MS Process Systems Engineering

Scheme of Studies

The student will have to take four core courses and four elective courses from the list given in Table 6.

Table 1: Program Structure

Course No.	**Course Structure**	**Course Title**	**Credits**
	Core Course Theory		
1	PSE-801	Process Systems Theory	3
2	PSE-802	Optimization and Decision Analysis	3
3	PSE-823	Advanced Process Dynamics and Control	3
4	PSE-852	Process Modelling and Simulation	3
		Elective Courses	
5	CSE-801	Computation Fluid Dynamics (CFD)	3
6	MGT-924	Supply Chain Management	3
7	EME-902	Numerical Methods for ChE	3
8	TEE-820	Process Intensification	3
9	TEE-810	Advanced Process Energy Analysis & Optimization	3
10	EME-921	Momentum Heat and Mass Transfer (MHMT) in Chemical Engg.	3
11	ENE-809	Waste water treatment & Design	3
12	CHE-847	Chemical Kinetics & Reactor Design	3
13	CHE-814	Product Technology	3
14	ESE-801	Biofuel Engineering	3
15	**Thesis**	Master Thesis Research	6

Table 2: Scheme of Studies: Semester-wise Breakdown

Course Code	Title	CHS
Semester I		
PSE-801	Process Systems Theory	3
PSE-852	Process Modelling and Simulation	3
xxxx	Elective	3
Semester II		
PSE-802	Optimization and Decision Analysis	3
PSE-823	Advanced Process Dynamics and Control	3
xxxx	Elective	3
Semester III		
xxxx	Elective	3
xxxx	Elective	3
Semester IV		
CHE-899	Master Thesis Research	6

Core Courses

PSE-801 Process Systems Theory

Credit Hours: 3
Pre-requisites: NIL

Educational Objectives

1. To give the student an understanding of the concepts of design, operation, and optimization of all kinds of chemical processes through the use of systematic computer-aided approaches.
2. To comprehend the intellectual challenges faced in the development of concepts, methodologies, and models for the prediction of performance and for decision-making for an engineered system.

Course Contents

- *Process Systems Design:* Explanation of systematic synthesize and design of chemical process systems. It will cover process synthesis and integration technology that can be applied in order to improve the economic efficiency and reduce the environmental impact of chemical processing plants.
- *Process and Energy Integration:* Process integration and solution strategies for the synthesis of energy recovery networks in the context of the overall chemical flowsheet are highlighted.
- *Optimization and Decision-Making:* Technology available to optimize process systems, business models and operations are taught. State of the art versions of modeling and optimization approaches in order to understand both the potential and the limitations of available techniques are included.

Course Outcome

- Students will learn-fundamental understanding of all important dimensions of Process Systems Engineering Specifically Process Systems Design, Process and Energy Integration, and Optimization and Decision-Making:

Recommended Reading (including Textbooks and Reference books)

Text Books	Advances in Process Systems Engineering: Volume 3 **Recent Advances in Sustainable Process Design and Optimization** Editors: Dominic C Y Foo, Mahmoud M El-Halwagi, Raymond R Tan **Publishers:** World Scientific **Year:**Jul 2012 Process Systems Engineering, Volume 7 **Process Integration** **Authors:** Mahmoud M. El-Halwagi **Publisher:** Academic Press; 1 edition **Year:** February 2006

References Books	Batch Processing Systems Engineering: Fundamentals and Applications for Chemical Engineering **Editors:** Reklaitis, G.V., Sunol, A., Rippin, D.W.T., Hortacsu, Ö. Publishers: Springer-Verlag Berlin Heidelberg Year: 1996

PSE- 802 Optimization and decision analysis

Credit Hours: 3

Pre-requisites: NIL

Educational objectives

- To give the students an understanding of the tools and theories by finding the optimal solutions of industrial problems.
- Student will be able to demonstrate the optimization and decision-making skills in managing industrial projects/ assignments.

Course Contents

This course covers material of the following topics

- Linear Programming
- Simplex Algorithm
- Sensitivity analysis
- Transportation model
- Goal programming
- Dynamic Programming
- Decision analysis
- Game theory
- Queuing systems
- Applications in science and engineering

Course outcomes

- Students will develop problem modeling and solving skills, and learn how to make intelligent decisions from the optimization point of view.

