SYLLABUS OF A MODULE

Polish name of a module	**Podstawy spalania**
English name of a module	**Combustion**
ISCED classification - Code	0715
ISCED classification - Field of study	*Mechanics and metal trades*
Languages of instruction	*English*
Level of qualification:	*2 – MSc (EQF 7)*
Number of ECTS credit points	*5*
Examination:	*EW – exam written*

Number of hours per semester:

Lecture	Exercises	Laboratory	Seminar	E-learning	Project
30	30	0	0	0	0

MODULE DESCRIPTION

MODULE OBJECTIVES

O1. Students know theory of combustion fundamentals.

O2. Students acquire skills in combustion issues calculations.

PRELIMINARY REQUIREMENTS FOR KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of mathematics and thermodynamics.
2. Fundamentals of thermal machinery principles.
3. Capability of using source literature.
4. Data analysis and presentation of results.

LEARNING OUTCOMES

LO 1 – The student possesses knowledge on combustion

LO 2 – The student possesses knowledge on fundamentals of construction and operation of thermal machinery

LO 3 – The student has ability to determine basic parameters in various combustion processes.

MODULE CONTENT

Type of classes – LECTURE	**Number of hours**
Lec 1 – Fundamental laws in thermodynamics and combustion science.	1
Lec 2-3 – Combustion definition. Premixed and diffusion combustion. Deflagration and detonation. Global reaction of combustion. Stoichiometry. Flammability limits. Enthalpy. UHV, LHV. Fuel specifications.	2
Lec 4-5 – Thermochemistry. Energy conservation law. Combustion at constant pressure and constant volume. Adiabatic flame temperature. Reactants and products. Chemical equilibrium. Dissociation. Gibbs function. Equilibrium constant.	2
Lec 6 – Introduction to collision theory. Elementary reactions and rates.	1
Lec 7-8 – Combustion mechanism. types of elementary reactions. Time scales.	2
Lec 9-10 – Selected combustion mechanisms: H_2-O_2, CO-O_2, methane, NO_x formation.	2
Lec 11-13 – Laminar premixed combustion. Description. Simplified analysis. Flame analysis in the Bunsen burner. Flame thickness. Laminar flame speed. Combustion in the spark ignited engine.	3
L 14 – Ignition. Theory and models by Semenov and Frank-Kamenetski.	1
L 15-16 – Laminar diffusion combustion. Flame length. Soot formation.	2
Lec 17 – Introduction to turbulent combustion.	1
Lec 18-19 – Combustion of liquid fuels. Simplified model of droplet evaporation and combustion. Combustion in the compression ignition engine.	2
Lec 20-21 – Solid fuel combustion. Models of carbon particle combustion. Examples. Coal burner description.	2
Lec 22-23 – Detonation combustion. Rankine-Hugoniot curve. Structure of detonation wave. Detonation speed.	2
Lec 24 – Measurements in combustion.	1
Lec 25-26– Toxic products of combustion. Regulations and limits for toxic emissions.	2
Lec 27-28 – Methods for toxic substances removal. Pretreatment and after treatment. 3-way catalytic converter. SCR and NSCR. PM traps.	2
Lec 29-30 – Trends in clean combustion technologies.	2
Suma	30
Type of classes – TUTORIAL	**Number of hours**
TUT 1-4 – Calculations of combustion process of gaseous, liquid and solid fuels. Reaction rate. Mole and mass fractions. Air-to-fuel stoichiometric ratio. Equivalence ratio.	**4**
Tut 5-8 – Calculations of enthalpy of reaction, heat of combustion, lower heating value (LHV) and higher heating value (HHV) of fuels.	**4**
Tut 9-10 – Thermodynamic equilibrium with species dissociation.	**2**
Tut 11-14 – Calculations of adiabatic flame temperature at C_P and C_V.	**4**
Tut 15-18 – Calculations of volumetric composition of the wet and dry flue gases.	**4**
Tut 19-22 – Determination of energy losses and boiler efficiency. Energy and exergy balance.	**4**
Tut 23 -26 – Solid particle combustion – one film model.	**4**
Tut 27-28 – Calculations of laminar flame speed.	**2**
Tut 29-30 – Calculation of detonation flame velocity.	**2**
Suma	**30**

TEACHING TOOLS

1. – Lecture with the use of multimedia presentations
2. – Tutorials of combustion calculation
3. – Instructions to classes
4. – Own codes and commercial software

WAYS OF ASSESSMENT (F – FORMATIVE, S – SUMMATIVE)

F1. - assessment of the ability to apply the acquired knowledge while doing the exercises
F2. - evaluation of reports on the implementation of exercises covered by the curriculum
F3. - assessment of activity during classes
S1. - assessment of the ability to solve the problems posed and the manner of presentation obtained results - pass mark *
S2. - assessment of mastery of the teaching material being the subject of the lecture - exam

*) in order to receive a credit for the module, the student is obliged to attain a passing grade in all classes as well as in achievement tests.

STUDENT'S WORKLOAD

L.p.	Forms of activity	Average number of hours required for realization of activity
1. Contact hours with teacher		
1.1	Lectures	30
1.2	Tutorials	30
1.3	Laboratory	0
1.4	Seminar	0
1.5	Project	0
1.6	Consulting teacher during their duty hours	5
1.7	Examination	3
	Total number of contact hours with teacher:	68
2. Student's individual work		
2.1	Preparation for tutorials and tests	17
2.2	Preparation for laboratory exercises, writing reports on laboratories	0
2.3	Preparation of project	0
2.4	Preparation for final lecture assessment	0
2.5	Preparation for examination	20
2.6	Individual study of literature	20
	Total number of hours of student's individual work:	57
	Overall student's workload:	125
Overall number of ECTS credits for the module		5 ECTS
Number of ECTS points that student receives in classes requiring teacher's supervision:		2.72 ECTS
Number of **ECTS** credits acquired during practical classes including laboratory exercises and projects:		1.20 ECTS

BASIC AND SUPPLEMENTARY RESOURCE MATERIALS

1. Cengel Y, Boles M, Thermodynamics: An Engineering Approach, McGraw-Hill Education; 8 edition, 2014
2. Moran JN, Shapiro HN, Principles of Engineering Thermodynamics, John Wiley & Sons Inc, 2015
3. Mayhew Y, Rogers GFC, Mayhew YR, Engineering Thermodynamics : Work and Heat Transfer, Longman, Pearson Education Limited, 1996
4. Borman GL, Ragland K.M.: Combustion Engineering, McGraw Hill, 1998
5. Drysdale D, An introduction to fire dynamics, New York, Wiley&Son 1990
6. Glassman I, Yetter R.A.: Combustion, Academic Press, 2008
7. Turns S, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2000
8. Warnatz J, Maas U, Dibble RW, Combustion: Physical and chemical fundamentals, modeling and simulation, experiments, pollutant formation, Springer 2001

MODULE COORDINATOR (NAME, SURNAME, E-MAIL ADDRESS)

Stanislaw Szwaja, Associate Professor, CzUT, Department of Thermal Machinery, szwaja@imc.pcz.pl