



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030091

Subject Name: Advanced Separation Techniques

| | |
|-------------------------|------------------------------|
| W.E.F. Academic Year: | 2024-25 |
| Semester: | 2 |
| Category of the Course: | Professional Elective Course |

| | |
|----------------------|---|
| Prerequisite: | Fundamentals of Mass Transfer Operations. |
| Rationale: | The aim of this subject is to impart comprehensive understanding to the students regarding various novel and advanced separation techniques and its advancement which have profound significance in Industrial and Research arenas. |

Course Outcome:

Upon successful completion of this course, students will be able to:

| No | Course Outcomes |
|----|--|
| 01 | Familiarize various advanced aspects of separation processes and the selection of separation processes |
| 02 | Understand principles and advanced techniques in distillation, adsorption, absorption and membrane separation |
| 03 | Introduce new trends used in the separation technologies |
| 04 | Apply advanced separation techniques to identify and study environmental as well as Chemical industries problems |

Teaching and Examination Scheme:

| Teaching Scheme (in Hours) | | | Total Credits L+T+(PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|----------------------------|---|----|-----------------------------|------------------------------|------------|----------|---------------------|-------------|
| L | T | PR | | C | Theory | | Tutorial/ Practical | |
| | | | ESE (E) | | PA/ CA (M) | PA/CA(I) | ESE (V) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 20 | 30 | 150 |

Course Content:

| Unit No. | Content | No. of Hours | %of Weightage |
|----------|---|--------------|---------------|
| 1 | Advances in Distillation: Introduction to Advances in Separation by Distillation, Introduction to Multi Component Distillation, Selection of | 14 | 28 |



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|--------------|---|-----------|------------|
| | Operating Pressure, Equilibrium for Multi component System, Methods for Multi Component Distillation, Design of Batch Distillation for Multi component with Rectification, with constant reflux and constant overhead component, Continuous distillation of multi component system, Energy Conservation in Distillation column, Advanced topics in distillation, Short path distillation. | | |
| 2 | Membrane Separation Processes: Membrane types, materials, Different membrane modules; Working principle, and Industrial Applications for individual Membrane Processes such as Reverse osmosis, Forward Osmosis, Ultrafiltration and Pervaporation. | 7 | 16 |
| 3 | Advances in Absorption: Criteria for selection of Packed tower, Tray tower, Spray chamber, Venturi Scrubber etc. Design of Falling Film Absorber, Design of Spray Chamber, Design of Venturi Scrubber, Important Design Aspects and Advantage of Falling Film Absorber. | 8 | 16 |
| 4 | Separation By Adsorption Techniques: Mechanism, Types and Selection of Adsorbents, Normal Adsorption Techniques, Types of equipment and commercial processes, Recent Advances and Case Studies on Adsorption. | 8 | 16 |
| 5 | Recent Developments in Separation Techniques: Separations involving Lyophilisation, Zone Melting, Freeze Crystallization, Adductive Crystallization, Supercritical Fluid Extraction, Case Studies of Advanced Separation Techniques. | 8 | 24 |
| 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 |
| 7 | 24 | 28 | 07 | 04 | 00 |

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



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References/Suggested Learning Resources:

(a) Books:

1. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader, Second edition Wiley India Pvt. Ltd.
2. Perry's Chemical Engineer's Handbook, by R.H.Perry & Green D. Ninth Edition, McGraw Hill, New York, 2018.
3. Mass Transfer Operation by Robert Treybal, Third Edition, McGraw Hill, New York, 2017.
4. Industrial Processing with Membranes by Lacey, R.E. and S.Loeb - Wiley -Inter Science, New York, 1972.
5. New Chemical Engineering Separation Techniques by Schoew, H.M. - Interscience Publishers, 1972.
6. Ronald W.Roussel - "Handbook of Separation Process Technology", John Wiley, New York, 1987.
7. Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt,Tata McGraw-Hill Ltd.,2007.

(b) Open-source software and 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.
- Students can develop their own programs/spreadsheets for the solution of problems excel, Chemcad and other simulation softwares.

Suggested Course Practical List:

1. To determination of percentage efficiency of separation of butyl acetate by reactive distillation
2. To determine the characteristics of adsorption of moisture on Silica gel
3. To Plot Freundlich Adsorption Isotherm for a System of oxalic Acid & Activated Charcoal.
4. To recover water/salt from salt solution via freeze crystallization.
5. To perform experiment on removal of organic acid from effluent via freeze crystallization.
6. To reduce COD of waste water using freeze crystallization.
7. Study of membrane modules and their parts for pressure activated Membrane separation process such as



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Reverse Osmosis, Ultra Filtration, Pervaporation.

Major Equipments Distillation Column, Cascade refrigerator, COD Apparatus, Refractometer, Membrane Modules

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Water supply and drainage in Lab Area
2. Weighing balance, Vacuum pump
3. Chemical Storage Cabinets
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Solve design problems for multi component distillation
- Separation of given components using short path distillation unit
- Application of nanofiltration in separation of solute from waste water of food processing units
- Design of a Pervaporation Unit
- Design of falling film absorber
- Study of green solvent based absorption processes
- Optimization of separation by Freeze Crystallization
- Applications of Freeze Crystallization in removal of pollutants from waste water
- Recovery of valuable materials using melt crystallization

Suggested Activities for Students:

- Explore emerging areas in advance separation techniques
- Understand design and scale-up of equipments required for advanced separation techniques
- Apply advance separation techniques effectively for real world separation problems
