TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

Course Name: Turbine Installations

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

Semester, year: semester 2, year 1

ECTS: 3

Total Hours: 108

Contact Hours: 48

- **Lectures:** 32
- **Practical experience:** 16

Self-study: 60

Assessment: Credit-test

Division: Nuclear Fuel Cycle

Director of Programme _____________ / Vera V. Verkhoturova

Instructor _____________ / Ivan A. Ushakov

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Course name: Turbine Installations

Course Overview

Course Objectives	The objective of the course is to develop students' theoretical knowledge and practical skills, which are necessary to conduct professional activities involving application of principles and techniques of turbine installations operation.
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** – methods of systematic and critical analysis; – methods of developing action strategy to identify and solve problem situation; – features of professional etiquette of Western and domestic cultures; – the basics of structuring a report and preparing presentations in a foreign language, accepted by the international audience; – modern methods of research, evaluation and presentation of the results of performed work; – the basics of using specialized software to determine parameters of the working fluid during calculation of turbine installations of nuclear power plants; – methods of collection and analysis of the initial for calculation of the units of turbine installations of nuclear power plants; – methodology for conducting critical analysis of operation of existing turbine installations of nuclear power plants and its application for units design of turbine installations of nuclear power plants; – methodology for calculating and designing units of turbine installations of nuclear power plants. **Upon completion of the course, graduates are also expected to develop the following skills to:** – apply methods of systematic approach and critical analysis of problem situations; – develop action strategy, make specific decisions for its implementation; – compile and present technical and scientific information used in professional activities in the form of presentation; – perceive authentic audio and video materials related to training; – apply modern research methods, evaluate and present the results of performed work; – use specialized software to determine parameters of the working fluid during calculation of turbine installations of nuclear power plants; – collect and analyze initial data for calculation of the units of turbine installations of nuclear power plants; – conduct critical analysis of operation of existing turbine installations of nuclear power plants and apply it for units design of turbine installations of nuclear power plants; – calculate and design units of turbine installations of nuclear power plants. **Upon completion of the course, graduates should acquire the practical experience in**: – methodology of systematic and critical analysis of problem situations; – setting goals, determining how to achieve them, and developing action

	strategies; – monologue utterance in a foreign language according to the profile of the major, reasonably expounding their position and using auxiliary means (tables, graphs, charts, etc.); – foreign language at a sufficient level for future professional activities; – applying modern research methods, evaluating and presenting the results of performed work; – using specialized software to determine parameters of the working fluid during calculation of turbine installations of nuclear power plants; – collecting and analyzing initial data for calculation of the units of turbine installations of nuclear power plants; – conducting critical analysis of operation of existing turbine installations of nuclear power plants and its application for units design of turbine installations of nuclear power plants; – conducting calculations and designing units of turbine installations of nuclear power plants.
Course Outline	This course is devoted to give students knowledge related to the process of thermal energy conversion into electrical energy; composition, specificity, technological equipment and physical and chemical processes in turbine installations of nuclear power plants. The target course is taught using a variety of teaching forms such as: – 32 hours of lectures; – 16 hours of practical experience; – 7 individual homework assignments. The course consists of 4 modules, which are given below. Module 1. Steam turbine installations of NPP Module 2. Working fluid flow in turbine rings Module 3. Energy conversion in the turbine stage Module 4. Multi-stage turbines Each module includes several lectures and practical sessions. *Learners' self-study* is arranged in a form of preparation to the defense of individual homework assignments and to the tests. During the course of study, learners are expected to complete 7 individual homework assignments and two tests. *Individual homework assignment* is a set of tasks each containing unique set of 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. The following parameters are subject to evaluation: correctness of the assignment results (4-6 points depending on the complexity of IHS), completeness of the solution (2-3 points depending on the complexity of IHS) and correctness of answers to questions of oral face-to-face defense (4-6 points depending on complexity IHS). *Tests* are carried out in writing as part of the conference weeks and consist in writing detailed solution of the given problems. Each student has three problems. Two tests are planned during the course - one at each conference week. The following parameters are subject to evaluation: correctness of the solution of problems, completeness of the solution (10 points).

