

## Hydrogen Energy

- 1.1 Course Number: CH504
- 1.2 Contact Hours: 3-0-0                      Credits: 9
- 1.3 Semester-offered: 4<sup>th</sup> Year-odd
- 1.4 Prerequisite: Not Required

2. **Objective:** The objective of course is to taught fundamentals of hydrogen energy as energy systems, production processes, storage, utilization, and safety. The course as an elective subject will equip the students with state-of-art of hydrogen energy technology and would increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.

3. **Course Content:**

Unit wise distribution of content and number of lectures

Unit	Topics	Sub-topic	Lectures
1	Introduction of Hydrogen Energy Systems	Hydrogen pathway's introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and Hydrogen production power plants	2
2	Hydrogen Production Processes	Thermal-Steam Reforming, Thermo chemical Water Splitting, Gasification, Pyrolysis, Nuclear thermo catalytic and partial oxidation methods; Electrochemical, Electrolysis, Photo electro chemical; Biological, Photo Biological; Anaerobic Digestion, Fermentative Micro-organisms	10
3	Hydrogen Storage	Physical and chemical properties, General storage methods, compressed storage, Composite cylinders, Glass micro sphere storage, Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage.	9
4	Hydrogen Utilization	Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications. Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx	14

		controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change	
5	Hydrogen Safety	Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management, and simulation of crash tests.	5
Total			40

#### 4. Readings

##### 4.1 Text Books:

1. Michael Ball and Martin Wietschel, "The Hydrogen Economy Opportunities and Challenges", Cambridge University Press, 2009
2. Bent Sørensen, Giuseppe Spazzafumo; "Hydrogen and Fuel Cells", 3rd Edition, Elsevier, 2018

##### 4.2 Reference Books:

1. Bockris. J.O.M, "Energy options: real economics and the solar hydrogen system", Halsted Press and London publisher, 1980

5. **Outcome of the Course:** The course will enable students to understand the fundamentals of the hydrogen technology, using it as a mean to store energy. The students will learn various hydrogen production methods are presented, with emphasis on producing hydrogen from renewable energies. The students will get an opportunity to know the emerging technologies on hydrogen storage methods and ways of electrical energy generation from hydrogen by using fuel cell technology.