GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170507
Semester – VII
Subject Name: Computer Aided Process Synthesis

Type of course:

Prerequisite: Basics of heat transfer, mass transfer and reaction engineering

Rationale: The design-synthesis activities focuses on the practical application of the fundamentals and integrates the considerations of numerous options to form a complete manufacturing system. The design engineer need to know the basics of fluids, heat transfer, separations, and reactor engineering for selection of the steps as individual operations and their integration to form an efficient process synthesis. Energy integration is the most important component of process synthesis for design optimization. Heat Integration, reactor network, separation trains, batch scheduling are the focus areas for effective process synthesis. The study of this course will help students to take their understanding of basic subjects to a new and higher level.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**The Design Process:** Objectives, Design Opportunities, Steps in Product Process Design, Environmental, Protection, Safety Considerations, Engineering Ethics, Role of Computers	3
2	**Reactor Design and Reactor Network Synthesis:** Objectives, Reactor Models, Reactor Design for complex configurations, Reactor Network Design using the Attainable Region	5
3	**Synthesis of Separation Trains:** Objectives, Introduction, Phase Separation of Reactor Effluent, Criteria for Selection of Separation Methods, Selection of Equipment, Sequencing of Ordinary Distillation for the Separation of Nearly Ideal Fluid Mixtures, Heuristics for Determining Favourable Sequences, Marginal Vapour Rate Method, Complex and thermally coupled distillation, Sequencing of Ordinary Distillation for the Separation of nearly Non-Ideal fluid mixtures	8

4	**Synthesis of Heat Exchanger Networks:** Objectives, Basic Heat Exchanger Network Synthesis (HENS), Minimum Utility Targets, Temperature Interval Method, Hohmann / Lochart Composite Curves (HCC), Grand Composite Curves (GCC), Pinch Design Approach to Inventing a Network, Networks for Maximum Energy Recovery, Minimum Number of Exchangers, Stream Splitting, Threshold and Optimum Approach Temperature, Derivation of Network Superstructures for Minimization of Annual Costs, Multiple Utility Design Problems	**16**
5	**Energy Integrated Distillation Processes:** Heat Integrated Distillation Trains, Impact of Pressure, Multi Effect Distillation, Heat Pumping, Vapour Recompression and Reboiler Flashing, Positioning of Heat Engines and Heat Pumps	**6**
6	**Design and Scheduling of Batch Processes:** Objectives, Introduction, Design of Batch Process Units, Design of Reactor-Separator Processes, Design of Single Product Processing Sequences, Design of Multi-Product Processing Sequencing	**7**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	10	25	15	10	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Lorens T. Biegler, E. Ignacio grossmann, Arthur W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International.
2. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, 2nd Edition, Wiley.
3. Robin Smith, Chemical Process: Design and Integration, Wiley.
4. James M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	identify minimum hot and cold utilities and develop heat exchanger networks using pinch design approach.	30
CO-2	develop reactor network synthesis using attainable region	10
CO-3	analyze various alternatives for heat integration of distillation columns	20
CO-4	design batch processes using cycle time for a single/multi product plants	15
CO-5	develop HENs using various tools	25

Suggested list of experiments to be performed (8 to 10 experiments are to be given)

Practical based on the syllabus topics to be planned. The list may include following experiments:

1. Minimum utility target and pinch point using temperature interval method
2. Minimum utility target and pinch point using HCC & GCC method in MS Excel
3. Minimum utility target and pinch point using HINT software
4. Minimum utility target and pinch point using LP in MS Excel
5. Minimum utility target and pinch point using LP in GAMS
6. Design of heat exchanger network using HINT Software
7. Application of GAMS to solve MILP model for HENS with minimum number of heat exchangers for minimum utility targets using expanded transhipment model
8. Attainable region for PFR & CSTR for Van De Vusse reaction system
9. Reactor network synthesis for manufacture of maleic anhydride
10. Design and scheduling of batch process
11. Sequencing of multiple distillation columns

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Heat Exchanger Network synthesis, design and analysis can be performed in HINT open source software. Student can use spreadsheet software for most calculations. Students can develop their own programs/spreadsheets. Student can use DWSIM, COCO, ChemSep open source software also.
- Students can use Scilab/GAMS software for the solution of LP, NLP, MILP optimization problems