S.No.	Topic	No. of Lectures
3.	Biochemical conversion of organic wastes.	1
4.	Methane production, vertical through digesters, high solid digestion.	2
5.	Sludge treatment.	1
6.	Lagoons: Composting, contact and filter digestion, reactors.	2
7.	Physical and chemical removal of dissolved materials.	2
8.	Activated sludge and other suspended culture process parameters.	2
9.	Waste waters	1
10.	Biological film flow processes, sanitation land fill, pre-digestion of waste.	2
11.	Engineering design of biogas units	2
12.	Biogas boosters, structural behaviour.	1
13.	Alternate construction materials.	1
14.	Multi-criteria optimization, immobilization.	2
15.	Modular biogas for tropical areas. Kinetic models	2
16.	Bioconversion of biomass to alcohol	1
17.	Types and pre-treatment of biomass production process.	2
18.	Fermenter design and process parameters.	2
19.	Economics of bio-alcohol production.	1
20.	Reaction kinetics, Gasohol.	1
21.	Bio-hydrogen from algae/biomass.	2
	Total	**32**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Lagoons and compositing.	1
2.	Analysis of biogas systems.	2
3.	Determination of methane production rate and parameters.	1
4.	Biogas storage, purification.	1
5.	Biogas storage utilization and kinetic equations.	1
6.	Alcohol production, optimization of process parameters.	1
7.	Fermenter designing and evaluation.	1
8.	Economic calculations of biogas and alcohol.	2
	Total	**10**

X. Suggested Reading

- Culp AW. 1979. *Principles of Energy Conversion*. McGraw Hill Book Company, New York, USA.
- Kiang YH. 1981. *Waste Energy Utilization Technology*. Marcel Dekkar, New York, USA.
- Klan E. 1985. *Energy from Biomass and Wastes.* Institute of Gas Technology, Chicago.
- Wilson DG and Reinhold VN. 1977. *Hand Book of Solid Waste Management*. McGraw Hill Book Company, New York, USA.

I. Course Title : Thermo-Chemical Conversion of Biomass

II. Course Code : REE 602

III. Credit Hours : 2+1

IV. Aim of the course

To help students to understand in depth knowledge of thermo-chemical conversion of organic waste, combustion chemistry and different heat based conversion technologies for fuel and power generation.

V. Theory

Unit I

Biomass: Characterization, resources and energy recovery. Thermo-chemical conversion of organic wastes.Chemical thermodynamics, stoichiometry and thermodynamics.

Unit -II

Combustion of fuels: Solid fuels, stoker, types, fluidised bed. Liquid fuels: Atomization, vapour concentration, combustion phenomena. Gaseous fuel: Flame characteristics, inflammability limits, submerged combustion, combustion with explosion flame, pulsating combustion.

Unit III

Biomass Gasification: Gasifier configurations, classification, entrained flow, fluidized bed, moving bed, plasma gasification. Coal gasification technologies.Syngas characteristics.Tar and particulates in gasification.Integrated coal gasification.Gas turbine technologies.

Unit IV

Pyrolysis: Models, regimes, kinetics and effect of process parameters. Radiant heat flux, heterogeneous reactions, wall heat transfer.Fluidised bed reactors: Heat transfer circulating beds, moving bed reactor.

Unit V

Torrefaction and charcoal production: Carbonization parameters, temperature zone, input output, energy density ratios and characterization of finished products.

VI. Practical

Combustion thermodynamics and phenomenon in solid, liquid and gaseous fuels.TGA studies. Liquid and gaseous burners, flame studies, flue gas, heat budgeting. Kinetic study on gasifiers. Producer gas based power generation systems. Kinetic and model studies for torrefaction, char coal and bio oil production.

VII. Learning outcome

Students will enable to critical analysis of combustion of fuel and system design for thermos chemical conversion technologies for domestic and industrial applications.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Biomass: Characterization, resources and energy recovery.	2
2.	Thermo-chemical conversion of organic wastes.	1
3.	Chemical thermodynamics and stoichiometry.	3
4.	Combustion of solid fuels: stoker, types, fluidized bed.	2
5.	Combustion of liquid fuels: Atomization, vapour concentration, combustion phenomena.	2
6.	Combustion of gaseous fuel: Flame characteristics, inflammability limits, submerged combustion, combustion with explosion flame, pulsating combustion.	2
7.	Biomass Gasification: Gasifier configurations, classification, entrained flow, fluidized bed, moving bed, plasma gasification.	3
8.	Coal gasification technologies, Integrated coal gasification.	2

S.No.	Topic	No. of Lectures
9.	Syngas characteristics, Tar and particulates in gasification.	2
10.	Gas turbine technologies.	2
11.	Pyrolysis: Models, regimes, kinetics and effect of process parameters.	2
12.	Radiant heat flux, heterogeneous reactions, wall heat transfer.	2
13.	Fluidized bed reactors: Heat transfer circulating beds, moving bed reactor.	2
14.	Torrefaction and charcoal production: Carbonization parameters, temperature zone, input output	2
15.	Energy density ratios and characterization of finished products.	2
	Total	**31**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Combustion thermodynamics and phenomenon in solid, liquid and gaseous fuels	2
2.	Determination of efficiency of improved chulha through water boiling test procedure.	1
3.	Thermo-gravimetric analysis of biomass sample	1
4.	Study of liquid burners	1
5.	Study of gaseous burners	1
6.	Flame studies and flue gases	1
7.	Study on heat budgeting	1
8.	Study on kinetics of fluidized bed gasifier	1
9.	Producer gas based power generation systems	1
10.	Kinetic and model studies for Torrefaction	2
11.	Kinetic and model studies for charcoal production.	2
12.	Kinetic and model studies for bio oil production.	2
	Total	16

X. Suggested Reading

- Culp AW. 1979. *Principles of Energy Conversion*. McGraw Hill Book Company, New York, USA.
- Glassman I. 1987. *Combustion*. Academic Press Inc. Orlando, Florida, USA.
- Klan E. 1985. *Energy from Biomass and Wastes*. Institute of Gas Technology, Chicago.
- Kiang YH. 1981. *Waste Energy Utilization Technology*. Marcel Dekkar, New York, USA.
- Rezaiyan J and Cheeremisinoff NP. 2005. *Gasification Technologies–A Primer for Engineers and Scientists*. CRC Press, Taylor and Francis group, New York, USA.
- Tchobanoglous G and Elliassen HTR. 1978. *Solid Wastes*. McGraw Hill Book Company, New York, USA.
- Wilson DG and Reinhold VN. 1977. *Hand Book of Solid Waste Management*. Van Nostrand Reinhold Company, New York.

I. Course Title : Advances in Renewable Energy Systems

II. Course Code : REE 603

III. Credit Hours : 2+1

IV. Aim of the course

To provide in depth knowledge, understanding and application oriented skills on advanced renewable energy systems and relevant technologies towards their effective utilization for meeting energy demand.