- Students are expected to apply the knowledge of optimization and decision analysis on different industrial case studies.

Recommended Reading (including Textbooks and Reference books)

Text books

- M. Doumpos, C. Zopounidis, and E. Grigoroudis, Robustness Analysis in Decision Aiding, Optimization, and Analytics: Springer International Publishing, 2016.
- H. A. Taha, Operations Research: An Introduction: Prentice Hall PTR, 2016.

Reference books

- J. Varela and S. Acuña, Handbook of Optimization Theory: Decision Analysis and Application: Nova Science Publishers, 2011.
- F. S. Hillier and G. J. Lieberman, Introduction to Operations Research: McGraw-Hill Higher Education, 2005.

PSE-823 Advanced Process Dynamics and Control

Credit Hours: 3
Pre-requisites: Instrumentation and Process Control course of UG level

Educational Objectives

Objectives of this course are:

- To provide an in-depth understanding of the process control, with emphasis on the automatic control which is an essential technology to maintain the safe, economical and environmentally benign operation of manufacturing processes.
- To specifically impasses on realizing the need and challenges for efficient control of complex and highly integrated processes in modern industrial plants

Course Contents

- **Modeling for Process Dynamics**

  Modeling Tools for Process Dynamics, Inversion by Partial Fractions
- **Linear Open-Loop Systems and Closed-Loop Systems**
- Second-Order and Transportation Lag, The Control System, Controllers and Final Control Elements, Block Diagram of a Chemical-Reactor Control System, Proportional Control of System with Measurement Lag, Stability
- **Frequency Response**

Control System Design by Frequency Response

- **State-Space Methods**

  State-Space Representation of Physical Systems, Transfer Function Multivariable Control

- **Nonlinear Control**

  Case-studies of Nonlinear Systems, Case-studies of Phase-Plane Analysis

- **Process Applications**

  Advanced Control Strategies, Controller Tuning and Process Identification, Theoretical Analysis of Complex Processes

- **Computers in Process Control**

  Microprocessor-Based Controllers and Distributed Control, Distributed Control

Course Outcomes

- This course will fill the gap between basic control configurations (Practical Process Control) and model predictive control (MPC).
- In addition, the economic aspects of the application of the various advanced control technologies are stressed throughout this course.

Text Books	Advanced Process Control: Beyond Single Loop Control by **Authors:** C. L. Smith, **Publisher:**Wily **Year:** July 2010 Process Systems Analysis and Control **Authors:** Donald R. Coughanowr and Steven E. LeBlanc, **Publisher:**McGraw-Hill Education; 3 edition **Year:** October 2008.
References Books	Advanced Practical Process Control **Authors:** Roffel, Brian, Betlem, Ben **Publisher:**Springer-Verlag Berlin Heidelberg **Year:** 2004

PSE-852 Process Modelling and Simulation

Credit Hours: 3
Prerequisites: Basic understanding of MATLAB and Aspen HYSYS/PLUS

Educational Objectives

- Introduction to the concepts and tools for mathematical modeling and simulation of refinery, petrochemical and other process systems.
- Specifically, the students will acquire knowledge of types of modeling tool in MATLAB and gain experience of applying the standard simulation environment of Aspen PLUS.

Course Contents

- Introduction to Modeling and Simulation, Modeling and Simulation through MATLAB and Aspen PLUS of the following process units: Batch Reactor, Continuous Stirred Tank Reactor Bioreactor, Compartmental Distillation Model, Ideal Binary Distillation Column, Activity Coefficient Models, Binary Batch Distillation Column, Binary Continuous Distillation Column, Multi-component Batch Distillation Column, Equilibrium Flash Vaporization, Equation of State Models, Refinery Debutanizer Column, Reactive Distillation Column, heat exchangers and furnaces design.

Course Outcomes

The students will learn:

- How the mathematical models of chemical processes are developed and simulated.
- The integrated treatment of process description mathematical modeling and dynamic simulation of realistic problems using the robust process model approach and its simulation with efficient numerical techniques.

