| Z1-PU7 | Edition 1 | Page 1 of 3 |
|---|---|---|

(*faculty stamp*) **COURSE DESCRIPTION**

| | |
|---|---|
| **1. Course title: TECHNICAL THERMODYNAMICS** | **2. Course code** |
| **3. Validity of course description:** 2018/19 | |
| **4. Level of studies:** BA, BSc programme / MA, MSc programme | |
| **5. Mode of studies: intramural studies** / 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 Białecki | |
| **12. Course classification:** common directional subject | |
| **13. Course status: compulsory** /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 mas 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 (30h lectures first semester, 15h second semester, 30h recitations both semesters, 15h lab second semester). ECTS- first semester 6 second semester 5

**19. Syllabus description:**

Lecture

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 Waals, 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.

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.

….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.**

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.

….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 Białecki – 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**

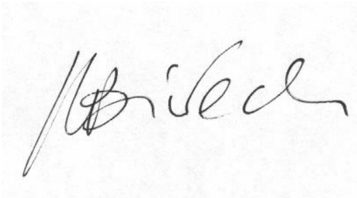
| Lp. | Teaching mode : | Contact hours / Student workload hours |
|---|---|---|
| 1 | Lecture | 45/45 |
| 2 | Classes | 60/120 |
| 3 | Laboratory | 15/15 |
| 4 | Project | / |
| 5 | BA/ MA Seminar | / |
| 6 | Other | 15/15 |
| | Total number of hours | 135/195 |

**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:** |



30.09.2018 …
*(date, Instructor's signature)*

(*date , the Director of the Faculty Unit signature)*