

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL (COMPUTER AIDED PROCESS DESIGN) (16)

Process Design and Synthesis

SUBJECT CODE: 3713014

SEMESTER: I

Type of course: Core - I

Prerequisite:

Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	<p>Unit 1: Introduction Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software</p>		
2.	<p>Unit 2: Product design and developments Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety</p>		
3.	<p>Unit 3: Reactor Networks Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps</p>		
4.	<p>Unit 4: Synthesis of Separation Trains Criteria for selection of separation methods, selection of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation -</p>		

	Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor flow rates for single columns, Residue curve basics, Non-ideal Distillation - Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressureswing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure		
5.	Unit 5: Heat Exchanger Network Synthesis Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming		
6	Unit 6: Mass Integration: Introduction, Minimum Mass Separating Agent (MSA), Mass Exchanger Networks Minimum External MSA, Minimum Number of Mass Exchangers		

References books:

- Douglas, J. “Conceptual Design of Chemical Processes”, New York, NY: McGraw-Hill Science / Engineering / Math, 1988. ISBN: 0070177627.
- Seider, W. D., J. D. Seader, and D. R. Lewin. “Product and Process Design Principles: Synthesis, Analysis, and Evaluation”, 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.
- Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., “Analysis, Synthesis, and Design of Chemical Processes”, 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6
- Biegler L.T., Grossmann I.E. and Westerberg A.W., “Systematic Methods of Chemical Process Design”, Prentice Hall, 1997

Course Outcome:

At the end of the course, the student will be able to:

1. Analyze alternative processes and equipment
2. Synthesize a chemical process flow sheet that would approximate the real process
3. Design best process flow sheet for a given product
4. Perform economic analysis related to process design and evaluate project profitability

List of Laboratory Experiments

- 1 Determine minimum utility requirements for the given process stream information.
- 2 Calculate pinch point and utility requirements for given process data.
- 3 Solution of linear programming model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.
- 4 Solution of MILP model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.

- 5 Analyze optimum approach temperature and parameters influencing it for the heat exchanger network synthesis using given stream information.
- 6 Estimate the area and cost of heat exchangers required for the given process plant data.
- 7 Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using sequential optimization.
- 8 Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using simultaneous optimization.
- 9 Plotting of Attainable Region for reactor networks.
- 10 Pinch point and utility requirement calculation for mass exchanger network synthesis.
- 11 Determine the best sequence of distillation column for multi-component system.
- 12 Course project by each student with analysis of HENS for industrial case study.