Recommended Reading (including Textbooks and Reference books)

Text Books	Chemical Process Modelling and Computer Simulation **Author:AmiyaK.Jana** **Publisher:** Phi Learning Pvt Ltd.; 2 edition **Year:** February, 2011
References Books	Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering **Author:** Ashok Kumar Verma **Publisher:** CRC Press; 1 edition **Year:**October 2014

<u>Elective Courses</u>

CSE-801 Computational Fluid Dynamics

Credit Hours: 3

Prerequisites: **Nil**

Course Objectives:

- Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems,
- Will provide the graduates essential numerical background for solving the partial differential equations governing the fluid flow,
- Will develop students' skills of using a commercial software package.

Course Contents

- What is Computational Fluid Dynamics?
- Governing Equations of Fluid Flow (Navier-Stokes Equations)
- Mathematical Behavior of Partial Differential Equations
- Finite Volume Method for Diffusion Problems
- Finite Volume Method for Convection – Diffusion Problems
- Solution algorithms for steady flows & Solution of discredited equations
- Finite Volume method for unsteady flows
- Implementation of boundary conditions and Errors and uncertainty in CFD Modeling.

Course Outcomes

- Understand solution of aerodynamic flows.
- Appraise & compare current CFD software.
- Simplify flow problems and solve them exactly.
- Define, and setup flows problem properly within CFD context.
- Performing solid modeling using CAD package and producing grids via meshing tool.
- Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for a solution.
- Use CFD software to model relevant engineering flow problems.
- Will be able to analyze the CFD results. Compare with available data, and discuss the findings.

Recommended Reading (including Textbooks and Reference books)

- H. Versteeg and W. Malalasekra, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2007.
- J.D. Anderson, Jr., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill, Inc., 1995.

- J.C. Tannehil, D.A. Anderson, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer , 2nd Edition, Taylor & Francis, 1997, ISBN 1-56032-046-X.
- Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor & Francis, 1980.

MGT-924 Supply Chain Management

Credit Hours: 3
Prerequisites: Nil

Course Objectives:

- After completion of the course the students should be able to:
- Understand the core concepts of supply chain management.
- Understand and identify special topics in supply chain management research.
- Identify emerging trends in supply chain management research.

Course Contents

- Session 1 Introduction to Supply Chain Management
- Session 2 Supply Chain Analysis
- Session 3 Planning demand and supply
- Session 4 Supply Chain Collaboration
- Session 5 Seminar on unique dynamics of global supply chains
- Session 6 Supply Chain Risk Management
- Session 7 Integrated Logistics
- Session 8 Relationship management
- Session 9 Relationship management
- Session 10 Seminar on Role of IT in Supply Chain Management
- Session 11 Supply Chain Agility
- Session 12 Distribution management
- Session 13 Supply Chain Strategies
- Session 14 Big Data Supply Chains
- Session 15 Sustainable Supply Chains

Course Outcomes
The completion of the course shall enable the participants to:

- Understand research process in supply chain management.

- Identify a research topic in the area of supply chain management.

Recommended Reading (including Textbooks and Reference books)

- Gilmour, Peter. "Benchmarking supply chain operations." International Journal of Physical Distribution & Logistics Management (2013).
- Demand PlanningChristophKilger and MichaelWagner Supply Chain Management and Advanced Planning by Stadtler, Kilger and Meyr CH7 Christopher, Martin. Logistics & supply chain management. Pearson Higher Ed, 2016.
- Christopher, Martin. Logistics & supply chain management. Pearson Higher Ed, 2016.

EME 902 - Numerical Methods in Chemical Engineering

Credit Hours:3

Prerequisites:Nil

Course Objectives

- To teach the students:
  - The type of roots.
  - The successive substitution.
  - The classification of ODEs for application in the chemical engineering.

Course Contents

- Introduction
- Types of roots and their approximation & The Wegstein method
- Method of successive substitution & Method of linear interpolation
- Newton-Raphson method & Newton’s method for simultaneous nonlinear equations
- Eigenvalue method, Matrix and vector operations & Cramer’s rule
- Gauss Elimination method & Gauss-Jordan Reduction method
- Gauss-Seidel substitution method, Jacobi method & Symbolic operations
- Backward Finite Difference, Central Finite Difference & Forward Finite Difference
- Difference equations and their solutions & Differentiation by backward
- Finite differences & Differentiation by central finite differences
- Differentiation by finite forward differences & Integration formulas
- Newton-Cotes formulas of integration & Linear ordinary differential equations

- Classification of ordinary differential equations
- Nonlinear ordinary differential equations- initial value problems
- Nonlinear ordinary differential equations- boundary value problems
- Classification of partial differential equations & Initial and boundary conditions
- Solution of partial differential equations using finite differences
- Stability analysis & Introduction to finite element methods.

