Course guide

295810 - 295HY031 - Low-temperature fuel cell systems engineering

Department: 729 - MF – Department of Fluid Mechanics

Coordinating lecturer: Attila P. Husar

Others: Vicente Roda Serrat (professor lab); Miguel Morales Comas

Prior skills: Basic knowledge of thermodynamics, heat transfer, fluid mechanics and process engineering

Requirements:

DEGREE COMPETENCIES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

TEACHING METHODOLOGY
- Lectures and conferences: knowledge exposed by lecturers or guest speakers.
- Participatory sessions: the collective resolution of exercises, debates, and group dynamics, with the lecturer and other students in the classroom; classroom presentation of an activity individually or in small groups.
- Theoretical/practical supervised work: classroom activity, carried out individually or in small groups, with the advice and supervision of the teacher.
- Homework assignments of reduced extension: carry out homework of reduced extension, individually or in groups.
- Group projects assignment of broad extension (PA): design, planning and implementation of a project or homework assignment of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.

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LEARNING OBJECTIVES OF THE SUBJECT

- To develop scientific and technical skills to design and test low-temperature fuel cells, and to set up the basis for their implementation, optimization and/or modification.
- To develop technical criteria to define and select a low-temperature fuel cell system with the participation of other energy devices (fuel processing, hybridisation with other energy storage devices e.i. batteries).
- To identify the problems and weaknesses of Polymer Electrolyte Membrane Fuel Cells (PEMFC), cells, stacks, balance of plant components, and systems configurations, and to provide engineering solutions.
- To develop scientific skills to develop new ideas related to low-temperature fuel cells.

Type	Hour	Percentage
Large group/Theory	33	22
Small group/Lab	9	6
Guided activities	21	14
Self-study	87	58

Total learning time: 150h

CONTENTS

Topic 1. INTRODUCTION

Description: Fuel cells fundamentals and operating principles.

Learning time: 9h
Large group/Theory: 3h
Self-study: 6h

Topic 2. THERMODYNAMICS AND ELECTROCHEMICAL KINETICS

Description: Operating characteristics of cells. Thermodynamic and electrochemical losses. Electrical efficiency and heat rejection. Cell performance variables.

Learning time: 11h
Large group/Theory: 3h
Guided activities: 2h
Self-study: 6h

Topic 3. CELL TYPES

Description: Polymer Electrolyte Membrane (PEM). Direct Menthol (PEM DMPEM). High-temperature PEM

Learning time: 11h

Large group/Theory: 6h
Guided activities: 2h
Self-study: 6h

Topic 4. CELL COMPONENTS
Description: Electrolyte materials. Anode materials. Cathode materials. Interconnect materials (Bipolar plates). Seal materials.

Learning time: 23h
Large group/Theory: 6h
Guided activities: 2h
Self-study: 15h

Topic 5. STACK DESIGNS
Description: Planar and tubular design. Cell fabrication. Single-cell performance. Stack performance. Stack scale-up.

Learning time: 32h
Large group/Theory: 6h
Small group/Lab: 3h
Guided activities: 5h
Self-study: 18h

Topic 6. OPERATION CONDITIONS OF CELLS AND STACKS
Description: Testing electrodes. Testing cells and stacks. Area-specific resistance (ASR). Comparison of test results on electrodes and on cells. Non-activated contributions to the total loss. Inaccurate temperature measurements. Cathode performance. Impedance analysis of cells. The problem of gas leakage in cell testing. Assessment of the size of the gas leak. Effect of pressure, temperature, flow rates, and humidity on stack performance.

Learning time: 36h
Large group/Theory: 6h
Small group/Lab: 6h
Guided activities: 6h
Self-study: 18h

Topic 7. SYSTEMS
Description: Fuel processing. Power conditioning. Balance of Plant (BoP). System optimization. System designs. Hybrids.

Learning time: 28h
Large group/Theory: 6h
Guided activities: 6h
Small group: 6h
Self-study: 18h

GRADING SYSTEM

Continuous assessment (2 exams; 30% each written exam), laboratory reports (20%), and final group project (20%).

EXAMINATION RULES

Written exams are individual. Laboratory projects are carried out in groups.

BIBLIOGRAPHY

Basic

- *Fuel Cell Handbook (Seventh Edition).* U.S. Department of Energy. By EG&G Technical Services, Inc. (2004).
- O'Hayre, Ryan P [et al.]. Fuel cell fundamentals. 3rd ed. Hoboken: John Wiley and Sons, [2016]. ISBN 9781119113805.

Complementary

- Barbir, Frano. PEM fuel cells: theory and practice. Academic press. ISBN 978-0-12-387710-9 [2012]
- Dicks, A.L. and Rand, D.A., Fuel cell systems explained 3rd ed. John Wiley & Sons. [2018] ISBN 9781118706961

RESOURCES

UPC Hydrogen Lab (EEBE Building C 3rd floor)
Energy Technologies Laboratory (EEBE Building A -1st floor)