| course title: **THERMODYNAMIC CYCLES** **Termodynamika obiegów cieplnych** | | |
|---|---|---|
| field of study: **Mechanical Engineering** | type of studies: **regular** | course code: **S4_5** |
| specialization: **Energy engineering** | level: **MSc** | year: **I** semester: **I** |
| types of classes: **lecture, laboratory, tutorials** | hours/week: **3Lec$^{E}$, 1Lab, 2T** | No of ECTS credits: **5** |

# COURSE DESCRIPTION

## COURSE TARGETS

C1. Providing the knowledge on thermodynamic cycles, thermal systems efficiency and methods of its improvement.

C2. Learning the skills to evaluate thermodynamic efficiency of thermal cycles and systems.

## ENTRY REQUIREMENTS IN TERMS OF KNOWLEDGE, CAPABILITIES AND COMPETENCES

1. Fundamentals of mechanics, physics and thermodynamics.
2. Application of mathematical tools to solve thermal problems.
3. Capability of using source literature.
4. Capability of individual work and collaboration in a group.
5. Data analysis and interpretation, presentation of results.

## EFFECTS OF TEACHING

EK1. Theoretical knowledge on thermodynamics of thermal cycles and thermal systems.

EK2. Knowledge on evaluation of thermal efficiency of thermal cycles and thermal systems.

EK3. Knowledge on new trends and solutions in thermodynamic analysis of thermal cycles and systems.

EK4. Knowledge on the methods of thermal efficiency improvement for different types of thermal cycles.

**COURSE CONTENT**

| **LECTURE** | **hours** |
|---|---|
| **W 1 –** Introduction into thermodynamics of displacement machines. | **3** |
| **W 2 –** Ideal engine operating cycles. Fundamentals. | **2** |
| **W 3 –** Engine operating cycles with supercharging/turbocharging. | **2** |
| **W 4 –** Overexpanded cycle. Geometric and thermodynamic compression ratio. | **2** |
| **W 5 –** Simplified thermodynamic cycle analysis of SI and CI engine. | **2** |
| **W 6 –** Analysis of p-v diagram. | **2** |
| **W 7 –** Analysis of heat released during combustion. | **2** |
| | |
| **W 8** - Fundamentals of thermal cycles modelling. Examples of conventional power plant cycle models. | **2** |
| **W 9 -** Introduction to IPSEpro software. Structure and extensions. | **2** |
| **W 10 -** Fundamental IPSEpro library for modelling power plant cycles. Examples of use of various modules. | **2** |
| **W11 -** Modelling simple thermal cycles. Methodology of model creation. | **2** |
| **W12 -** Modelling complex thermal cycles. Example of power plant with inter-stage steam reheat and feed water heating with extraction steam. | **3** |
| **W13 -** Introduction to Model Development Kit (MDK). Creation of own cycle components.. | **2** |
| **W14 -** Examples of calculation of complex thermal cycles with the use of modified library components. | **2** |
| | |
| **W 15** – Ideal gas processes - isothermal, isobaric, isochoric, isentropic, politropic, irreversible adiabatic, diffusion. Thermodynamic cycle. Second law of thermodynamics, Carnot cycle, mathematical description of the second law of thermodynamics, exergy. | **3** |
| **W 16** –Phase change of homogeneous substances, state of agregation. Isobaric process of evaporate of water, specific volume of saturated vapour and superheated steam, thermodynamic equations of state and characteristic conversions of saturated vapour and superheated steam. | **4** |
| **W 17** – Basic thermal cycle of power station. Technological processes of power stations with condensing turbine, back-pressure and extraction turbine. Thermal schemes, balances of mass and energy, efficiency of Clausius-Rankine power station , basics parameters of power stations. | **6** |
| **W18** – Power plant for supercritical parameters. | **2** |
| **TUTORIALS** | **hours** |
| **C 1 –** Calculation of ideal operating cycle of a freely aspirated reciprocating engine | **3** |
| **C 2 –** Calculation of ideal operating cycle of a boosted engine | **4** |
| **C 3 –** Heat release rate computation on basis of p-v diagram | **4** |
| **C 4 –** Modeling process of heat released in a reciprocating engine | **4** |
| **C 5 –** Superheated steam and saturated vapour, steam diagrams: T-s and i-s. | **6** |
| **C 6 –** Basic thermal cycles of power station with condensing turbine, back-pressure and extraction turbine. Thermal schemes, balance of energy and mass efficiency of power stations. | **6** |
| **C 7 –**Supercritical power station. | **3** |
| **LABORATORY** | **hours** |
| **L1 -** Application of IPSEpro environment to model and simulate thermodynamic systems. | **2** |
| **L2 -** Modelling and simulation of simple thermal cycles. | **2** |

| | |
|---|---|
| **L3 -** Modelling and simulation of power plant cycles. | **4** |
| **L4 -** Optimisation of thermal cycle parameters. | **2** |
| **L5 -** Application of Model Development Kit (MDK) to create own cycle modules. | **2** |
| **L6 -** Modification of existing modules of IPSEpro library, their application to model complex thermal cycles. | **3** |

**TEACHING TOOLS**

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|---|
| 1. Lecture with the use of multimedia presentations |
| 2. Tutorial teaching aids |
| 3. Books and textbooks, lecturing handouts |
| 5. Instructions to laboratory exercises |
| 6. Computer laboratory, software for thermal systems simulation |

**STUDENT LOADING**

| **activity** | **hours** |
|---|---|
| contact hours with teachers | 45Lec + 30Tut + + 15Lab → 90h |
| preparation to tutorials | 15 h |
| preparation to lab exercises | 15 h |
| writing reports on labs | 15 h |
| preparation to assessment | 15 h |
| **Sum** | ∑ **150 h** |

**SOURCE LITERATURE**


| |
|---|
| 1. Holman J.P.: Thermodynamics. McGraw-Hill, 1988 |
| 2. Heywood J.B.: Internal Combustion Engines Fundamentals, McGraw-Hill, 1988. |
| 3. Kowalewicz A.: Doładowanie silników spalinowych, Wyd. Politechniki Radomskiej, 2002. |
| 4. Laudyn D, Pawlik M., Strzelczyk F.: Elektrownie. WNT, Warszawa 2000. |
| 5. Merkisz J.: Ekologiczne problemy silników spalinowych, Wyd. Politechniki Poznańskiej, 1999. |
| 6. Mysłowski J.: Doładowanie silników, WKŁ, 2002. |
| 7. Pastucha L., Mielczarek E.: Podstawy termodynamiki technicznej. Wyd. Politechniki Częstochowskiej, Częstochowa 1998. |
| 8. Rychter T., Teodorczyk A.: Teoria silników tłokowych, WKŁ, 2006. |
| 9. Stone R.: Introduction to Internal Combustion Engines, Macmillan Press, 2002. |
| 10.Szargut J.: Termodynamika. PWN, Warszawa 2000. |
| 11.Szargut J.: Termodynamika techniczna. Wyd. Politechniki Śląskiej, Gliwice 2005. |


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