Course Outcomes

- The students will gain expertise in mathematical evaluation using the mathematical modeling
- Will learn, the techniques in the chemical engineering.

Reading List

- Advanced Engineering Mathematics, KREYSIZIG (7th Edition)
- Computational & Applied Mathematics for Engineering Analysis, ASCAKMAK

TEE-820 Process Intensification

Credit Hours: 3

Prerequisites: Nil

Course Objective

The objectives of this course are:

- To elaborate the generic principles of process intensification.
- To design a sustainable chemical plant, including the elements of inherent safer process design.
- To explain the boundaries of PI and interrelations with other engineering disciplines.
- To enlighten with the concept of energy conservation through process intensification.
- To describe the current engineering applications of PI along with their status of development.
- More specifically, the aim is to: (i) recognize and explain technical challenges, and limitations for a particular process, (ii) assess alternative technologies to improve the process, by upgrading process steps or re-designing the overall process, (iii) 4 evaluate the options to arrive at an optimal process configuration; and (iv) perform a feasibility design.

Course Contents

- Introduction and fundamentals of process intensification
- Process intensification in temporal domain (Time)
- PI in spatial domain (structural)
- PI in thermodynamic domain
- Synergy domain
- Reactive separations and hybrids
- Light in process intensification
- Rotating fluidized beds
- Process Intensification design problems

Course Outcomes

The course should enable the student to:

- Comprehend process Intensification technologies, their characteristics and industrial applications.
- Grasp the business drivers, rules of thumb, heuristics and quantitative economic information for when to choose micro reactors, multi-function integrated columns or external field forced reactors or conventional technologies.
- Consider 'out-of-the-box' concepts in processing technology, where knowledge from multi-disciplinary domains (e.g. physics, electronics, mechanics, thermodynamics, etc.) is incorporated in new solutions.

Recommended Reading (including Textbooks and Reference books)

- Stankiewicz, J. A. Moulijn Re-Engineering the Chemical Processing Plant: Process Intensification, CRC Press, New York, 2005.
- D. Reay, C. Ramshaw, A. Harvey Process Intensification Engineering for Efficiency, Sustainability and Flexibility, Elsevier Ltd, 2008.
- K. Boodhoo, A. Harvey Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, John Wiley & Sons, New York, 2013.

- F. Gallucci, M. V. S. Annaland Process Intensification for Sustainable Energy Conversion, John Wiley & Sons, New York, 2015.

TEE-810 Advanced Process Energy Analysis & Optimization

Credit Hours: 3

Prerequisites: Nil

Course Objective

The objectives of this course are:

- To elaborate the essential concepts of energy conservation, integration, and optimization.
- To explain the pinch analysis for energy integration and targeting.
- To discuss in detail the first law analysis for process plants.
- To enlighten with the concept of exergy analysis
- To provide the essential knowledge of heat exchanger network performance analysis. To describe the heat exchanger equipment and retrofitting of heat exchanger networks. To enable students to carry out energy integration analysis using SuperTarget.

Course Contents

- The nature of process design and integration
- Heat Exchanger Networks I- Energy Targets
- Heat Exchanger Networks II – Capital and Total Cost Targets
- Heat Exchanger Networks III – Network Design
- Heat Exchanger Networks IV – Stream Data
- Heat Integration
- Energy Targeting using SuperTarget
- Energy Optimization

Course Outcomes

The course should enable the student to:

- Calculate targets ("best performance") for external heating/cooling with maximum heat integration.
- The design of heat exchanger networks with minimum external heating/cooling with the fewest number of units and the lowest possible total area in the heat exchangers.
- Suggest energy optimal integration solutions for distillation columns, evaporators, heat and power systems (steam turbines with extraction), heat pumps and refrigeration.

