TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

**Course Name: Research Reactor Operational Practice**

**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:** 2020

**ECTS:** 3

**Total Hours:** 108

**Contact Hours:** 32

- **Labs:** 32

**Self-study:** 76

**Assessment:** Credit-test

**Division:** Nuclear Fuel Cycle

**Director of Programme** _____________ / Vera V. Verkhoturova

**Instructor** _____________ / Artem G. Naymushin

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

**Course name: Research Reactor Operational Practice**

**Course Overview**

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| **Course Objectives** | The objective of the course is to develop practical knowledge and skills among learners to prepare them for conducting their professional activity closely connected with the determination of physical parameters of the research reactor operation. |
| **Learning Outcomes** | **Upon completion of the course, a graduate will obtain knowledge of:**<br>– the basic methods of creating scientific reports and presentations in a foreign language in accordance with accepted industry standards.<br>– advanced methods and techniques for experimental and theoretical research, criteria for evaluating the scientific and technical results of the work.<br>– the characteristics of structural and functional materials used as reactor fuel, coolant, moderator and structural elements.<br>– the basic calculation methods used in the process of supporting the operation and planning of a physical experiment.<br>– the basic experimental methods for evaluating the parameters of breeding systems and shim rods for excess reactivity.<br>– the criteria for the necessary volume of source data for scientific and technical work.<br>– the basic engineering approaches to the design of nuclear installations.<br>– the basic requirements of regulatory documentation for protective, localizing and normal operation systems of nuclear installations.<br>**Upon completion of the course, a graduate will obtain skills:**<br>– to present the results of the analysis of scientific and technical information on their professional topics in the form of a multimedia presentation.<br>– to apply advanced methods and techniques for experimental and theoretical research, evaluate the results of the work.<br>– to make three-dimensional models of nuclear reactor designs, taking into account the features of the structural and functional materials.<br>– to use modern software for neutronic and thermohydraulic calculations of the main processes in nuclear reactors.<br>– to choose the correct research methodology, based on the characteristics of the breeding system, analyze the results and suggest ways to improve the studied system.<br>– to organize scientific and technical information for the design of new technologies for the use of nuclear materials.<br>– to analyze projects of existing and future nuclear installations.<br>– to develop individual units and technological complexes of equipment of nuclear facilities, instruments and products used in the nuclear industry. |

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| | **Upon completion of the course, a graduate will have experience in:**<br>– oral presentation of information in a foreign language (English) on their professional topics, expounding outlining their position using information visualization tools (infographics, charts, etc.).<br>– speaking a foreign language to realize his professional activities.<br>– advanced methods and techniques for conducting experimental and theoretical research, analysis and presentation of the obtained scientific and technical results.<br>– computer modeling of components of research, industrial and nuclear power plants in stationary and non-stationary operating modes.<br>– developing models of nuclear reactor core and using benchmark calculations to verify.<br>– conducting research on the neutronic characteristics of breeding systems.<br>– organizing scientific and technical information for the design of new technologies for the use of nuclear materials.<br>– designing control systems and maintaining the fission chain reaction in various nuclear facilities.<br>– conducting computational research using specialized software tools for a wide profile of professional tasks. |
| **Course Outline** | The course consists of two sections.<br>**Section 1. Research Reactor Operation (22 hours)**<br>This section consists of 11 labs:<br>1. The study of structural and design solutions of the IRT-T reactor<br>2. Structures, functions and operating rules of the control system of the IRT-T reactor<br>3. Structures, functions and operating rules of the instrumentation and automation system of the IRT-T reactor<br>4. Procedure for preparing the IRT-T reactor for launch<br>5. Features of launching a nuclear reactor in manual mode<br>6. Features of launching a nuclear reactor in automatic mode<br>7. Measurement of the differential and integral characteristics of control rods by acceleration method<br>8. Measurement of the differential and integral characteristics of the control rods by compensation method<br>9. Measurement of technological parameters of the IRT-T reactor in various operating modes<br>10. Operating of the primary circuit coolant filtration system. Requirements for water coolant for research nuclear reactors<br>11. Measurement of coolant contamination by radionuclides<br>**Section 2. Methods of a scientific experiment using a nuclear reactor (10 hours)**<br>This section consists of 5 labs:<br>12. Study of the experimental facilities of the IRT-T reactor, preparation for physical experiments<br>13. Measurement of uniformity energy release and flux densities of reactor radiation over the core section<br>14. Research of neutron-transmutation doping technologies<br>15. Spectrometry of gamma and x-ray radiation |

