

(faculty stamp)

COURSE DESCRIPTION

Z1-PU7

Edition 1

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1. Course title: TECHNICAL THERMODYNAMICS		2. Course code		
3. Validity of course description: 2016/17				
4. Level of studies: BA, BSc programme / MA, MSc programme				
5. Mode of studies: <u>intramural studies</u> / extramural studies				
6. Field of study: POWER ENGINEERING		(FACULTY SYMBOL)RIE		
7. Profile of studies: general academic				
8. Programme: Power Engineering				
9. Semester: 3 and 4				
10. Department teaching the course: Institute of Thermal Technology				
11. Course instructor: Prof. Ryszard Bialecki				
12. Course classification: common directional subject				
13. Course status: <u>compulsory</u> /elective				
14. Language of instruction: English				
15. Pre-requisite qualifications: Mathematics, Physics, Mechanics, Fluid Mechanics, Basic Chemistry				
16. Course objectives: Teaching fundamentals of applied thermodynamics accompanied by skills of performing basic thermodynamical calculations				
17. Description of learning outcomes:				
Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	Calculation of thermodynamic properties of gases, vapors, humid gases, liquids and solids.	Exam, tests, lab reports	Lectures, recitations, labs	K-W12
2.	Setting up mass and energy balances of industrial processes.	Exam, tests	Lectures, recitations	K_W12, K_U12, K_U19
3.	Diagnostics of energy processes based on the Second Law	Exam	Lectures, recitations	K_W12, K_U11, K_U19
4.	Principles of thermodynamic cycles of heat engines, refrigerators and heat pumps.	Exam, tests, lab reports	Lectures, recitations, labs	K_W12, KU_19
5.	Mass and energy balances of chemical processes, with special stress on combustion	Exam, tests	Lectures, recitations	K_W12, K_U11
6.	Taking basic heat measurements	Lab reports	Labs	K_U1, K_U19
18. Teaching modes and hours				
45h Lecture / 60h recitations/ 15h labs				
19. Syllabus description:				
<u>Lecture</u>				
General conservation laws. Mass and energy balances. Thermodynamics – historical development and contemporary axiomatic structure.				
Basic dimensions and units, SI system, mass, mass rate, mass flux, pressure (absolute, gage, static, dynamic), work, heat, energy, power. Zeroth Law of Thermodynamics, temperatures, extensive and intensive properties, density, internal energy, enthalpy, entropy, mass and mole fractions.				
.....Zeroth Law of Thermodynamics, Thermal equation of states (ideal gas, real gas), mixtures of ideal gases				
First Law of Thermodynamics- conservation of energy. Notion of ideal and semi-ideal gases. Internal energy of ideal and semi-ideal gases. Mechanisms of energy transfer: work, heat, mass flow. Types of work: boundary (absolute) work, shaft (technical) work, useful work. Enthalpy of ideal and semi-ideal gases. Energy balance for closed and open systems. Rate form of energy balance. Steady state vs transient. Caloric equation of state (internal energy and enthalpy), reference values.				
.....Second Law and reversibility. Caloric equation for entropy. Principle of entropy increase. Entropy transfer by heat and mass. Second Law applied to heat engines, heat flow. Maximum efficiency of heat engines, refrigerators and heat pumps. Gouy Stodola law. Elementary irreversible processes. Removing				

irreversibilities, optimal level of irreversibility.

.... p-v and T-s diagrams. Characteristic gas processes: isobaric, isochoric, isothermal, polytropic, isentropic, irreversible adiabatic processes and their internal efficiency, throttling, Joule Thomson effect.

....Thermal equation of state of real gases examples (van der Waalse, Redlich Kwong, Benedict Webb Rubin), virial. Caloric equation of state of real gases, departure functions. Phase change,

Phase diagram, isobaric heating of water. Equation of state for water, properties of wet steam.

Humid air, thermal and caloric equation. Dew point. Foggy air. Isobaric processes of wet air. Enthalpy –humidity diagram. Isobaric heating and cooling, adiabatic mixing of two streams of humid air, humidifying of air, measuring the humidity: wet and dry bulb thermometers (psychrometers), hair, condensation and electronic hygrometers. Air conditioning.

....Combustion. Notation. Composition of fuels, composition of reactants. Combustion chemistry. Theoretical air, air excess ratio. Composition of products complete and total combustion. Dew point temperature of flue gases. Enthalpy of substances involved in chemical reactions: heat of formation, lower and upper heating values. Energy balances of chemical processes.

End of first semester.

Thermodynamic cycles. Clockwise and anticlockwise cycles. Carnot cycles, cycles with heat regeneration. Vapor Carnot cycles. Clausius Rankine cycle, fossil fuel and nuclear power station (PWR). Increasing the efficiency of CR cycle: lowering condenser pressure, superheating, increasing pressure (supercritical and ultra supercritical), reheating, heat regeneration, Cogeneration plants.

....Refrigeration and heating cycles. Reversed Carnot cycle. Gas refrigeration cycles without and with regeneration. Vapor refrigeration cycles, real vs ideal. Flash chamber multistage, household two pressures cycle, cascade. P-h diagram, absorption refrigeration cycle. Heating and refrigerating dual cycle.

Internal combustion engines. Brayton cycle of gas turbine and its efficiency, optimal and typical pressure ratios. Influence of irreversibility. Advantages and disadvantages. Main areas of application. Increasing efficiency: blade cooling, regeneration, multistep compression. Ericsson cycle. Otto and Diesel cycles, their efficiency advantages. Dual combustion system (Seilinger Sabathe)

Exergy: definition, exergy balance, exergy transfer by mechanical, boundary and shaft work, heat, stream of mass, exergy change of system, exergy drop. Application in diagnostics of heat processes, difference between energy, entropy and exergy balances, notion of exergy efficiency.

Recitations

Problem solving. The problems will illustrate the questions discussed at lectures. Skills of using software packages, diagrams and tables will be developed.

Labs

Experimental determination of isobaric specific heat, humidity, efficiency of refrigeration cycle, saturation curve, density of gas, heating value.

20. Examination: Yes

21. Primary literature sources:

1. Ryszard Bialecki – presentations, lecture notes
2. Wojciech Adamczyk – selection of problems in thermodynamics
3. Yunus A. Cengel , Michael A. Boles **Thermodynamics An Engineering Approach, McGraw Hill 2016**
- 4.

22. Secondary sources:

1. Claus Borgnakke, Richard E. Sonntag, Gordon J. Van Wylen, **Fundamentals of Thermodynamics 7th International student edition**
2. Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, **Fundamentals of Engineering Thermodynamics 28th ed. 017 ,**

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	45/45
2	Classes	60/120
3	Laboratory	15/15
4	Project	/
5	BA/ MA Seminar	/
6	Other	15/15
	Total number of hours	135/195

24. Total hours: 330

25. Number of ECTS credits: 11

26. Number of ECTS credits allocated for contact hours: 5

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 1

26. Comments:

(date, Instructor's signature)

13.09.2016

(date, the Director of the Faculty Unit signature)



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