Recommended Reading (including Textbooks and Reference books)

- R. Smith Chemical Process Design and Integration, John Wiley and Sons, New York, 2005.
- W. D. Seider, J. D. Seader, D. R. Lewin, S. Widagdo Product and Process Design Principles: Synthesis, Analysis and Design, John Wiley & Sons, New York, 2010.
- I. C. Kemp Pinch Analysis and Process Integration, second edition, Elsevier Ltd, 2006.
- J. Klemes Handbook of Process Integration, Woodhead Publishing, 2013.
- Frank Zhu Energy and Process Optimization for the Process Industries, John Wiley & Sons, New York, 2014
- S. Sieniutycz, J. Jeżowski Energy Optimization in Process Systems, Elsevier Ltd, 2009.

EME 921 - Momentum, Heat & Mass Transfer in Chemical Engineering Separation Processes

Credit Hours: 3

Prerequisites: Nil

Course Objective

- To provide expertise in the area of Momentum, Heat & Mass Transfer in Chemical Engineering separation processes.
- To teach the techniques related to laws of viscosity and mechanism of momentum transport, velocity distribution in laminar flow, diffusely in mass transport.
- Ultimately, teach them thermal separation processes.

CourseContents

- Viscosity and mechanism of momentum transport
- Newton’s Law of viscosity&Non-Newtonian fluids

- Temperature and pressure dependence of viscosity&Theory of viscosity of gasses
- Velocity distribution in Laminar flow&Shell momentum balance
- Flow of falling film&Flow through circular tube&Flow through an annulus
- Equation of change for isothermal systems&Equation of continuity
- Equation of motion equation of energy
- Use of equation of change for steady state flow problems
- Dimensional analysis of equation of change&Friction factor for flow in tubes/ducts
- Viscosity and mechanism of heat transport&Fourier’s law of heat conduction
- Temperature and pressure dependence of thermal conductivity
- Theory of thermal conductivity of gasses&liquids& solids
- Temperature distribution in Laminar flow&Shell energy balance
- Boundary conditions&Heat conduction with an electric heat source
- Nuclear heat source, A chemical heat source&Heat convection in boundary layers
- Heat conduction through composite walls&Heat convection in tubes/ducts
- Equation of change for non-isothermal systems&Equation of energy
- Energy equation for curvilinear coordinates&Unsteady heat conduction in solids
- Use of equation of change for steady state heat transfer
- Dimensional analysis of equation of change&Definition of concentration
- Heat transfer coefficient for forced convection in tubes
- Heat transfer coefficient for mixed convection in tubes
- Diffusivity and mechanism of mass transport&Velocities and mass fluxes
- Fick’s law of diffusion&Temperature and pressure dependence of diffusivity
- Theory of diffusion in gasses, Theory of diffusion in liquids
- Concentration distribution in Laminar flow&Shell mass balance
- Boundary conditions&Diffusion through a stagnant gas film
- Diffusion with a chemical reaction&Diffusion into a falling film liquid
- Diffusion and chemical reaction inside a porous catalyst
- Equation of change for multi-component systems
- Equation of continuity for binary mixtures&Unsteady mass diffusion
- Equation of continuity for curvilinear coordinates&Efficiency

- Use of equation of change for steady state diffusion&Trays packing
- Dimensional analysis of equation of change&Design procedures
- Mass transfer coefficient for forced convection in tubes&Hybrid systems
- Thermal separation processesDistillation&Membrane phase contractors
- Introduction, Equilibrium & equilibrium stages&Alternative distillation process
- Distillation economics, AdsorptionIntroduction&Adsorption, and Desorption
- Adsorption processes, Design considerations&Membrane separation processes
- Membrane Processes&IntroductionSelectivity Flux &Driving force
- Membrane structure and materials,Membranemodules&Pore model
- Membrane separation processes, Design considerations&Fuel Cell
- Modeling heat & mass transfer in membranes&Heat transfer model
- Solution-diffusion model, Dusty gas model&Combined heat, and mass transfer
- Application of membrane processes in chemical industry&Reverse osmosis
- Ultrafiltration, Gas separation, Pervaporation, Ion-conducting membranes

Course Outcomes

- After studying this course student will be able to apply, the gained knowledge in the research area related to chemical engineering separation processes.

