Fuel cells and hydrogen production

Faculty of	**Mechanical and Power Engineering**
Name in English	**Fuel cells and hydrogen production**
Name in Polish	**Ogniwa paliwowe i produkcja wodoru**
Main field of study	**Power Engineering**
Specialization	**-**
Level of studies	**II level**
Form of studies	**full-time**
Kind of subject	**optional-specialization**
Subject code	**W09ENG-SM2353**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		25		
Form of crediting	Zaliczenie		Zaliczenie		
For group of courses mark final course with (X)					
Number of ECTS points	2		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BU) classes	1,28		0,76		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.	Knowledge and skills in chemistry, elekctrochemistry, physics, thermodynamics.

SUBJECT OBJECTIVES

C1	Introduction to the principle of fuel cell operation - the basics of electrochemistry .
C2	To become familiar with the classification and general characteristics of fuel cells and to design solutions, general construction and operation of fuel cells and to familiarize with the purpose of different types of fuel cells.
C3	Acquaintance with current hydrogen production and storage technologies and hydrogen characteristics.
C4	Acquainting with development directions of fuel cells in transport application and with energy production systems integrated with fuel cells.
C5	Developing skills to determine fuel cell efficiency and hydrogen production by electrolysis.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	The general classification of fuel cells and their purpose.
PEU_W02	Explanation of the operation of the PEM hydrogen cell.
PEU_W03	Explanation of the operation of other kinds of fuel cells, define the basic parameters characterizing their work.
PEU_W04	Knowledge of the application of fuel cells.
PEU_W05	Characterization and description hydrogen production and storage technologies.

relating to skills:	
PEU_U01	Perform basic measurements of current, voltage and power of fuel cells and electrolyzers.
PEU_U02	Use known measurement techniques to calculate cell efficiency and hydrogen production efficiency.
relating to social competences:	
PEU_K01	

PROGRAMME CONTENT

Form of classes - lecture		Number of hours
Wy1	Hydrogen as an energy carrier. Review of current hydrogen applications, assessment of its physical and chemical properties. Safety rules for working with hydrogen.	2
Wy2	Hydrogen production methods - discussion of the main methods used on an industrial scale from raw natural fuels.	2
Wy3	Biological production of hydrogen, photosynthesis ,hydrogen production by digestion processes.	2
Wy4	Hydrogen storage - technology review.	2
Wy5	Hydrogen Fuel Cells – Basic principles. History of fuel cell formation.	2
Wy6	Basics of electrochemistry. Redox reactions and their role in the processes taking place in electrolysers and fuel cells.	2
Wy7	Galvanic cells and batteries. Comparison of primary and secondary cells.	2
Wy8	Classification of fuel cells.	2
Wy9	Proton Exchange Membrane and Direct Methanol Fuel Cell- as low temperature kind of fuel cells.	2
Wy10	Alkaline Fuel Cells, Phosphoric Acid Fuel Cells.	2
Wy11	Less known fuel cells: Direct Carbon Fuel Cells, Phosforic Acid Fuel Cells.	2
Wy12	High temperature fuel cells:Molten Carbonate Fuel Cells, Solid Oxide Fuel Cell.	2
Wy13	Application of fuel cells for automotive, robotics and power engineering.	2
Wy14	Fuel Cell Systems Analyzed.	2
Wy15	Colloquium.	2
Suma godzin		30

laboratory		Number of hours
La1	Organizational classes - form of assessment, safety rules in the laboratory.	1
La2	Electrolysis of aqueous alkaline and salt solutions.	4
La3	Hydrogen production in the PEM electrolysis process (with proton exchange membrane).	3
La4	Fuel cell system performance testing.	3
La5	Determination of the efficiency of a methanol cell.	2
La6	Determination of the efficiency of hydrogen production in a system powered by renewable energy, with a fuel cell.	2
Suma godzin		15

TEACHING TOOLS USED	
N1	Lecture: - traditional lecture using multimedia presentation. - own work - independent studies and preparation for the exam.
N2	Exercises at research positions; - short written tests; - own work - preparation for laboratory exercises and test reports.
N3	Consultations.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F– forming (during semester), C– concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01-PEU_W05	Colloquium.
F2	PEU_U01-PEU_U02	Average of grades from reports and tests.

PRIMARY AND SECONDARY LITERATURE

Primary literature	
1	C. Spiegel, "Designing and Building Fuel Cells", McGraw-Hill, 2007
2	S.A. Sherif , D. Yogi Goswami , Elias K. Stefanakos , Aldo Steinfeld, Handbook of Hydrogen Energy,2014
Secondary literaturę	
1	M. A. Energii, "The future of hydrogen", 2019
2	"The Hydrogen Economy: A Non-Technical Review", United Nations Environment Program E, 2006.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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