Zarqa University

Faculty of Engineering
Department: Mechanical Engineering/**Energy Engineering**
Course title: Special topics in mechanical engineering/**Fuel cells and hydrogen production technology**

Prerequisite: Heat Transfer 1/Renewable Energy 1
Instructor:TBD
Lecture's time:TBD
Office Hours: TBD

Course description

Overview of the various types of fuel cells followed by a detailed discussion of proton-exchange membrane (PEM). Fuel cell fundamentals: thermodynamics, heat transfer, kinetics, overall design and performance characteristics of PEM fuel cells. Hydrogen production technology, hydrogen systems modelling, hydrogen applications, life-cycle analysis methods, hydrogen production from hydrocarbons, hydrogen delivery, storage systems and safety.

Aims of the course

Students will be able to:

1. Describe how fuel cell cars work and compare the fuel cell cars/vehicles with internal combustion engine vehicles, hybrid engine vehicles and electric cars.
2. Characterise fuel cell operation and performance.
3. Demonstrate the components of a fuel cell and explain the purpose of each one.
4. Apply appropriate principles (e.g., conservation of energy, conservation of mass, etc.) to fuel cells to derive relevant model equations.
5. Explain and analyse dynamic fuel cell behavior.
6. Show the advantages of fuel cell utilisation and obstacles encountered during design and operation.
7. Analyse critically the potential for fuel cells to improve efficiency and reduce pollution by integrating social, economic and technical factors.
8. Characterise hydrogen production, hydrogen systems modelling, applications, life-cycle analysis, hydrogen production from hydrocarbons, delivery, storage systems and safety.

Intended Learning Outcomes (ILOs)

Upon completion of the course, the students will earn:

1. Thorough understanding of electrochemical systems **through:**Comparing electrochemical reactions with thermochemical reactions such as combustion, describing the general operating principles of an electrochemical cell and its main components (anode, cathode and electrolyte), identifying these components in a sketch, characterising the main chemical reactions occurring at anode, cathode, and for the cell as a whole, assuming H_2 and O_2 as reactants.
2. In-depth knowledge on fuel cells**by:**Listing the main characteristics (advantages/disadvantages) for fuel cells. Identifying the main components of power plant containing a fuel cell, classifying fuel cell types according to operational temperature: proton exchange membrane, alkaline, phosphoric acid, molten carbonate, solid oxide and describing some of the general features of fuel cell stacks equipped with different cooling technique cycles.
3. Comprehensive overview on hydrogen technologies**via:**Listing the main possible conversion pathways involving hydrogen and describing how hydrogen can be used to complement renewable energy technologies in terms of supply and demand matching.

Course structures

Week	CHrs	ILOs	Topics	Teaching Procedure	Assessment methods
1		1	Syllabus, course schedule, revision on thermodynamics, heat transfer and kinetics.	PDF and notes	
2		1,2	Introduction to fuel cells and the their importance	PDF and notes	Quizzes and Homework
3		1,2	Fuel cells principle of operation, advantages and drawbacks	PDF and notes	
4		1,2	Mechanical properties of porous structures	PDF and notes	
5		1,2	Types of fuel cells	PDF and notes	
6		1,2	Design problem on fuel cells operated with low conversion efficiency.	PDF and notes	
7		1,2	Design problem on fuel cells operated with low conversion efficiency (cont.)	PDF and notes	
8		1,2	Design problem on fuel cells operated with fins, air duct and fan for conversion efficiency enhancement.	PDF and notes	
9		1,2,3	Cooling water cycles used in proton exchange membrane fuel cells (four scenarios incorporated)	PDF and notes	
10		1,2,3	Design problem on fuel cells: avoiding harmful freezing.	PDF and notes	
11		1,2,3	Design problem on hydrogen storage in cars operated with fuel cell stacks.	PDF and notes	
12		3	Hydrogen production, systems modelling, applications and life-cycle analysis.	PDF and notes	
13		3	Hydrogen production from hydrocarbons, delivery, storage systems and safety.	PDF and notes	
14			Review and Final Exam.		Presentations in PowerPoint

References

1. Bagotsky, V. (2010) Fuel Cells: Problems and Solutions. 2nd edition,John Wiley & Sons, Inc.

Assessment Methods

Methods	Grade	Date
Quizzes and Homework	10	
1st Exam	20	
2nd Exam	20	
Final Exam	50	