Recommended Reading (including Textbooks and Reference books)

- Transport Phenomena, R. B Bird & W.E STEWART.
- Transport Phenomena, R.S BROD KEY, & HC HERSHEY

ENE-809 Waste Water Treatment & Design

Credit Hours: 3

Prerequisites:Nil

Course Objectives:

Wastewater Treatment and Design provides an in-depth introduction to the wastewater quality and analytical techniques of measuring pollutant concentrations. The courses provide the fundamentals of biological treatment including microbial metabolism, bacterial growth, and microbial growth kinetics. It also provides information on modeling of suspended and attached growth treatment processes. Lastly, the course introduces the design of activated sludge process for domestic wastewater treatment.

Course Contents

- Wastewater Engineering Overview
- Wastewater Constituents
- Biological Processes
- Suspended Growth Treatment Process
- Attached Growth Treatment Process
- Nitrification
- Denitrification
- Phosphorous Removal
- Membrane Biological Process
- Waste Stabilization Ponds

Recommended Reading (including Textbooks and Reference books)

:• Metcalf & Eddy, G. Tchobanoglous, H.D. Stensel, R. Tsuchihashi, F. Burton, Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, McGraw-Hill Education, 2013

• C. P. Leslie Grady Jr., G.T. Daigger, N.G. Love, C.D.M. Filipe, Biological Wastewater Treatment, 3rd Edition, CRC Press, 2011

CHE-847 Chemical Kinetics & Reactor Design

Credit Hours:3

Prerequisites:Nil
Course Objectives

- The course aims at:
  - Basic understanding of chemical reactor design
  - Methodologies incorporate both scale-up and hazard analysis.

Course Contents

- Reaction mechanism and rate expressions & Thermodynamics of chemical reactions
- Reaction rate expressions & Fundamentals of reactor design
- Non-isothermal reactors & Fluid mixing in reactors
- Residence time distribution in flow reactors & Application of CFD in reactors
- Biochemical reactions & Safety in chemical reaction engineering
- Reactor sizing and scale up
- Details of lab work workshops practice (if applicable).

Course Outcomes

- How to select the best reactor for any particular chemical reaction
- To estimate its size, to obtain the best-operating conditions.

Recommended Reading (including Textbooks and Reference books)

- Modeling of chemical kinetics and reactor design By A.K. Coker
- Introduction to Chemical reaction engineering and kinetics By R.W. Missen, C.A. Mims, B. A. Saville
- Introduction to Chemical reaction engineering and kinetics by Joel H. Ferziger, MilovanPerić
- Introduction to Chemical reaction engineering and kinetics By Panagiotis D. Christofides

CHE-814 Product Technology

Credit Hours:3

Prerequisites:Nil

Course Objectives

- The students will be able to learn the technical elements include chemistry, engineering, production technology (i.e. both classic chemical processes and processing/shaping technology).

- Students will be able to know the non-technical elements of Product design as well that include product and production economics, marketing, intellectual property (patent) know-how, and environmental aspects.
- Students will also go through the technology and chemistry of some major product groups: composites, adhesives, coatings, and foams.

Course Contents

- Overview of Product Technology
- Processing industry (the conversion industry)
- Design methodology and innovation
- Origin of ideas or problems, define specifications, orientation, redefine specifications and option selection
- House of Quality, a case study of chemical products for example paints, baby food, cosmetics.
- Process- Product- Processing relationship (P3R)
- Brain storming for different chemical product and case studies
- Divide students into groups and discuss different chemical products for case study i.e. Paints, cosmetics, food products, beverages, packaging materials. Discuss the requirements and options.
- Material (Metals, ceramics, polymers) structure and their basic properties
- Material structure and their basic properties (Metals, ceramics, polymers),
- Product, structure Matrix-formulation, Polymers and composites
- Technology Mapping, Case study of the different chemical product will be discussed.
- Describe the product that has to be replaced and define all parts i.e.
- Material, structure, and properties
- Development of new products, shaping technology, Coating, calendaring
- Gas and solid dispersions, Foams and their applications.
- Costing and business plan.
- Costing and business plan
- Economy of scale, discussion of projects given to students
- Presentation of projects

- Protect your ideas, Patent and scientific publications

Course Outcome

- After taking this course student will be able to use some tools that will help them in the design of a (new) product that can be considered as the outcome of the process and product technology industry.
- After taking this course, students will not only be able to understand the chemistry, engineering, and designing of the new product but also how to do marketing and fulfill the need of the customer.
- Students will be able to think like a designer to speed up the design and development of new products.

