module title: **COMBUSTION**		
field of study: **Mechanical Engineering**	type of study: **full-time**	course code: **S6_1-4**
course: **Modelling & Simulation in Mechanics**	degree: **Master (MSc)**	year: **I** semester: **II**
type of classes: **lecture, classes, EXAM**	hours per week: **2L, 2C**	No of ECTS credits: **5**

MODULE DESCRIPTION

TARGETS

T1. Provide theory of combustion fundamentals.
T2. Acquire skills in combustion calculations.

PREREQUISITES & ADDITIONAL REQUIREMENTS

1. Fundamentals of chemistry, mathematics and thermodynamics.
2. Fundamentals of thermal machinery principles.
3. Capability of using source literature.
4. Capability of individual work and collaboration in a group.
5. Data analysis and presentation of results.

LEARNING OUTCOMES

LO1. Knowledge on combustion thermodynamics and kinetics.
LO2. Knowledge on fundamentals of construction and operation of thermal machinery.
LO3. Knowledge on trends in combustion technologies.
LO4. Ability to determine basic parameters in various combustion processes.
LO5. Knowledge on technologies for toxicity removal from exhaust gases.

TEACHERS

module coordinator: dr Stanisław Szwaja, assoc. prof. - szwaja@imc.pcz.czest.pl
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- dr Stanisław Szwaja, assoc. prof. - szwaja@imc.pcz.czest.pl
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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

MODULE CONTENT

LECTURES	hours
L 1 – Fundamental laws in thermodynamics and combustion science.	**1**
L 2,3 – Combustion definition. Premixed and diffusion combustion. Deflagration and detonation. Global reaction of combustion. Stoichiometry. Flammability limits. Enthalpy. UHV, LHV. Fuel specifications.	**2**
L 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**
L 6 – Introduction to collision theory. Elementary reactions and rates.	**1**
L 7,8 – Combustion mechanism. types of elementary reactions. Time scales.	**2**
L 9,10 – Selected combustion mechanisms: H_2-O_2, CO-O_2, methane, NO_x formation.	**2**
L 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**
L 17 – Introduction to turbulent combustion.	**1**
L 18,19 – Combustion of liquid fuels. Simplified model of droplet evaporation and combustion. Combustion in the compression ignition engine.	**2**
L 20,21 – Solid fuel combustion. Models of carbon particle combustion. Examples. Coal burner description.	**2**
L 22,23 – Detonation combustion. Rankine-Hugoniot curve. Structure of detonation wave. Detonation speed.	**2**
L 24 – Measurements in combustion.	**1**
L 25,26– Toxic products of combustion. Regulations and limits for toxic emissions.	**2**
L 27,28 – Methods for toxic substances removal. Pretreatment and aftertreatment. 3-way catalytic converter. SCR and NSCR. PM traps.	**2**
L 29,30 – Trends in clean combustion technologies.	**2**

CLASSES	hours
C 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**
C 5-8 – Calculations of enthalpy of reaction, heat of combustion, lower heating value (LHV) and higher heating value (HHV) of fuels.	**4**
C 9-10 – Thermodynamic equilibrium with species dissociation.	**2**
C 11-14 – Calculations of adiabatic flame temperature at C_P and C_V.	**4**
C 15-18 – Calculations of volumetric composition of the wet and dry flue gases.	**4**
C 19-22 – Determination of energy losses and boiler efficiency. Energy and exergy balance.	**4**
C 23 -26 – Solid particle combustion – one film model.	**4**
C 27-28 – Calculations of laminar flame speed.	**2**
C 29-30 – Calculation of detonation flame velocity.	**2**

REFERENCES

1. Borman G.L., Ragland K.M.: Combustion Engineering, McGraw Hill, 1998
2. Drysdale D.: An introduction to fire dynamics, New York, Wiley & Sons, 1990
3. Glassman I., Yetter R.A.: Combustion, Academic Press, 2008
4. Kuo K.K.: Principles of Combustion, Wiley & Sons, 2005
5. Turns S.: An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2000
6. Warnatz J., Maas U., Dibble R.W.: Combustion: Physical and chemical fundamentals, modeling and simulation, experiments, pollutant formation, Springer, 2001