analysis, and solution of the technical problems in nuclear science and technology;

	– to use the creative approach to develop new ideas and methods for designing objects of the nuclear fuel cycle, and also to modernize and improve the applied technologies of nuclear industry. Graduates should acquire **the practical experience in**: – application of knowledge of nuclear reactor materials characteristics and properties for the development of advanced nuclear reactor components.
Course Outline	The course includes the following parts: – 12 lectures; – 12 practical lessons; – 1 review; – 2 colloquiums; – exam. Exam is conducted in a written form. Main sections of the course: – The structure of materials. – Mechanical, physical and chemical properties of metals and alloys. – The general requirements to materials and constructions of nuclear reactors. – Nuclear fuel. – Coolants. – Moderators. – Constructional materials of reactor core. – Absorption materials.
Prerequisites (if available)	-
Course Structure	**Section 1. The structure of materials.** Atomic and crystal structure of materials. Interatomic binding. Anisotropy. Polymorphism. Types of crystallographic defects. **Section 2. Mechanical, physical and chemical properties of metals and alloys.** Elastic and plastic deformation. Plastic and brittle conditions of metals. Proportionality limit, elastic limit, tensile strength. Elongation and reduction. Thermal conductivity, heat capacity and thermal expansion of metals and alloys. The phenomenon of corrosion of metals and alloys **Section 3. The general requirements to materials and constructions of nuclear reactors.** Mechanical, thermal, strength, corrosion requirements for various materials and systems of nuclear reactors. **Section 4. The main mechanisms of thermo-irradiation damage.** Classification of radiation damages. The main properties of point-like flaws. The main radiation effects. Radiation hardness and radiation durability. **Section 5. Nuclear fuel.** The definition and main requirements to the nuclear fuel. Types of nuclear fuel and fuel cycles. Energy-producing and burn-up range. Fission products and changes of nuclide compound of the fuel. Structure and properties of metallic uranium. Ceramic fuel. **Section 6. Coolants.** Requirements for the coolants. The main types of the coolants. Operating conditions of the coolants. The requirements to water as a coolant. Gas coolants. Liquid metal coolants.

	Section 7. Moderators. The general requirements for the moderators. The properties of graphite and its radiation hardness. The features of the reactors with the graphite moderator. The main characteristics of beryllium, problems and perspectives of its application in nuclear industry. The moderation properties of light and heavy water. **Section 8. Constructional materials of reactor core.** The magnesium, aluminum and zirconium alloys. Austenitic stainless steels. Heat-resistant and high-melting point alloys. Their thermophysical and mechanical properties. **Section 9. Absorption materials** Absorption materials and their properties. The ways of absorption materials application.
Installations and Equipment	Lecture hall with the multimedia equipment: Lenina ave., 2, building 10, room 248.
Grading Policy	In accordance with TPU assessment 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 (individual homework assignments and group review). Max score for current assessment is 80 scores, min – 44 scores. - Course final assessment (exam/ credit test) is performed at the end of the semester. Max score for course final assessment is 20 scores, min – 11 scores. The final score is determined by summing the scores of the current assessment during the semester and exam (credit test) scores at the end of the semester. Maximum overall rating corresponds to 100 scores, min pass score is 55.
Course Policy	Attendance is strictly controlled. All classes are obligatory to presence.
Teaching Aids and Resources	**Compulsory reading:** 1. Mittemeijer E. J. Fundamentals of Materials Science / E. J. Mittemeijer. – Berlin: Springer, 2011 – 608 p. – Текст: электронный // SpringerLink.– URL: https://link.springer.com/book/10.1007/978-3-642-10500-5 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Was G.S. Fundamentals of Radiation Materials Science. Metals and Alloys /G. S. Was. – 2 edition. - Berlin: Springer, 2017 – 1014 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-1-4939-3438-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Дополнительная литература:** 1. Yoshiaki, O. Nuclear Reactor Design / O. Yoshiaki. - New York : Springer, 2014. - 337 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-54898-0 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Shimjith, S. R. Modeling and control of a large nuclear reactor / S. R. Shimjith, A. P. Tiwari, B. Bandyopadhyay. – New York : Springer, 2010. – 327 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-30589-4 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.

Instructors	1. Dr. Oleg Dolmatov, Associate professor, Nuclear Fuel Cycle Division, School of Nuclear Science & Engineering, TPU, Tel. + 7 (3822) 701-777 (2301), e-mail: dolmatov@tpu.ru, personal site: https://portal.tpu.ru/SHARED/d/DOLMATOV