AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Fuel cells

Academic year: 2013/2014 Code: STC-2-209-CF-s ECTS credits: 3

Faculty of: Energy and Fuels

Field of study: Chemical Technology Specialty: Clean Fossil and Alternative Fuels Energy

Study level: Second-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 2

Course homepage: —

Responsible teacher: prof. nadzw. dr hab. inż. Dudek Magdalena (potoczek@agh.edu.pl)

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Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Skills			
M_U001	Student can assemble fuel cell from elements, operates the fuel cell and stack of fuel cells, as well as measure its basic parameters (e.g. the maximum power, electrical efficiency)	TC2A_U07, TC2A_U09	Report
Knowledge			
M_W001	Student can explain the ionic conductivity, types of electrolytes and electrode processes	TC2A_W03, TC2A_W01	Oral answer, Participation in a discussion
M_W002	Student exolains principles of operation of main electrochemical devices: electrolyzers, sensors and galvanic cells and their applications in practice	TC2A_W04, TC2A_W01, TC2A_W08	Oral answer, Report, Participation in a discussion
M_W003	Student distinguishes between primary cell, rechargeable battery, flow battery and fuel cell and how they are employed in energy applications.	TC2A_W04, TC2A_W17, TC2A_W01, TC2A_W08	Oral answer, Participation in a discussion

M_W004	Students explains characterizes main types of fuel cells and their characteristics.	TC2A_W04, TC2A_W10, TC2A_W08	Oral answer, Report, Participation in a discussion
M_W005	Studentcan discuss the importance of new approach to energy problems, in particular where effectiveness of conversion and environment protection is concerned. She/he can explain fundamental laws of hydrogen economy.	TC2A_W04, TC2A_W07, TC2A_W14	Oral answer, Participation in a discussion

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Others	Fieldwork classes	Workshops	E-learning
Skills												
M_U001	Student can assemble fuel cell from elements, operates the fuel cell and stack of fuel cells, as well as measure its basic parameters (e.g. the maximum power, electrical efficiency)	-	-	+	-	-	-	-	-	-	-	-
Knowledge												
M_W001	Student can explain the ionic conductivity, types of electrolytes and electrode processes	+	-	-	-	-	-	-	-	-	-	-
M_W002	Student exolains principles of operation of main electrochemical devices: electrolyzers, sensors and galvanic cells and their applications in practice	+	-	+	-	-	-	-	-	-	-	-
M_W003	Student distinguishes between primary cell, rechargeable battery, flow battery and fuel cell and how they are employed in energy applications.	+	-	-	-	-	-	-	-	-	-	-
M_W004	Students explains characterizes main types of fuel cells and their characteristics.	+	-	+	-	-	-	-	-	-	-	-

M_W005	Studentcan discuss the importance of new approach to energy problems, in particular where effectiveness of conversion and environment protection is concerned. She/he can explain fundamental laws of hydrogen economy.	+	-	-	-	-	-	-	-	-	-	-

Module content

Lectures

1.Mechanism of ionic conductivity in liquid and solid electrolytes (aqueous , molten salts, polymer and ceramic). Characteristic parameters of ionic conductors.
2.Electrolysis. Faraday law. Electrochemical water splitting. Practical application of electrolysis in industry.
3.Thermodynamics and kinetics of galvanic cell: reversible voltage of the cell (Nernst equation); activation, concentration and ohmic polarizations. Electric efficiency of galvanic cell. Systems of galvanic cells.
4.Primary and rechargeable electrochemical cells, flow batteries, fuel cells. Principles of operation. Main representatives of each galvanic cell type.
5. Hydrogen economy. Hydrogen-oxygen fuel cells: AFC, PAFC, PEMFC, MCFC and SOFC. Electric efficiency of fuel cell, their stacks and systems.
6.Fuel cell supplied with liquid fuels (methanol, formic acid, hydrocarbons), special types of fuel cells (direct fuel cells, direct carbon fuel cell, regenerative, etc.)
7.State-of-the-art technology of fuel cells, practical application – stationary, domestic, portable. Automotive and military application.

Laboratory classes

Electrolysis of water (polimer electrolyzer). Proton Exchange Membrane (polymeric) (PEMFC), Solid Oxide (SOFC), Direct Methanol and Ethanol (DMFC and DEFC), Direct Carbon (DCFC) Fuel Cells – characteristics, efficiency, parallel and serious connection of the cells, stack of fuel cell.

Method of calculating the final grade

Average of oral examination and laboratory exercises

Prerequisites and additional requirements

Fundamental knowledge of chemistry and physics

Recommended literature and teaching resources

1. S. Srinivasan, Fuel cells. From Fundamentals to applications, Springer, 2006
2. Hydrogen as a Future Energy Carrier. Eds. A. Zuttel, A. Borgschulte, L. Schlapbach, Weinheim, Wiley-VCH Verlag GmBH&Co, 2008.
3. J. Larminie, A. Dicks. Fuel Cell Systems Explained, 2nd Edition. John Wiley and Sons, 2003.
4. EG&G Technical Services, Inc. Fuel Cell Technology-Hand book, 7th Edition. U.S. Department of Energy, 2004.

Scientific publications of module course instructors related to the topic of

the module
Additional scientific publications not specified

Additional information
None

Student workload (ECTS credits balance)

Student activity form	Student workload
Participation in lectures	15 h
Realization of independently performed tasks	25 h
Participation in laboratory classes	30 h
Preparation for classes	20 h
Summary student workload	90 h
Module ECTS credits	3 ECTS