

4.1 MASS TRANSFER – I

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RATIONALE

In this subject the basic concepts of mass transfer are covered to enable the students to understand working of various mass transfer equipments like absorption columns and extraction columns etc which are used in industries for purification of products

DETAILED CONTENTS

1. Introduction to mass transfer operations and classification (4 hrs)
2. Diffusion (12 hrs)

Definition of diffusion and its classification viz diffusion under concentration gradient, diffusion under pressure, thermal and forced diffusion, eddy diffusion.

Role of diffusion in mass transfer

Theory of diffusion: Fick's law, types of fluxes, equimolal diffusion diffusivity – definition, physical significance, dimensions, relation between diffusivities

Simple numerical problems based on Fick's law definition and physical meaning of mass transfer coefficient. Important correlations (no derivation), meaning of each term

3. Gas absorption and desorption (12 hrs)
 - i) Equipment used
 - ii) Types of tower packing
 - iii) Packing tower construction details
 - iv) Problems encountered during operation like flooding, loading, channeling
 - v) Choice of solvent for absorption
 - vi) Ideal solution – Raoult's law
 - vii) Non ideal solution – Henry's law

Material balance when one component transferred for counter current flow and co-current flow only final equation and meaning of terms therein

Rate of absorption – only final equations and meaning of terms therein

4. Humidification and Dehumidification (12 hrs)

Definition of humidity, saturated gas, relative humidity, percentage humidity, humid heat, humid volume, dew point, total enthalpy

Phase equilibria – relation between equilibrium, mole fraction and saturation humidity, use of humidity chart

Dry bulb and wet bulb temperature, meaning and principle only

Gas liquid contact operation: names of adiabatic and non-adiabatic equipment – natural draft cooling tower, humidifier and dehumidifier, different cooling tower arrangements, spray chambers, spray ponds

5. Leaching and Extraction (8 hrs)

Importance of leaching and extraction, leaching equipment, bollman extractor, hilde brandt extractor, extraction equipment, plate tower, packed tower, spray tower, mixer settler extraction system

LIST OF PRACTICALS

1. Diffusion coefficient measurement in liquids
2. Diffusion coefficient measurement in solids
3. Wetted wall column experiment
4. Experiment on packed bed absorption tower
5. Determination of wet bulb temperature and adiabatic saturation on psychometric chart
6. Experiment on liquid-liquid extractor
7. Experiment on vapour – liquid extractor

RECOMMENDED BOOKS

1. Mass Transfer Operations by Treybal, Kogakusha Publication
2. Introduction to Chemical Engineering by Badger and Banchero, McGraw Hill Publication
3. Unit Operation of Chemical Engineering by Mc Cabe and Smith; McGraw Hill Publication
4. Mass Transfer by Sherwood Pigford and Wilke, McGraw Hill Publication
5. Chemical Engineers Handbook by Perry and Chilton, McGraw Hill Publication

4.2 ENGINEERING THERMODYNAMICS

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RATIONALE

It is a core subject of Chemical Engineering and is essential for understanding basic concepts, thermodynamic properties of fluids & performance of thermal systems used in industry.

DETAILED CONTENTS

1. Introduction & basic concepts
Systems, processes & surroundings, homogenous & heterogeneous systems, closed, open & isolated systems, intensive & extensive properties, state & path functions. Concept of internal energy, enthalpy, entropy, free energy & equilibrium. Equation of state, ideal gas law, Vander Waal's eqn., Amagat's law, Dalton's law, Henry's law, Raoult's law, Zeroth law of Thermodynamics.
(12 hrs)
2. First law of Thermodynamics for open & closed systems.
Calculation of internal energy, enthalpy, heat and work for ideal gas undergoing reversible, isometric, isothermal, isobaric, adiabatic and polytropic process
(9 hrs)
3. Second law of thermodynamics
Entropy change and its calculations for a closed & open system, Carnot's cycle and its efficiency, thermodynamic temperature scale, reversible & irreversible process.
(9 hrs)
4. Third law of thermodynamics and its applications
(4 hrs)
5. Applications of the laws of thermodynamics
Refrigeration coefficient of performance, vapour compression refrigeration system, absorption refrigeration, properties & applications of refrigerants, reciprocating air compressors; single stage compressor, isothermal efficiency, volumetric efficiency, clearance & clearance volume.
(10 hrs)
6. Phase equilibria
Vapour liquid equilibria, dew point and bubble point, Gibbs Duhem Equation.
(4 hrs)

