Course guide
295811 - 295HY032 - High-Temperature Solid Oxide Cells

Last modified: 27/06/2024

Unit in charge: Barcelona East School of Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics.

Degree: ERASMUS MUNDUS MASTER IN HYDROGEN SYSTEMS AND ENABLING TECHNOLOGIES (HYSET) (Syllabus 2024). (Optional subject).
MASTER'S DEGREE IN MECHANICAL TECHNOLOGIES (Syllabus 2024). (Optional subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: Morales Comas, Miguel

Others: Husar, Attila Peter

PRIOR SKILLS

Basic knowledge in materials and chemical engineering; process engineering; thermodynamics

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 professor.
- Homework assignment of reduced extension: carry out homework of reduced extension, individually or in groups.
- Homework 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.

LEARNING OBJECTIVES OF THE SUBJECT

- To develop scientific and technical skills to design and test high-temperature fuel and electrolyzer cells, and to set up the basis for their implementation, optimization and/or modification.
- To develop technical criteria to define and select a high-temperature fuel and electrolyzer cell system with the participation of other energy devices (fuel processing, hybridization with other fuel cells, or other energy technologies).
- To identify the challenges and weaknesses of Solid Oxide Cells materials, cells, devices, and systems, and to provide engineering solutions.
- To develop scientific skills to implement new ideas related to high-temperature fuel and electrolyzer cells.

STUDY LOAD

Type	Hours	Percentage
Hours large group	21,0	14.00
Self study	108,0	72.00
Hours small group	21,0	14.00

Total learning time: 150 h

CONTENTS

Topic 1. Introduction

Description:
Fuel and electrolyzer cells fundamentals and operating principles.

Full-or-part-time: 3h 30m
Theory classes: 1h
Self study : 2h 30m

Topic 2. Thermodynamics and electrochemical kinetics

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

Full-or-part-time: 7h 10m
Theory classes: 2h
Self study : 5h 10m

Topic 3. Cell types

Description:
Molten Carbonate Fuel Cell (MCFC). Solid Oxide Cell (SOC). Protonic Ceramic Fuel Cell (PCFC).

Full-or-part-time: 21h 25m
Theory classes: 6h
Self study : 15h 25m

Topic 4. Cell components

Description:
Electrolyte materials. Anode materials. Cathode materials. Interconnect materials. Seal materials.

Full-or-part-time: 21h 25m
Theory classes: 6h
Self study : 15h 25m

Topic 5. Cell and stack designs

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

Full-or-part-time: 32h 10m
Theory classes: 6h
Laboratory classes: 3h
Self study : 23h 10m

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.

Full-or-part-time: 32h 10m
Theory classes: 6h
Laboratory classes: 3h
Self study : 23h 10m

Topic 7. Systems

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

Full-or-part-time: 32h 10m
Theory classes: 6h
Laboratory classes: 3h
Self study : 23h 10m

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 and 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.
- M Morales, et al.. Materials Issues for Solid Oxide Fuel Cells Design. Handbook of Clean Energy Systems, 2015.
- Mandeep Singh, et al.. Solid oxide fuel cell: Decade of progress, future perspectives and challenges. 46: International Journal of Hydrogen Energy, 2021. ISBN 27643.
- Muneeb Irshad, et al. "A Brief Description of High Temperature Solid Oxide Fuel Cell's Operation, Materials, Design, Fabrication Technologies and Performance.". Progress in Materials Science [on line]. Applied Sciences, 6, p. 75Available on: https://www.mdpi.com/2076-3417/6/3/75.

Complementary:
- Neelima Mahato, et al.. "Progress in material selection for solid oxide fuel cell technology: A review". Progress in Materials Science [on line]. Volume 72, Pages 141-337,Available on: https://www.sciencedirect.com/science/article/abs/pii/S0079642515000195.- M.B. Mogensen, et al.. "Reversible solid-oxide cells for clean and sustainable energy. Clean Energy". Clean Energy [on line]. Clean Energy, 3, p 175 - 201Available on: https://doi.org/10.1093/ce/zkz023.- Minghai Shen, et al. "Progress and prospects of reversible solid oxide fuel cell materials". iScience [on line]. Volume 24, Issue 12, 17 December 2021, 103464Available on: https://www.sciencedirect.com/science/article/pii/S2589004221014358.- Catarina Mendonça, et al.. "Towards the Commercialization of Solid Oxide Fuel Cells: Recent Advances in Materials and Integration Strategies". Fuells [on line]. 2021, 2(4), 393-419Available on: https://doi.org/10.3390/fuels2040023.- Shabri HA, et al.. "Recent progress in metal-ceramic anode of solid oxide fuel cell for direct hydrocarbon fuel utilization: a review". Fuel Processing Technology [on line]. Volume 212, February 2021, 106626Available on: https://www.sciencedirect.com/science/article/abs/pii/S0378382020309176.- Shen M, et al.. "Progress and challenges of cathode contact layer for solid oxide fuel cell". International Journal of Hydrogen Energy [on line]. Volume 45, Issue 58, 27 November 2020, Pages 33876-33894Available on: https://www.sciencedirect.com/science/article/abs/pii/S0360319920335874.