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 dehumidifer, different cooling tower arrangements, spray chambers, spray ponds

5. Leaching and Extraction (8 hrs)

Importance of leaching and extraction, leaching equipment, boltman extractor, hilde brandt 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 CHEMICAL ENGINEERING THERMODYNAMICS AND REACTION ENGINEERING

L	T	P
3	1	-

RATIONALE

It is a core subject of chemical engineering and is essential for understanding basic concepts, thermodynamic properties of fluids and performance of thermal systems used in industry. It is also essential for understanding the kinetics of various reactions, types of reaction vessels and the performance of reactive systems used in the industry.

DETAILED CONTENTS

1. Introduction and Basic Concepts (10 hrs)

   Systems, processes, surroundings, homogeneous and heterogeneous systems, closed, open and isolated systems, intensive and extensive properties, state and path functions, concept of internal energy, enthalpy, entropy, free energy and equilibrium, equation of state, ideal gas law, Vanderwaal's equation, Amagat's law, Dalton's Law, Henry's law, Raoult's law, zeroth law of thermodynamics

2. First law of thermodynamics for open and closed systems, calculation of internal energy, enthalpy, heat and work for ideal gas undergoing reversible isometric, isothermal, isobaric, adiabatic and polytropic process (6 hrs)

3. Second law of thermodynamics – entropy change and its calculations for a closed and open system, carnot cycle and its efficiency (6 hrs)

4. Reaction Engineering – single and multiple reactions, elementary and non-elementary reactions, fundamentals of chemical reaction, molecularity, effect of temperature and pressure on equilibrium constant, representation of reaction rate, variables affecting reaction rate, zero order, first order, second order reaction for reversible and irreversible reactions, temperature dependent term of a rate equation, activation energy and temperature dependency (14 hrs)

6. Reactors – basic reactor types, construction details, steady state mixed flow reactor, steady state plug flow reactor, general graphical comparison of batch, mixed and plug flow reactor

RECOMMENDED BOOKS

1. Introduction to Chemical Engineering by Ghoshal and Sanyal; Prentice Hall Publication

2. Chemical Reaction Engineering by Levenspiel, John Wiley Publication

3. Elements of Chemical Reaction Engineering by Fogler; Prentice Hall Publication

4. Chemical Engineering Thermodynamics by Dodge; McGraw Hill Publication

5. Introduction to Chemical Engineering Thermodynamics by Smith and Vanness, McGraw Hill Publication

6. Reaction Kinetics for Chemical Engineers by Wales; McGraw Hill Publication

4.3 PULP WASHING AND CLEANING

L	T	P
3	-	-

RATIONALE

The basic idea of washing, screening, cleaning and bleaching should be given to the students with an aim to reduce pollution load on one side and energy and chemical recovery on the other in order to get a clean and bright pulp. The technological overview based on block diagram should only be emphasized. Elementary ideas of emission from a bleach plant should be given.

DETAILED CONTENTS

1. Introduction (4 hrs)

   General Principle and objectives of washing

2. Brown Stock Washing (30 hrs)

   Washing principle and construction of brown stock washer, description of multistage brown stock washer, operating procedure including startup and shut down

   Variables affecting efficiencies of brown stock washer, production rates and loading factors

   High heat diffusion washing in continuous digester (in brief)

   Generation and maintenance of vacuum, concept of dilution factor, displacement rates, thickening factor, soda loss and their importance

   Washing equipments other than rotary vacuum filters

3. Screening (14 hrs)

   Principles and objectives of screening, various types of screens e.g. vibratory screen, gravity centrifugal screen, pressure screen and their working, concept of screening and cleanliness efficiency, variables effecting the screen performance

   Principle and objective of centri-cleaner, and its working, various affecting efficiency of centri-cleaner

RECOMMENDED BOOKS

1. Handbook of Paper and Pulp Technology by KW Britt
2. Handbook of Paper and Pulp Technology by GA Smook
3. Pulp and Paper Chemistry and Chemical Technology by JP Casey

4.4 PROCESS INSTRUMENTATION

L	T	P
3	-	3

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

L	T	P
3	-	3

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 desception 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 boilers, can chraine boiler, Babcoxs and wil coxs, wilan 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 7^{th} 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 PULP BLEACHING

L	T	P
3	-	3

RATIONALE

The basic ideas of cleaning and bleaching should be given to the students with an aim to reduce pollution load on one side and energy and chemical recovery on the other in order to get a clean and bright pulp. The technological overview based on block flow diagram should only be emphasized

DETAILED CONTENTS

1. General principle of bleaching and its objectives

   Bleachability and its measurement, simple numerical problems based on bleachability (8 hrs)

2. Bleaching process – single stage and multi stage (flow diagram) using chlorination, alkali extraction, hypochlorite and chlorine dioxide, sulphur dioxides, process variables and parameters for the above bleaching stages (12 hrs)

3. Other bleaching agents used in industry like peroxide, oxygen, concept of TCF (Total chlorine Free) bleaching and use of sulphanic acid (12 hrs)

4. Preparation of bleaching chemicals, like calcium hypochlorite, chlorine dioxide

   Important equipment used in bleach plant like agitator, tower, chlorine mixer, and washer (12 hrs)

5. Importance of brightness reversion of bleached pulp and post color number (4 hrs)

LIST OF PRACTICALS

1. Determination of Kappa number of washed pulp

2. Determination of Hypo number of unbleached pulp

3. Wash test of last BSW pulp

4. Analysis of bleach liquor

5. Analysis of bleaching powder

6. Determination of copper number of bleached pulp

7. Determination of bleachability of pulp
8. Bleaching of unbleached pulp using chlorination
9. Alkaline extraction of chlorinated pulp
10. Bleaching of extracted pulp by hypo

RECOMMENDED BOOKS

1. Handbook of Pulp and Paper Technologists by GA Smook
2. Handbook of Pulp and Paper Technology by KW Britt
3. Handbook of Pulp and Paper Technology by C Bieemann
4. Bleaching of Pulp by RP Singh
5. Pulp and Paper Manufacture Vol. 5 by MJ Kowrek

4.7 MINOR PROJECT WORK

L	T	P
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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:

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	Bajpur (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:

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