RECOMMENDED BOOKS:

1. Introduction to Chemical Engineering Thermodynamics by Smith and Vanness, Mc Graw Hill.
2. Chemical Engineering thermodynamics by K.V. Narayanan, Prentice Hall India.
3. Chemical Engineering Thermodynamics by Dodge, Mc Graw Hill.
4. Chemical Engineering Thermodynamics by YVC Rao
5. Engineering Thermodynamics by PK Nag
6. Thermal Engineering by Balleny

4.3 REACTION ENGINEERING

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RATIONALE

It is a core subject of Chemical Engineering and is essential for understanding the kinetics of various reactions, types of reaction vessels and the performance of reactive systems used in industry.

DETAILED CONTENTS

1. Introduction (8 hrs)
Homogeneous Reactions: definition and examples, heterogeneous reactions: definition and examples, catalytic and non catalytic reactions, elementary and non elementary reactions, simple and multiple reactions, reversible and irreversible reactions, chemical equilibria: Le-Chatelier principle and factors affecting chemical equilibria like temperature, pressure, concentration, catalyst.
2. Kinetics of Homogeneous Reactions (8 hrs)
Definition of reaction rate, variables affecting reaction rate, effect of temperature on reaction rate, Arrhenius equation, Activation energy. Molecularity and order of reaction, methods of find the order of the reaction, zero order, first order and second order reactions.
3. Terms in Chemical Reaction Engineering (6 hrs)
Residence time, space time and space velocity, limitant reactant, reactant ratio, conversion, conversion per pass, overall conversion, recycle ratio, ultimate yield, yield per pass, overall yield, selectivity.
4. Reactors (16 hrs)
Basic reactor types: Batch reactor, plug flow reactor and continuous stirred tank reactor. Classification based on shape and mode of operations such as coiled tube, multitubular flow, jacketed tube, premixed feed, split feed, single feed reactors, flow reactors, CSTR, fixed bed, moving bed, fluidized, semi-fluidized bed, trickle bed reactors, bubble phase reactors, slurry phase reactors (their constructional detail and applications). Types of agitators and baffles arrangement used.
5. Utilities in Reactors (6hrs)
Heat exchange arrangement in reactors, arrangement of vacuum and pressure.

6. Catalysis (8 hrs)

Definition and effects on reaction, uses of catalyst and inhibitors, catalyst system, active catalyst, carriers, promoters, fouling and catalyst poisoning and regeneration of catalyst.

LIST OF PRACTICALS

1. To study the batch reactor for a given system of reactant.
 - (a) Variation of composition with time
 - (b) Measure the temperature variation.
2. To study the CSTR
 - (a) Time to achieve the steady state
 - (b) Residence time
3. To Study the Plug flow Reactor
 - (a) Time to achieve the steady state
 - (b) Residence time
4. Study of different reactions for determination of
 - (a) Rate of reaction
 - (b) Rate constant
 - (c) Order of reaction

RECOMMENDED BOOKS

1. Introduction to Chemical Engineering by Ghoshal and Sanyal.
2. Chemical Reaction Engineering by Levenspiel, John Wiley Publication.
3. Elements of Chemical Reaction Engineering by Fogler, Prentice Hall of India

4.4 PROCESS INSTRUMENTATION

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RATIONALE

This subject gives the knowledge of various instruments used to measure various process parameters. This course will impart knowledge on working principle, construction, repair and use of these instruments

DETAILED CONTENTS

1. Introduction (30 hrs)

Importance of instrument in chemical process industry, general classification of instruments, indicating and recording type instruments, static and dynamic characteristics of instrument, description and construction details, working principle, range and application of following instrument:

