Biomass/Coal Gasification-ESE-906

Background

1. Give brief rundown of the existing program.

   i. Biomass is becoming one of the most important sources for energy in Pakistan, and has a potential to substitute up to 33% of the total current energy consumption

   ii. Students should have better understanding of different processes in converting biomass into syngas, liquid fuels, power/electricity generation and challenges associated with each process.

   iii. The course will mainly focus on two platforms for converting biomass/coal into liquid fuels: thermochemical and biochemical

   iv. Students will be introduced to the concept of overall mass and energy balance and life cycle analysis

   v. Understanding of Thermodynamics and chemical kinetics involved in gasification

Rationale

1. Rationale for offering/launching the new course.

   - It is essential to produce scientists who will make significant contributions in the field of application of available Biomass/Coal for energy production.
   - To design and develop Biomass/Coal gasification technology for energy systems.

Educational Objectives

3. Objectives of the program under which the proposed course will be conducted

   The objectives of this I course are:

   - To identify various types of biomass for energy production
   - To discuss advantages and disadvantages of comprehensive demonstration of a community-scale biomass energy system
   - To recognize key factors of reactions occurring in gasification
   - To evaluate the sustainability of mass balances and analytical methods for biomass pretreatment experiments

- To discuss the stability and selectivity of the FT catalyst
- To describe and discuss the Thermodynamics and chemical kinetics of gasification process
- To understand Biomass gasification power generation plant with Integrated gasification combine cycle (IGCC)
- To discuss Hydrogen and Methane production for utilization as a renewable fuel
- To recognize the Axes of development in chemical and process engineering for converting biomass to energy
- To discuss the financing strategies for industrial scale gasification technology and technology development start-ups

International Practice

4. Specify the universities of repute where the proposed course is being conducted.

- University of Minnesota
- University of Northern British Columbia
- Burlington County College
- AGH University of Science and Technology

Proposed Timeframe of Commencement

5. Specifying semester with year. Summer 2015

Course Contents

6. Give details of the course, on the following lines:

- Theoretical 3CH
- Practical 1CH
- Contact hours 45 hrs.
- OHT -1 15%
- OHT-2 15%
- Final 50 %

- Assignments 5%~10%
- Quizzes 10%~15%

The Content of this Biomass/Coal Gasification for Energy Systems course are:

- Introduction to biomass and its chemistry
- Comprehensive demonstration of a community-scale biomass energy system
- Mass balances and analytical methods for biomass pretreatment experiments
- Biomass/coal conversion by liquefaction and gasification
- Advanced technologies for biomass hydrolysis
- Advanced product recovery technologies
- Process engineering for energy production
- Syngas cleaning and pretreatment methods
- Thermodynamics and chemical kinetics of gasification process
- Hybrid approach to synthesize liquid fuels
- Clean biomass gasification process description
- Biomass/coal gasification power generation plant with Integrated gasification combine cycle (IGCC)
- Hydrogen and Methane production and utilization as a renewable fuel
- Axes of development in chemical and process engineering for converting biomass to energy
- Financing strategies for industrial scale gasification technology and technology development start-ups
- Carbon capture techniques

Expected Outcome

The Expected Outcome of this course are:

- The students will be able to comprehend the world energy challenge and the advantages and disadvantages of the basic energy carriers.
- The students will be able to differentiate between different types of catalysis and next generation energy production systems.

- The students will be familiar about the catalyst requirements and advancement in biofuel production.
- The course will provide knowledge about XTL technologies and basic principles of catalysis.
- The topic of artificial photosynthesis and photo-catalysis will be important for the advance energy production technologies.

f. Contents with suggested contact hours

No.	Topics	Theory/Practical
1	**Introduction to biomass and its chemistry** • Biomass Availability & Potential • Traditional Biomass and Energy Crops • Biomass Characterization • Structure of Wood	Theory
2	**Comprehensive demonstration of community-scale biomass energy system** • Demonstration of bench scale Biomass energy system • Line tracing and process control • Critical dimensions of gasifier, such as reactor diameter, air nozzle (no and diameter), distance between air nozzle and grate • Case study • Field trip	Theory
3	**Mass balances & analytical methods for biomass pretreatment experiments** • Feed stocks characteristics • Pretreatment methods • Process integration • Field trip	Theory
4	**Biomass conversion by liquefaction and gasification** • Coal to liquid fuel • Direct biomass liquefaction • Fischer-Tropsch Synthesis	Theory

	• Flash Pyrolysis	
5	**Advanced product recovery technologies** • Steam reforming • Water gas shift reaction • Membrane separation • Advanced technologies	Theory
6	**Syngas cleaning and pretreatment methods** • Syngas cleaning methods • Pretreatment techniques • Gasification and its future	Theory
7	**Thermodynamics and chemical kinetics of gasification process** • Gasification reactions thermodynamics and modeling • The chemical kinetics of gasification and reactor theory • Gasification processes • Classification of different gasifiers • Practical issues related with pressurization ,sizing, particulate removal • Designing and selection of gasifier system components like air blowers and producer gas burners • Material selection for various components of the gasifier system and best practices of gasifier operation, how to start and shut down • Industrial case study/field trip	Theory
8	**Power generation plants** • Economics of power generation • Combined cycle power generation • Steam generators and steam turbines • Diesel engine and gas turbine power plants	Theory
9	**Axes of development in chemical and process engineering for converting biomass to energy** • Global outlook • Enhancement of raw biomass • Conversion of biomass to fuels and chemicals • Chemical engineering development	Theory

10	**Financing strategies for industrial scale gasification technology and technology development start-ups** • The financial environment • Govt. incentives and funding sources • Case study	Theory

g. Recommended Reading (including Textbooks and Reference books).

S. No.	Title	Author(s)	Books
1.	Biomass to biofuels, Wiley-VCH, Weinheim, 2010	Allian A, Vertes	Text
2.	Hydrogen and Syngas Production and Purification Technologies, Wiley-VCH, Weinheim, 2010	Ke Liu, Chunshan Song	Text
3.	Advances in Fischer-Tropsch Synthesis, Catalysts, and Catalysis.CRC, 2010	B. H. Davis, Mario L. Occelli	Reference
4.	Biomass Gasification, Pyrolysis and Torrefaction: Practical Design and Theory, 2013	Prabir Basu	Reference
5.	Gasification 2008	Christopher Higman, Maarten van der Burgt	Reference