GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Energy Engineering
Subject Code: ME02075021
Subject Name: Hydrogen Energy

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Knowledge of I. C. Engine, Alternate fuels
Rationale:	The course is design to provide comprehensive and logical knowledge of hydrogen production, storage and utilization, understanding of various fuel cell technologies, application of hydrogen and various challenges to use hydrogen as a fuel.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
CO-1	Explain fundamental physical, chemical and other properties of hydrogen, which are useful for hydrogen applications.	Understand
CO-2	Demonstrate various methods to produce hydrogen with different_available technologies.	Understand
CO-3	Explain various storage techniques to store hydrogen, Design and develop suitable hydrogen storage systems to be used along with fuel cell systems.	Apply
CO-4	Compare various applications of hydrogen as fuel and distinguish various techniques to use the hydrogen.	Analyze
CO-5	Apply techniques to minimize environmental hazards associated with the use of hydrogen storage and fuel cell technology.	Apply

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Hydrogen as a fuel:** physical and chemical properties of hydrogen, properties of hydrogen as a fuel (likes Energy content, Flammability, Flash point, Auto ignition temperature, Octane number, Ignition energy, Burning speed, Quenching gap, Flame characteristics), Comparisons of hydrogen as fuel with others fuels	6	14
2.	**Hydrogen Production Processes:** Natural gas reforming, Coal gasification, Thermochemical water splitting, Solar thermochemical hydrogen (STCH), Photo electrochemical (PEC), Photo biological, Biomass gasification, Biomass-derived liquid reforming, Microbial biomass conversion, Electrolysis via different kind of electrolyzers like Alkaline electrolyzers, Solid oxide electrolyzer, Polymer electrolyte membrane	10	21
3.	**Hydrogen Storage:** General storage methods, Compressed storage-composite cylinders, Glass micro sphere storage, Zeolites, Metal hydride storage, Chemical hydride storage and cryogenic storage, Carbon based materials for hydrogen storage	11	25
4.	**Applications of Hydrogen:** History, principle, working, thermodynamics and kinetics of fuel cell process, Performance evaluation of fuel cell, comparison between battery and fuel cell, types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, Microbial fuel cells, Relative merits and demerits. Fuel cell usage for domestic power systems, automobile, future trends in fuel cells	11	25
5.	**Hydrogen safety:** Hydrogen powered vehicles, Hydrogen safety aspects, Backfire, Pre-ignition, Hydrogen emission NOx control techniques and strategies.	7	15
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**40**	**30**	**20**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Alternative Transportation Fuels by Arumugam S. Ramadhas, CRC Press
2. Alternative Fuels; Concepts, Technologies and Developments by S. S. Thipse, Jaico Book Distributors
3. Hydrogen and Fuel Cells: Advances in Transportation and Power by M. F. Hordeski, The Fairmont Press, Inc.
4. Hydrogen and Fuel Cells: Emerging Technologies and Applications by B. Sorenson, Bent Sorenson, Academic Press
5. Hydrogen and Fuel Cells: A Comprehensive Guide by R. L. Busby, Penn Well Books
6. Fuel Cells, Principles, Design and Analysis by Shripad T. Revankar and Pradip Majumdar, CRC Press
7. Hydrogen and Fuel Cells by Bent Sorensen, Academic Press

(b) Open-source software and website:

1. https://onlinecourses.nptel.ac.in/noc22_ch66/preview
2. https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics

Practical List:

1. To Study the various production techniques of hydrogen.
2. To Study the various methods to store the hydrogen.
3. To study hydrogen production via biological processes.
4. To study the hydrogen production via Electrolysis process.
5. Case study on HHO as substitute fuel for automobile vehicles.
6. To study and Performance of I.C. Engine with hydrogen as fuel.
7. To study and performance of dual fuel (hydrogen-Gasoline) I.C. Engine.
8. To study fuel cells.
9. Comparative study of hydrogen performance as a fuel with gasoline and diesel.
10. To Study the infrastructure requirement for hydrogen production and storage.

List of Laboratory/Learning Resources Required: Single/Multi cylinder Petrol/Diesel Engine, HHO Kit, Gas analyzer, Electrolysis Kit, Hydrogen Generator

Suggested Project List:

Suggested Activities for Students: Student can make the demonstration model of hydrogen generator which works based on electrolysis

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