Załącznik nr 6 do ZW 121/2020

FACULTY OF MECHANICAL AND POWER ENGINEERING

SUBJECT CARD

Name of subject in Polish:	Ogniwa paliwowe i produkcja wodoru
Name of subject in English:	Fuel cells and hydrogen production
Main field of study (if applicable):	Energetyka
Specialization (if applicable):	Renewable Sources of Energy
Profile:	academic
Level and form of studies:	2nd level, full-time
Kind of subject:	optional/specialization
Subject code:	W09ENG-SM0042
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)	60		30		
Form of crediting	exam		crediting with grade		
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		0.75		

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Knowledge and skills in thermodynamics, physics, chemistry.

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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 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 - list the general classification of fuel cells and their purpose,
PEU_W02 - explain the operation of the PEM hydrogen cell
PEU_W03 - explain the operation of basic methanol and alkaline cell assemblies, define the basic parameters characterizing their work,
PEU_W04 - characterize the structure and operation of a ceramic cell and their application in power plant systems,
PEU_W05 - characterize and describe hydrogen production technologies,

PEU_W06 - list hydrogen storage techniques.
Relating to skills:
PEU_U01 - perform basic measurements of current, voltage and power of fuel cells,
PEU_U02 - use known measurement techniques to calculate cell efficiency and hydrogen production efficiency

PROGRAM CONTENT

	Lectures	**Number of hours**
Lec1	Hydrogen as an energy carrier. Review of current hydrogen applications, assessment of its physical and chemical properties. Safety rules for working with hydrogen.	2
Lec 2	Hydrogen production methods - discussion of the main methods used on an industrial scale from raw natural fuels.	2
Lec 3	Biological production of hydrogen- photosynthesis ,hydrogen production by digestion processes.	2
Lec 4	Hydrogen storage - technology review.	2
Lec 5	Hydrogen Fuel Cells – Basic principles. History of fuel cell formation.	2
Lec 6	Basics of electrochemistry. Redox reactions and their role in the processes taking place in electrolysers and fuel cells.	2
Lec 7	Thermodynamics of fuel cells.	1
Lec 8	Galvanic cells and batteries. Comparison of primary and secondary cells.	2
Lec 9	Fuel Cell Types.	2
Lec 10	Proton Exchange Membrane Fuel Cells.	2
Lec 11	Alkaline Electrolyte Fuel Cells.	1
Lec 12	Direct Methanol Fuel Cells .	1
Lec 13	Direct Carbon Fuel Cells.	1
Lec 14	Molten Carbonate Fuel Cells.	1
Lec 15	Phosforic Acid Fuel Cells.	1
Lec 16	The Solid Oxide Fuel Cell .	1
Lec 17	Microbial Fuel Cells, Direct Formid Acid Fuel Cells.	1
Lec 18	Application of fuel cells for automotive, robotics and power engineering	2
Lec 19	Fuel Cell Systems Analyzed	2
	Total	30

	Laboratory	**Number of hours**
Lab1	Organizational classes- form of assessment, safety rules in the laboratory.	1
Lab 2	Electrolysis of aqueous alkaline solutions - Hoffman apparatus.	2
Lab3	Hydrogen production in the PEM electrolysis process (with proton exchange membrane).	2
Lab4	Gasification of solid fuel - to assess the degree of fuel conversion to hydrogen.	2
Lab5	NEXA 1.2 kW PEM cell performance testing-, depending on the parameters of the hydrogen inlet.	2

Lab6	The test of PEM fuel cell- NEXA depending on the stream of hydrogen and oxygen at the inlet .	2
Lab7	Examination of the hydrogen storage capacity with metal hydrides.	2
Lab8	Calculations regarding the determination of the amount of hydrogen produced and the costs of its production.	2
	Total	15

TEACHING TOOLS USED

N1. Lecture:
- traditional lecture using multimedia presentation.
- own work - independent studies and preparation for the exam

N2. Laboratory:
- exercises at research positions;
- short written tests;
- own work - preparation for laboratory exercises and test reports.

N3. Consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes numer	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01÷PEU_W06	Written exam
P (laboratory)	PEU_U01÷PEU_U06	Average of grades from reports and tests.

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] S.Shiva KumarV.Himabindu, “Hydrogen production by PEM water electrolysis – A review,Materials Science for Energy Technologies Vol. 2, Issue 3, December 2019, Pages 442-454.

[2] Arshad, Adeel; Ali, Hafiz Muhammad; Habib, Arslan; Bashir, Muhammad Anser; Jabbal, Mark; Yan, Yuying,” Energy and exergy analysis of fuel cells: a review”, Thermal Science and Engineering Progress, Mar 30, 2019, Vol.9, 308-321.

[3] Ryan P. O'Hayre, Whitney Colella, Friedrich B. Prinz, Suk Won Cha, “Fuel cells fundamentals”, 2005.

SECONDARY LITERATURE:

[1] Barbir F., Yazici S. "Status and development of PEM fuel cell technology", 2008, Int. J. Energy Res., 32:369-378

[2] Nexa - Training System Instruction Manual Heliocentris Energiesysteme GmbH 2008

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

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