GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3731605
Semester – III
Subject Name: Process Intensification

Type of course: Program Elective – V

Prerequisite: Knowledge of chemical engineering unit processes and unit operations.

Rationale: This subject deals with the process intensification and its application in chemical industry. Syllabus covers an overview to process intensification, advantages and disadvantages, mechanisms involved in PI. PI in heat exchangers ,various reactors, separation processes and mixers is covered. Applications of PI in various industries like pharmaceuticals industry , petrochemical sector , drugs and fine chemicals is included alongwith some case studies.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Syllabus Content:

Sr. No.	Content	Total Hrs
1	**General Introduction to Process intensification** Introduction, Overview and brief history. Advantages with respect to safety, environment and energy. Barriers to Process intensification, mechanisms involved in process intensification. Classification of enhancement techniques	7
2	**Heat exchangers** Construction and working of compact and micro heat exchangers, plate heat exchangers, printed circuit heat exchangers , mesh heat exchangers , foam heat exchangers etc. and industrial applications.	10
3	**Reactors** Reactor engineering theory, reaction kinetics, RTD, mass transfer and heat transfer in reactors, construction and working of Spinning disc reactors, rotating packed bed reactors, oscillatory baffled reactor, micro reactors, catalytic plate reactor etc. and industrial applications.	10
4	**Process intensification in separation processes** Process intensification in Distillation, HiGee, drying, centrifuging, crystallization etc. Reactive distillation, Reactive adsorption Reactive extraction , membrane reactors, field enhanced reactions including sonochemical reactors, microwave enhancement etc.	9
5	**Intensified mixing** Inroduction, various in line mixers, static mixers, ejectors, mixer heat exchanger.	3

6	**Introduction to other Industrial Applications** Application of PI in petrochemicals, fine chemicals, pharmaceutical, textiles, nuclear processing etc sectors. Some related case studies.	**9**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**15**	**20**	**5**	**5**	**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) David Reay, Colin Ramshaw, Adam Harvey, "Process Intensification: Engineering for efficiency, sustainability & flexibility" 2nd Edition, Pergamon Press, Oxford, 2005
2) Perry's Chemical Engineering Hand book, 8th Edition, McGraw- Hill ,USA.
3) S.V.Shivakumar, N.Kaistha, D.P.Rao, "Innovations for process intensification in the process industry." IIT, Kanpur.
4) Chemical Engineering and processing : Process intensification Journal.

Course Outcomes:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Understand the concept of Process Intensification	10
CO-2	Understand about need of Process Intensification	10
CO-3	Comprehend about applications of PI in various chemical process industries	20
CO-4	Learn about implementation of PI and advantages of PI to various reactors , heat exchangers , mixers etc.	10
CO-5	Familiarize with various process intensification techniques applied in chemical industry.	20

List of Open Source Software/learning website:

NPTEL open source