GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)

ADVANCED PROCESS SYNTHESIS

SUBJECT CODE: 2723012

SEMESTER: II

Type of course: Chemical Engineering (Major Elective--III)

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

Rationale: For sustainable industrial activity, processes should use raw materials as efficiently as is economic and practicable, both to prevent the production of waste that can be environmentally harmful and to preserve the reserves of raw materials as much as possible. Processes should use as little energy as economic and practicable. Water must also be consumed in sustainable quantities. Chemical Process Synthesis requires the selection of a series of processing steps and their integration. Extensive applications of computer softwares, simulators and optimization tools in the process industries have made it mandatory to understand computer aided design tools.

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)		
						ESE	OEP	PA	RP	
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**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	**21**	**39**
2	**Energy Integrated Distillation Processes:** Heat Flows in Distillation, T-Q Diagram, Interheating / Intercooling, Thermal Condition of Feed, Heat Flows in Side Strippers and Side Enrichers Heat Integrated Distillation Trains, Impact of Pressure, Multi Effect Distillation, Heat Pumping, Vapour Recompression and Reboiler Flashing, Positioning of Heat Engines and Heat Pumps	**9**	**17**
3	**Synthesis of Separation Trains:** Objectives, 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	**6**	**11**
4	**Mass Integration:**	**6**	**11**

	Introduction, Minimum Mass Separating Agent (MSA), Mass Exchanger Networks Minimum External MSA, Minimum Number of Mass Exchangers		
5	**Reactor Design and Reactor Network Synthesis:** Objectives, Reactor Models, Reactor Design for Complex Configurations, Reactor Network Design Using the Attainable Region	**6**	**11**
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	**6**	**11**

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.

Course Outcome:

After learning the course the students should be able to:

1. Compute the minimum usage of heating and cooling utilities when exchanging heat between the hot and cold streams in a process.
2. Design a network to meet the minimum energy requirement targets.
3. Use the grand composite curve to assist in the selection and positioning of appropriate types of hot and cold utilities in the network.
4. Design energy-efficient distillation trains.
5. Understand the need to position heat engines to satisfy power demands of processes, and the need to position heat pumps to accomplish refrigeration to reduce power requirements.
6. Be familiar with more widely used industrial separation methods and their basis for separation.
7. Understand how distillation columns are sequenced and how to apply heuristics to narrow the search for the optimal sequence.
8. Determine if a reactor network should be considered and, if so, design it using the concept of the attainable region.
9. Compute the minimum usage of external mass-separating agents to determine the minimum operating cost target.
10. Design a mass exchanger network that meets minimum operating cost target.
11. Schedule recipes for the production of a single chemical product.
12. Understand how to batch plants for the production of multiple products.

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 softwares/spreadsheets.
- Most of these examples do not require specialist software and can be performed on spreadsheet software. Students can develop their own programs/spreadsheets for the solution of problems. Students can use GAMS software for the solution of LP, NLP, MILP, etc. optimization problems.

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website