Course Structure	The course “Turbine Installations” includes 4 Modules comprising lectures, practical experiences. **Module 1. Steam turbine installations of NPP** Introduction. Thermodynamic cycles of steam turbine installations (STI). Absolute efficiency of the turbine installation and relative efficiency of the turbine. Methods to improve the cycle efficiency. Effect of initial parameters on the efficiency of an ideal cycle and turbine installation. Effect of the final pressure on the efficiency of STI. Steam reheating. Features of thermodynamic cycles of steam turbine installations at NPP. Separation and reheating of steam at NPP. Steam expansion in NPP turbines. Regenerative heating of feed water. Calculation of turbine installation efficiency. Combined generation of electrical energy and heat. Cycle arrangements of NPP turbine installations. **Module 2. Working fluid flow in turbine rings** Basic equations of motion of compressible fluid: states, continuity, momentum and conservation of energy. The concept of plane-parallel and spatial flow. Flow characteristics for gas expansion in channels. Stagnation parameters. Confluence and diffuser flow. Determination of the output velocity for gas expansion in a stationary channel. Critical parameters and critical speed. Critical flow rate. The change in the channel cross-section versus relative pressure. Expansion of gas in channels followed by available energy losses. Characteristics of real flows in rings of turbine profiles. **Module 3. Energy conversion in the turbine stage** Heat drop in stages, nozzle and working rings. Stage reactivity rate. Active and reactive stages. Absolute and relative flow rates in the stage and their measurement. Velocity diagrams. Energy conversion in working blades. Circular and axial flow force in blades. Stage power. Specific work. Loss of available energy in nozzles, working blades and output speed. Determination of the output relative flow rate in the rotating channel of the working rings. Relative efficiency in stage blades and determining factors. Speed ratio as a criterion of stage efficiency. Optimal speed ratio. Optimal available heat drop in the stage. The process of stage gas expansion in the hs-diagram. Relative internal efficiency of the turbine stage. **Module 4. Multi-stage turbines** Diagram of an active and reactive turbine. Heating process in a multi-stage steam turbine. Major advantages of multi-stage turbines. Use of output speed loss in stages. Reheat factor. Turbine end seals. Scheme of extraction and supply of steam in the seal. Types of end seals. Emergency power of a single-flow turbine and methods for obtaining the turbine's power exceeding that. Axial forces acting on the turbine rotor. Working blade erosion and techniques for its elimination.
Facilities and Equipment	Lecture hall with multimedia equipment: Tomsk, Lenin ave. 2/4, building 11, room 303.
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 (tests, tasks, problem solving). Max score for current assessment is 100 points, min – 55 points.
Course Policy	For successful completion, a student must attend all classroom activities and submit reports for all practical sessions or other associated tasks applicable to the course.
Teaching Aids and Resources	**Compulsory readings:** 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 (дата обращения: 20.09.2021). - Режим доступа : для авториз. пользователей. 2. Костюк, А. Г. Паровые и газовые турбины для электростанций : учебник для вузов / Костюк А. Г. - Москва : Издательский дом МЭИ, 2017. - ISBN 978-5-383-01157-7. - Текст : электронный // ЭБС "Консультант студента" : [сайт]. - URL : https://www.studentlibrary.ru/book/ISBN9785383011577.html (дата обращения: 20.09.2021). - Режим доступа : для авториз. пользователей. **Additional readings:** 1. Крайнов А В. Тепловые процессы в энергосистемах = Heat Processes in Energy Systems : учебное пособие / А. В. Крайнов, Г. В. Швалова. – Томск : Изд-во ТПУ, 2013. – URL : http://www.lib.tpu.ru/fulltext2/m/2013/m167.pdf (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. – Текст : электронный.
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