 - a) Pressure and vacuum gauge: liquid column gauge, bourden tube gauge
 - b) Thermometer and Pyrometer: liquid expansion thermometer, bimetallic thermometer, thermocouple, resistance thermometer, optical and radiation pyrometer
 - c) Liquid level meter: visual indicator, float actuated level meter, static pressure instrument
 - d) Flow meters: Orifice, venturi, pitot tube, rotameter
 - e) Analysers: pH meter, chemical composition analyzer, various types of analyzer i.e. oxygen analyzer, infra red analyzer, orsat analyzer
2. Transmission (4 hrs)

Pneumatic and electrical transmission (Induction Transmission only) and their field of application
3. Process Instrumentation (9 hrs)

Recording instruments indicating and recording instruments

Transmission of instrument reading, control centre, instrument diagram, instrumentation in modern chemical plant
4. Basic concept of process control, types of controllers and control valves (5 hrs)

LIST OF PRACTICALS

1. Calibration of pressure gauge/vacuum gauge
2. Calibration of resistance thermometer
3. Calibration of thermocouple
4. Characteristics of a flapper nozzle system
5. Study of on-off controller for temperature control
6. Study of constructional detail of chart recorder
7. Study of constructional details of strip chart recorder
8. Study the composition analysis using pH meter/conductivity meter

RECOMMENDED BOOKS

1. Industrial Instrumentation by Donald P Eckman, Wiley Eastern Publication
2. Principles of Industrial Instrumentation by D Patranabis, Tata McGraw Hill Publication
3. Process System Analysis and Control by Coughnour, McGraw Hill Publication
4. Industrial Instrumentation by SK Singh, Tata McGraw Hill Publication

4.5 HEAT TRANSFER - II

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RATIONALE

This subject enables the students to apply the understanding of heat transfer mechanisms such as conduction, convection and radiation for understanding the performances of various heat transfer equipment such as heat exchangers, condensers, boilers, evaporators etc used in almost all chemical and related industries

DETAILED CONTENTS

1. Heat Exchanger (14 hrs)
 LMTD; introduction, LMTD for co-current, counter current and cross flow, construction and description of (i) double pipe (ii) shell and tube heat exchanger. Simple numerical problems concerning single pass 1 – 1 exchanger, 1 – 2 parallel counter flow heat exchangers. Fouling factors, roughness of surfaces and their effect, overall heat transfer coefficient, extended surface equipment and their efficiency

2. Condenser (8 hrs)
 Construction details and working of shell and tube condenser and contact condenser

3. Boilers (10 hrs)
 Coal and oil fired boiler - cochran boiler, Babcox and wilcox boiler, simpler boiler, oil fired boiler (nestler), lanka Shire boiler

4. Evaporators (8 hrs)
 Concept of evaporators, types of evaporators; open pan, standard type, long tube evaporator, falling films, forced circulation

5. Furnaces (8 hrs)
 Classification based on fuel used (oil fired, coal fired, gaseous fuel fired) and their constructional details

LIST OF PRACTICALS

1. To determine the heat transfer coefficient with the help of double pipe heat exchanger using parallel flow
2. To determine the H.T coefficient with the help of double pipe heat exchanger using counter flow
3. To determine heat transfer coefficient in shell and tube heat exchanger using counter flow
4. To determine heat transfer coefficient in shell and tube heat exchanger using parallel flow
5. To determine the heat transfer coefficient in a condenser varying the steam pressure
6. To determine the rate of evaporation in a jacketed bottle (open pan evaporation)
7. Experiment on a single effect evaporator and determination of steam economy
8. To determine heat transfer coefficient in a condenser varying rate of flow of liquid
9. Experiment on cooling tower and to determine rate of cooling
10. Study of oil fired boiler
11. To determine heat transfer rate in finned tube heat exchanger
12. To find the effect of concentration on boiling point of a solution (Duhring's rule)

RECOMMENDED BOOKS

1. Process Heat Transfer by Kern DQ, McGraw Hill Book, New York
2. Heat Transer 7th Ed. By Holman JP; McGraw Hill, New York
3. Applied Process Design for Chemical and Petrochemical Plants, Volume III by Ludwig, E; Gulf Publishing Co., Houston, Texas
4. Heat Transfer Principles and Applications by Binary K Dutta; Prentice Hall, India.