Recommended Reading (including Textbooks and Reference books)

1. Kalpakjian & Schmid: Manufacturing Processes for Engineering Materials; 5th Edition
2. Cussler & Moggeridge: Chemical Product Design; 2d Edition!
3. Mitchell: An introduction to Materials Engineering and Science for Chemical and Material Engineers (Wiley)
4. Ulrich & Eppinger: Product Design and Development (McGraw-Hill)
5. Crawford: New Products Management (McGraw-Hill)
6. Cooper: Winning at New Products (Addison Wesley)
7. van Krevelen: Properties of Polymers (Elsevier)
8. Cross: Engineering Design Methods – Strategies for Product Design (Wiley)
9. Ashby: Materials Selection in Mechanical Design (Elsevier)
10. Callister: Fundamentals of Materials Science and Engineering (Wiley)
11. Shackelford: Material Science for Engineers (Pearson)

ESE- 801 Biofuel Engineering

Credit Hours: 3

Pre-requisites: NIL

Educational objectives

The primary objectives of this course are to familiarize students with practical applications of the principles of Biofuel processes and engineering pertaining to the production of biofuels i.e. Biodiesel and Ethanol.

<u>Course Contents</u>

Process Machinery: This course will provide knowledge of machinery commonly found in a processing facility such as pumps, valves, heat exchangers, cooling towers, centrifuges, compressors, thermal oxidizers, distillation towers, compressors, refrigeration principles and boiler systems. Startup, shutdown, operation, and troubleshooting of each of these mechanical systems will be explained.

Instrumentation and Control: Study in details P& ID terminologies with applied applications. PFDs will be used to examine the sequence of operation, including residence time, pressures, and temperature seen in various stages of production.

Process Dynamics: Cover in details about major chemical process separations units, apply appropriate criteria for selecting among alternative separation technologies. Complete design calculations for equilibrium staged separation processes (e.g., distillation, absorption, solvent extraction). Applying mass transfer fundamentals to calculate rates of mass transfer for practical situations and to identify rate limiting processes.

Biodiesel Technologies and Regulatory Issues: Investigates the underlying research and reaction processes that are used to produce biodiesel. Studying feedstock options coupled with past and present technologies provides foundational knowledge about the industry. The course includes an in-depth review of the ASTM Standards for biodiesel and the regularity issues that can arise from noncompliance.

Biodiesel Processes Analysis: Provides detailed information regarding the overall process of biodiesel production. The course will include a review of biodiesel chemistry, process engineering, post reaction processing, fuel specification and properties, feedstock preparation, treatment and recovery of side streams, fuel transportation storage and general plant operations.

Ethanol Process and Separation Technology: Covers in detail the overall fundamentals process of ethanol production. A process flow Diagram (PFD) of a typical ethanol plant will be used to examine the sequence of operation, including residence time, pressures, and the temperatures seen in various stages of production. This course will explain the rationale for feedstock and additives used in ethanol processing as well as product and coproduct production and use. Covers the basic principles of ethanol distillation, evaporation, and dehydration. Included will be an understanding of the operating components in a distillation system; demonstrable familiarity with a startup, cleaning operating, and shutdown procedures; and the ability and its role in processing plants will also be converted as well as the theory of the molecular sieve dehydration and how it is used in the ethanol process.

Reaction Kinetics and Reactor Design: Covers in detail the kinetic data, determination of rate laws, analysis of complex reaction networks and design of ideal isothermal reactors. Analyze data for heterogeneous catalytic reactions. Design reactor systems for given synthesis with special emphasis on trans-esterification and bio fermentation.

Course outcomes

The course will provide an intensive treatment in biofuel production technologies; the students will be able to appreciate the design concepts of plant & machinery involved in the production chain i-e Crude production, bio-refining, and characterization.

Recommended Reading (including Textbooks and Reference books)

Text books

- Drapcho, Caye M., Nghiem Phu Nhuan, and Terry H. Walker. Biofuels engineering process technology. No. Sirsi) i9780071487498. New York, NY, USA: McGraw-Hill, 2008.

Reference books

- Silla, Harry. Chemical process engineering: design and economics. CRC Press, 2003.
- Avallone, E. A., I. T. Baumeister, and Ali Sadegh. Marks' Standard Handbook for Mechanical Engineers. 10. New York: McGraw-Hill, 2006.