MEC7106: Thermo-chemical Energy Engineering

Hours per Semester				Weighted Total Mark	Weighted Exam Mark	Weighted Continuous Assessment Mark	Credit Units
LH	PH	TH	CH	WTM	WEM	WCM	CU
30	15	15	45	100	60	40	3

Course description:

This course covers alternative and renewable fuels derived from biological sources and their applications as an energy source for homes, industry and transportation. Wood, urban and agricultural solid waste are discussed as potential sources of energy. Furthermore, knowledge of relevant fundamental aspects connected to the utilization of biomass and the biomass fractions of waste streams for energy purposes in thermo-chemical conversion processes are presented. The major areas are: combustion, gasification, pyrolysis and liquefaction of biofuels. The economic and environmental aspects of thermo chemical processes including energy efficiency, costs and environmental impact assessments, will be analyzed. Future prospects of bio-fuels and bio-energy including both advantages and disadvantages of Bio-fuels as an energy source.

Course Objectives:

The aims of this course are to:

- Give students a background for understanding thermo chemical processes
- Provide students with in-depth knowledge of the relevant fundamental aspects connected to the utilization of biomass.
- Expose the students to practical application of bioenergy conversion systems

Course Learning Outcomes:

Upon completion of the course, the student will be able to:

- Communicate effectively with both lay and technical audiences about the challenges and opportunities of a bio-based economy.
- The students have gained core knowledge on advanced thermo-thermal processes
- Describe the theory of operation of the different types of bio-fuels energy sources and how they produce energy.

- The students are in position to carry out advanced analysis of real problems in thermal applications
- Demonstrate recommended applications of various commercially available bio-fuels energy technologies.

Course Outline

Biomass Formation (2 Hours)

- Biomass resources: Classification and characteristics;
- Techniques for biomass assessment;
- Application of remote sensing in forest assessment; Biomass estimation

Fundamentals of combustion (3 Hours)

- Introduction to applied combustion and enthalpy
- Combustion of fuel (solid, liquid and gas)

Thermo-chemical Conversion **(4 Hours)**

- Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction;
- Economics of thermo-chemical conversion

Solid Waste **(3 Hours)**

- Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste:
- Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

Energy Generation from Waste **(6 Hours)**

- Thermo-chemical conversion: Sources of energy generation, Gasification; Types of gasifiers; Briquetting; Industrial applications of gasifiers;
- Utilization and advantages of briquetting; Environment benefits of thermo-chemical conversion

Pyrolysis **(6 Hours)**

- Fundamentals
- Feed materials
- Fast and conventional pyrolysis processes,
- Charcoal production
- Pyrolysis kinetics
- Applications of pyrolysis and environmental aspects

Power generation **(6 Hours)**

- Utilisation of gasifier for electricity generation; Operation of spark ignition and compression ignition engine with wood gas ;
- Biomass integrated gasification/combined cycles systems. Sustainable co-firing of biomass with coal;
- Biomass productivity: Energy plantation and power programme.

Delivery Methods

- Lectures, exercises, laboratory work, assignment, study visits

Laboratory: **(10 Hours)**

- Experimental Study on thermal performance and efficiency of biomass downdraft gasifier and sampling and analysis of air and flue gas from biomass energy system (gasifier, combustor and cook stoves using as chromatography technique)
- Biogas production by anaerobic digestion and analysis
- Fuels: density, viscosity, flash-point, fire point, pour-point, ASTM distillation of liquid fuels
- Proximate and ultimate analysis, calorific value of solid fuels

Method of Assessment

- Written exam, laboratory reports, written assignment, and seminars

References

1. Donald L. Klass, "Biomass for Renewable Energy, Fuels, and Chemicals", Academic Press, 1998, ISBN-13: 978-0-12-410950-6, ISNB-10: 0-12-410950-0
2. Stephen R. Turns, "An Introduction to Combustion: Concepts and Application", 2nd Edition, McGraw-Hill, 2006, ISNB: 978-007-126072-5
3. David Boyles, "Bio Energy Technology Thermodynamics and costs", Ellis Hoknood, Chichester, 1984
4. Parker, Colin, & Roberts, "Energy from Waste - An Evaluation of Conversion Technologies", Elsevier Applied Science, London, 1985
5. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000
6. Rich, Gerald et.al., "Hazardous Waste Management Technology", Podvan Publishers, 1987
7. Bhide AD., Sundaresan BB, "Solid Waste Management in Developing Countries", INSDOC, New Delhi,1983.
8. P. Quaak, H. Knoef, H. Stassen, Energy from Biomass, A review of Combustion and Gasification Technologies, World Bank technical paper No 422 Energy Series