GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Subject Code: ME02072091
Subject Name: Process Intensification

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

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

Course Outcome:

After completion of the course, student will able to:

No	Course Outcomes
01	Understand the concept of Process Intensification
02	Infer the need of Process Intensification
03	Identify the applications of PI in various chemical process industries
04	Examine the implementation of PI through latest developments in various reactors , heat exchangers , mixers, separators, etc.
05	Evaluate the various process intensification techniques for application in chemical industry.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	1	0	4	70	30	20	0	120

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
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	5	15
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.	6	15
3.	**Reactors:** Mass transfer and heat transfer in reactors, Spinning disc reactors, rotating packed bed reactors, oscillatory baffled reactor, micro reactors, monolithic reactor, catalytic plate reactor etc., multifunctional reactors like heat exchanger reactors, Reactive distillation, Reactive adsorption, SMBR, Reactive extraction, membrane reactors, sonochemical reactors, etc. and industrial applications.	8	20
4.	**Process intensification in separation processes** Process intensification in Distillation, drying, centrifuging, crystallization, supercritical extraction, advanced equipments like divided wall column, HiGee, hybrid separation like membrane adsorption, membrane distillation, etc.,	8	20
5.	**Intensified mixing:** Introduction, various in line mixers, static mixers, ejectors, mixer heat exchanger.	6	10
6.	**Alternative energy sources:** Introduction, ultrasound, microwave, cavitation, plasma technology, other non-conventional energy sources and their applications.	6	10
7.	**Introduction to Industrial Applications** Application of PI in petrochemicals, fine chemicals, pharmaceutical, textiles, nuclear processing etc sectors. Some related case studies.	6	10
	Total	**45**	**100**

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

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1) Andrzej Stankiewicz & Jacob A. Moulijn, "Re-engineering the Chemical process Plant", Marcel Dekker, 2004.
2) David Reay, Colin Ramshaw, Adam Harvey, "Process Intensification: Engineering for efficiency, sustainability & flexibility" 2nd Edition, Pergamon Press, Oxford, 2005
3) Perry's Chemical Engineering Hand book, 8th Edition, McGraw- Hill ,USA.
4) S.V.Shivakumar, N.Kaistha, D.P.Rao, "Innovations for process intensification in the process industry." IIT, Kanpur.

(b) Open source software and website:

1. NPTEL open course on Chemical Process Intensification
   (https://archive.nptel.ac.in/courses/103/103/103103152/)
   (https://onlinecourses.nptel.ac.in/noc19_ch18/preview)

Suggested Activities for Students:

Students may be allotted one Open-ended Project / Mini Project on any of the above topic. Detailed literature review based on the research papers published in reputed journals to be incorporated.

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