4.6 MINOR PROJECT WORK

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Minor project work aims at exposing the students to field practices, size and scale of operation and work culture at practical sites. For this purpose, students during middle of the course, are required to be sent for a period of 4 weeks at different work sites. Some of the good industries are suggested by the expert group as follows:

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| 1. | Ballarpur Industried Limited. | Yamunanagar (Haryana) |
| 2. | Century Pulp & Paper Mills. | Lalkuan (Uttaranchal) |
| 3. | Star Paper Mills Ltd. | Saharanpur (U.P) |
| 4. | Shiva Paper Mills Ltd. | Rampur (U.P) |
| 5. | Panipat Refinery | Panipat (Haryana) |
| 6. | National Fertilizers Ltd. | Panipat (Haryana) |
| 7. | Bharat Starch & Chemicals Ltd. | Yamunanagar (Haryana) |
| 8. | Ruchire Paper Mills Ltd. | Kala Amb (Himachal) |
| 9. | Amrit Banaspati Paper Ltd | Hoshiarpur (Punjab) |
| 10. | Maghan Paper Mills Ltd. | (Punjab) |
| 11. | Khanna Paper Mills Ltd. | (Punjab) |
| 12. | Nalco Chemicals Ltd. | (Delhi) |
| 13. | Ion Exchange Ltd. | (Hydrabad) |
| 14. | Hercules Chemicals Ltd. | (Delhi) |
| 15. | Karnal Coopretive Sugar Mills Ltd. | Karnal (Haryana) |
| 16. | National Dairy Research Institute | Karnal (Haryana) |
| 17. | Shreeyan Paper Mills Ltd. | Ropar (Punjab) |
| 18. | CardinalChemicals Pvt. Ltd. | (Chandigarh) |
| 19. | Chadha Paper Mills Ltd. | Bilaspur, Nanital (Uttranchal) |
| 20. | Cheema Paper Mills | Bazpur (U.P) |
| 21. | Vapi Paper Mills Ltd. | (Gujrat) |
| 22. | Zenith Paper Mills Ltd. | (Punjab) |
| 23. | Agarwal Paper Mills Ltd. | Muzaffarnager (U.P) |
| 24. | Varinder Agro Paper Mills Ltd. | Bernala (Punjab) |
| 25. | Amrit Banaspati Ltd. | Rajpura(Punjab) |
| 26. | National Insecticides & Chemicals Ltd. | Sangrur (Punjab) |
| 27. | Indian Acrylic | Bhawanigarh |
| 28. | Pepsi Foods | Channo (Bhawanigarh) |
| 29. | Rolson Tyres | Ludhiana |
| 30. | Mukerian Paper Mills Ltd. | Mukerian (Punjab) |
| 31. | Max. India Ltd. | Ropar (Punjab) |
| 32. | Pamwi Tissues Ltd. | Barotiwala, Solan (H.P) |
| 33. | Sethia Paper Mills Ltd. | Muktsar (Punjab) |
| 34. | Bebani Pigments | Haryana |

As a minor project activity, each student is supposed to study the material and technology used at site and prepare a detailed project report of the observation of process seen by him/her. These students should be supervised and guided by respective subject teachers. Each teacher may guide a group of four to five students.

The teacher along with field supervisors will conduct performance assessment of students. This minor project work will carry 200 marks. 100 marks will be given by Industrial/field supervisors and 100 marks by the teacher supervising this training. The components of evaluation will include the following:

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| a) | Punctuality and regularity | 15% |
| b) | Initiative in learning new things | 15% |
| c) | Relationship with workers | 15% |
| d) | Industrial training report | 55% |