Course code	Course Name	L-T-P-Credits	Year of Introduction
CH484	FUEL CELL TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To expose the students to the fundamental knowledge required in the development of fuel cell technology.

Syllabus

Introduction to Fuel Cells and Fuel Cell Technology, General Thermodynamics, Reaction Kinetics, Charge and Mass Transport, Overview of Fuel Cell Types, Stack Design, Fuel Cell Characterization, Hydrogen Economy.

Expected Outcome

At the end of the course the students will be able to:

1. Know the fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer, appropriate for the design or review of components of fuel cells and fuel cell systems.
2. Analyze the fuel cell technology and compare different types of fuel cell systems.
3. Calculate the various losses in fuel cells and analyze the fuel cell power plant subsystems.
4. Defend the significance of fuel cell technology in the new global energy scenario.
5. Distinguish the expectances of hydrogen as a fuel and energy vector in the context of renewable energy.

References Books:

1. Andreas Zuttel; Andreas Borgschulte; Louis Schdaptach, Hydrogen as a future energy carrier, Wiley-VCH Verlag GmbH & Co., KGaA, Weinheim, 2008.
2. Costamagna, P.; Srinivasan, S, J Power Sources 2001, 102, 242-269..
3. Frano Barbir. PEM Fuel Cells: Theory and Practice. Elsevier, 2005
4. Fuel Cell Handbook,7the Edn., EG & G Technical Services, Nov 2004
5. Hordeski, M. F. Alternative Fuels: The Future of Hydrogen, The Fairmont Press: Lilburn, GA, 2007.
6. Kordesch, K.; Simader, G. Fuel Cells and Their Applications. VCH: 1996
7. Larminie, J.; Dicks, A. Fuel Cell Systems Explained. John Wiely & Sons Ltd: Chichester, 1999.
8. Ryan P. O'Hayre, Suk-Won Cha, Whitney Colella & Fritz B. Printz, Fuel Cell Fundamentals, John Wiley & Sons, Inc., New Jersey, 2006
9. Vielstich, W, Gasteiger, H. A. Lamm, A. (Eds):Handbook of Fuel Cells- Fundamentals, Technology and Applications. John Wiely & Sons Ltd: NY, 2003; Vols1-4

Course Plan

Module	Contents	Hours	Sem. exam marks
I	**Introduction:** Fuel Cell, Brief History of fuel cells, Types of Fuel Cells, Working of a PEM fuel Cell, Fuel Cell and conventional processes – comparison, Energy & power relations, units, Application scenarios, Advantages and disadvantages.	7	15%

	General Thermodynamics: Enthalpy-Heat potential of fuel, Gibb's free energy-Work potential of fuel, Reversible voltage - NERNST Equation, Voltage and P, T and concentration dependence – examples, Faraday's Laws, Efficiency: thermodynamic, voltage and fuel.		
II	**Reaction Kinetics**: Electrochemical reaction fundamentals, electrode kinetics, Charge transfer and activations energy, Exchange current density - slow and fast reactions, Potential and equilibrium - galvanic potential, Reaction rate and potential - Butler Volmer equation & Tafel equation, Electrocatalysts and reaction kinetics – typical exchange current densities, Electrode design basics	7	15%
FIRST INTERNAL EXAMINATION			
III	**Charge and Mass Transport**: Charge transport resistances, voltage losses, Ionic and electronic conductivites, Ionic conduction in different FC electrolytes: Aquesous, polymeric and ceramic, Diffusive transport & voltage loss: Limiting current density, Nerstian and kenetic effect, Convective transport: flow channels, gas diffusion / porous layer, gas velocity, pressure, Flow channel configurations	7	20%
IV	Overview of Fuel Cell Types: PAFC, PEMFC, AFC, MCFC, SOFC. Major Cell Components, Material Properties, Processes and Operating Conditions of PEMFC.	7	20%
SECOND INTERNAL EXAMINATION			
V	**Stack Design**: Sizing of a Fuel Cell Stack, Stack Configuration, Uniform distribution of Reactants, Heat removal, Stack Clamping **Fuel Cell Diagnostics**: Polarization Curve, Current Interrupt, AC Impedance Spectroscopy, Pressure drop as a diagnostic tool.	7	15%
VI	**Fuel Cell System Design**: Hydrogen-Oxygen Systems, Hydrogen-Air Systems, Fuel Cell Systems with Fuel Processor, System Efficiency **Fuel Cells and Hydrogen Economy**: Hydrogen Energy Systems, Hydrogen Energy Technologies, Transition to Hydrogen Economy	7	15%
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum Marks: 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.
(2 x20= 40 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.
(2 x15= 30 Marks)