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| | 16. Elemental analysis methods for the qualitative and quantitative analysis of irradiated samples<br>Within the framework of the course, students perform 16 labs using the equipment of the IRT-T research reactor. Reports on each of the labs should be submitted by students within the course study. Lab reports should be presented in paper and formatted according to the TPU guidelines. The number of pages for the report (except for the title page and the list of references) should be at least 5 and not more than 10. The maximum score for a lab report is 5. Scoring each lab report is performed according to the system of knowledge assessment.<br>Final assessment is performed orally using an exam paper. Each exam paper includes three questions or tasks. Preparation time is 20 minutes. The maximum score is 20 points; the minimum required score is 12. Total score is formed in accordance with three criteria:<br>– Knowledge of professional subject (0-4 scores),<br>– Logical and well-structured answers (0-6 scores),<br>– Correctness and completeness of answers (0-10 scores). |
| **Prerequisites (if available)** | 1. Dosimetry and Protection from Ionizing Radiation.<br>2. Control and Safety of Nuclear Reactor.<br>3. Reactor Physics.<br>4. Nuclear and Radiation Safety.<br>5. Reactor Kinetics and Control. |
| **Course Structure** | Within the framework of the course, students study the following sections:<br>*Section 1. Research Reactor Operation.*<br>Labs referring to this section are aimed at developing learners' practical skills on the following topics:<br>1. The main decisions in the design and construction of a research reactor<br>2. Formation of control and protection system and technological parameters control system and their features in the operation of a research reactor.<br>3. Ensuring safety during manual and automatic start-up.<br>4. Control of the main technological parameters during the research reactor operation.<br>*Section 2. Methods of a scientific experiment using a nuclear reactor.*<br>Labs referring to this section are aimed at developing learners' practical skills on the following topics:<br>1. Experimental methods for measuring the distribution and absolute values of the neutron flux density in the core and the experimental channels of a nuclear reactor.<br>2. Studying the technology of neutron-transmutation doping.<br>3. Fundamentals of work with a semiconductor gamma spectrometer.<br>4. Fundamentals of neutron activation analysis. |
| **Facilities and Equipment** | 1. IRT-T Research Nuclear Reactor.<br>2. Control and protection system on the basis of security modules "Mirage MB".<br>3. Instrumentation and control system.<br>4. Activation foils and wires detectors.<br>5. The complex of neutron-transmutation doping of silicon.<br>6. Gamma-spectrometer Canberra with germanium detector. |
| **Grading Policy** | In accordance with TPU rating system we use: |

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| | – 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 (lab completing, problem solving). Max score for current assessment is 100, min – 55.<br>The final score is determined by summing the scores of the current assessment during the semester and credit test scores at the end of the semester. Maximum overall score corresponds to 100, min pass score is 55. |
| **Course Policy** | Current assessment is performed in a form of lab reports defense. Lab reports must be presented in paper and formatted according to the TPU guidelines. The number of pages in the report (except for the title page and the list of references) should be at least 5 and not more than 10. The maximum score for a report is 5. The number of scores received by a student for each lab is determined according to the system of knowledge assessment.<br>Final assessment is carried out orally using exam paper. Each exam paper includes three questions or tasks. Preparation time is 20 minutes. The maximum score is 20 points; the minimum required score is 12. Total score is formed in accordance with three criteria:<br>– Knowledge of professional subject (0-4 scores),<br>– Logical and well-structured answers (0-6 scores),<br>– Correctness and completeness of answers (0-10 scores). |
| **Teaching Aids and Resources** | **Compulsory reading:**<br>1. Oka Y. Nuclear Reactor Design / Y. Oka. – Tokyo : Springer, 2014. – 327 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.<br>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.<br>3. Takigawa N. Fundamentals of Nuclear Physics / N. Takigawa K. Washiyama. — Tokyo : Springer, 2017. — 269 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-55378-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.<br>**Additional reading**:<br>1. Hoffelner W. Materials for Nuclear Plants. From Safe Design to Residual Life Assessments / W. Hoffelner. – New York : Springer, 2013. – 502 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-1-4471-2915-8 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ<br>2. Nuclear Thermal Hydraulics / H. Akimoto, Y. Anoda, T. Kazuyuki [and others] – Tokyo : Springer. 2016. – 464 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-55603-9 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. |

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