POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Thermal engineering [S2EJ1>TC]

Course

Field of study
Nuclear Power Engineering

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
30

Projects/seminars
0

Number of credit points

5,00

Coordinators

prof. dr hab. inż. Ewa Tuliszka-Sznitko
ewa.tuliszka-sznitko@put.poznan.pl

Lecturers

Prerequisites

Mathematics: the fundamentals of differential and integral calculus, solving simple ordinary differential equations. Requirements also include fundamentals of thermodynamics, heat transfer and fluid mechanics.

Course objective

The aim of the course is to expand the student's knowledge of thermodynamics, heat transfer and fluid mechanics so that he/she can solve simple thermodynamic/flow problems occurring in nuclear power plants.

Course-related learning outcomes

Knowledge:
1. The student knows and understands the basic quantities describing the thermodynamic and fluid mechanic processes. Knows computational methods and knows IT tools useful for analysing work results.
2. The student efficiently uses the first and second laws of thermodynamics and the equation of state to solve the discussed thermodynamic examples. The student describes and analyses the gas and steam processes of thermodynamic cycles. The student knows the thermodynamics of moist air and the

fundamentals of thermodynamics in the field of combustion.
3. The student has the knowledge needed to identify physical phenomena occurring in simple thermodynamic systems (open and closed). The student correctly describes the energy conversion methods occurring in these systems.
4. The student is able to balance the thermal devices of a power plant: boiler, pump, cooling system, heat exchangers.

Skills:
1. The student is able to use the acquired knowledge to calculate simple (model) thermal systems of nuclear power plants.
2. The student is able to formulate hypotheses regarding the investigated thermodynamic/flow problems.

Social competences:
1. The student understands the need for teamwork in solving theoretical and practical problems.
2. The student understands the need to systematically expand his/her knowledge and skills.
3. The student is aware of the need for social dialogue on matters related to the impact of nuclear energy on the environment.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The lecture is assessed on the basis of a written exam (90 minutes). Students answer 12 short questions. A list of all considered questions is provided during the last lecture. The exam result is determined during the oral part of the exam. Additionally, continuous assessment is performed in each class, activity and participation in discussions are rewarded. Blackboard classes are passed on the basis of the final test.
The laboratory part is assessed on the basis of reports.

Programme content

Lecture: Equations of conservation of mass, momentum, energy and engineering equivalents of these equations. Units, SI system. Basic thermodynamic/flow parameters: temperature, pressure, density and velocity. Open and closed systems. Heat and work, establishing signs. Water, steam, air, exhaust gases as thermodynamic fluids. Heat and work. Energy dissipation. The first and second laws of thermodynamics. Basic thermodynamic processes: isobar, isochore, isotherm, isentrope. Polytropic processes. Carnot engine and Brayton engine. The 1st and 2nd laws of thermodynamics in the area of wet steam. Rankine cycle and its optimization. Entropy/enthalpy diagram for water vapor, Maxwell's equations. Critical point and its importance for technology. Fundamentals of heat transfer: Fourier equation, thermal conductivity equation. Forced and free convections. Evaporation curve (boiling crises). Condensation. Thermodynamics of wet gases. Thermodynamics of combustion processes. Thermomechanics of a compressible medium, examples. Engineering applications of CFD in thermomechanics.
Blackboard classes: solving fluid flow examples using the 1st and 2nd laws of thermodynamics and the equations of state (an ideal and real gas models). Calculations of: model thermal cycles, selected examples of heat transfer, examples of the flows with losses.
Laboratory classes: analysis of selected examples (discussed during the blackboard classes) using standard educational computer software.

Course topics

The conservations equations of: mass, momentum and energy, the engineering equivalents of these equations. Mass flow rate, Bernoulli equation, flow momentum equation. The basic physical parameters used in thermomechanics, i.e. pressure, temperature, volume, mass, velocity, and their units. The examples of heat processes occurring in technology and nature. The ideal gas equation (individual gas constant, universal gas constant). Definition of work and the dissipation heat. The external reversible work and the technical reversible work. The state functions: internal energy and enthalpy. The first law of thermodynamics (closed and open system). The specific heat at constant pressure and specific heat at constant volume. The molar specific heat. The dependence of specific heat on temperature. Computational examples (the first law of thermodynamics and the ideal gas equation). The next state function: entropy.

The second law of thermodynamics, examples. Analysis of the basic thermodynamic processes: isobar, isochor, isotherm - examples with simple technical applications. The isentropic process. The polytropic process, polytropic heat, example (two-stage compressor with interstage cooling). The mixtures of ideal gases, constitutive equations (Dalton's law). Examples. The thermodynamic cycle equation, thermal efficiency of the cycle. Carnot cycle and Brayton-Joule cycle (with regeneration). The phase changes of water, the (s, h) diagram of wet and superheated steam. Rankine cycle - computational example. Cooling systems and their energy balance. The thermodynamics of humid air, basic parameters: absolute humidity, relative humidity, moisture content, dew point. The computational examples. Thermodynamics of the combustion process. The heat transport methods: conduction, convection and thermal radiation. Fourier's law, the thermal conductivity coefficient. The thermal conductivity equation. Newton's law, the heat transfer coefficient and its unit. Computational examples. The natural convection and forced convection. Similarity numbers: Reynolds, Prandtl, Nusselt, Grashof. The empirical dependencies on the Nusselt number - computational examples. The thermal radiation and its basic parameters. Stefan-Boltzmann law. Emissivity. The heat exchange by radiation between two infinitely long plates perpendicular to the ground. The heat exchange by radiation between real bodies.
Thermomechanics of a compressible medium, examples. Engineering applications of CFD in thermomechanics.
Laboratory classes: analysis of selected examples (discussed during the blackboard classes) using standard educational computer software.

Teaching methods

Lecture delivered remotely using synchronous access methods.
Lecture: multimedia presentation (with drawings and animations).
Blackboard classes: sample technical problems are solved on the board.
Laboratory classes: analysis of selected examples discussed during classes using educational computer software.

Bibliography

Basic:
1. Zohuri, B., McDaniel, P., Thermodynamics in Nuclear Power Plant Systems, Springer, 2019.
2. Badur, J. Pięć wykładów ze współczesnej termomechaniki płynów, IMP PAN Gdańsk, www.imp.gda.pl/struktura/O2/Z3/publications jako plik: pięćwykładów.pdf.
3. Tuliszka-Sznitko, E., Wybrane zagadnienia z mechaniki płynów wirujących, WPP, 2011.
4. Furmański, P., Domański, R., Wymiana ciepła, Przykłady obliczeń i zadania, Oficyna Wydawnicza Politechniki Warszawskiej, 2002.

Additional:
1.Cengel, Y., Boles, M.A., Thermodynamics, an engineering approach, Mc Graw Hill, 2008.
2. Incropera, F., DeWitt, D., Fundamentals of heat and mass transfer, Wiley, 2008.
3. Ghiaasiaan, M., Convective heat and mass transfer, Cambridge University Press, 2014.

Breakdown of average student's workload

	Hours	ECTS
Total workload	137	5,00
Classes requiring direct contact with the teacher	77	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,00