

# Department of Chemical Engineering

## 3<sup>rd</sup> year B.Tech Course structure

### Semester- V

| Sr. No. | Course Code | Subject Title                              | Contact Hours |   |   | Credits |
|---------|-------------|--|---------------|---|---|---------|
|         |             |  | L             | T | P |         |
| 01      | CH 3101     | Chemical Engineering Thermodynamics - II   | 3             | 1 | - | 8       |
| 02      | CH 3102     | Organic Chemical Technology                | 3             | - | - | 6       |
| 03      | CH 3103     | Mass Transfer Operations - I               | 3             | 1 | - | 8       |
| 04      | CH 3104     | Optimization Techniques                    | 3             | 1 | - | 8       |
| 05      | Ch 3105     | Process Equipment Design & Drawing - I     | 3             | - | - | 6       |
| 06      | CH 3106     | \$Heat Transfer Equipment Design           | 2             | - | 2 | 4       |
| 07      | CH 3107     | Chemical Engineering Operations – III Lab  | -             | - | 2 | 2       |
| 08      | CH 3108     | Organic Chemical Technology Lab            | -             | - | 2 | 2       |
| 09      | CH 3109     | Process Equipment Design & Drawing – I Lab | -             | - | 2 | 2       |
| Total   |             |  | 17            | 3 | 8 | 46      |

\$ Intra semester assessment

### Semester- VI

| Sr. No. | Course Code | Subject Title                             | Contact Hours |   |   | Credits |
|---------|-------------|---|---------------|---|---|---------|
|         |             |   | L             | T | P |         |
| 01      | CH 3201     | Mass Transfer Operations - II             | 3             | 1 | - | 8       |
| 02      | CH 3202     | Chemical Reaction Engineering - I         | 3             | 1 | - | 8       |
| 03      | CH 3203     | Process Instrumentation & Control - I     | 4             | - | - | 8       |
| 04      | CH 3204     | Energy Engineering                        | 3             | - | - | 6       |
| 05      | CH 3205     | Plant Utilities & Safety                  | 3             | - | - | 6       |
| 06      | CH 3206     | \$Process Equipment Design & Drawing – II | 2             | - | 2 | 4       |
| 07      | CH 3207     | Mass Transfer Operations -I Lab           | -             | - | 2 | 2       |
| 08      | CH 3208     | Seminar                                   | -             | 2 |   | 4       |
| 09      | CH 3209     | *Industrial Training                      | -             | - | - | -       |
| Total   |             |   | 18            | 4 | 4 | 46      |

\$ Intra semester assessment. \* Mandatory course (to be completed during summer vacation and assessed in VIIth semester)

## **CH 3101      Chemical Engineering Thermodynamics – II**

### Unit 1

#### **Vapour/Liquid Equilibrium Introduction:**

The nature of equilibrium, the Phase Rule, Duhem's Theorem, VLE: Qualitative behaviour, Simple models for vapour/liquid equilibrium, VLE by modified Raoult's Law, VLE from K- value correlations.

### Unit 2

#### **Solution Thermodynamics: Theory:**

Fundamental property relation, The chemical potential and phase equilibria, Partial properties, Ideal gas mixtures, Fugacity and fugacity coefficient.

### Unit 3

#### **Solution Thermodynamics: Theory: (continued)**

Fugacity and fugacity coefficient: Species in the solution, Generalized correlations for the fugacity coefficient, The ideal solution, Excess properties.

### Unit 4

#### **Solution Thermodynamics: Applications:**

Liquid-phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing, Heat Effects of mixing processes.

### Unit 5

#### **Chemical Reaction Equilibria:**

The reaction coordinate, Application of equilibrium criteria to chemical reactions, The standard Gibbs energy change and equilibrium constant, Effect of temperature on the equilibrium constants.

### Unit 6

#### **Chemical Reaction Equilibria: (continued)**

Relation of equilibrium constants to composition, Equilibrium conversions for single reactions, Phase rule and Duhem's theorem for reacting systems, Multi reaction equilibria, Fuel cells.

#### **Text/Reference books:**

1. J. M. Smith, H.C. Van Ness, and M.M. Abbott, Chemical Engineering Thermodynamics, 6<sup>th</sup> ed, Tata McGraw Hill edition, 2003.
2. Y. V. C. Rao, "Chemical Engineering Thermodynamics", University Press 1997
3. S. I. Sandler. "Chemical Engineering Thermodynamics", Wiley, New York, 1999.

## **CH 3102      Organic Chemical Technology**

### **UNIT I**

Unit Processes:

Principles of a few selected unit processes such as oxidation alkylation sulphonation nitration chlorination and polymerization.

### **UNIT II**

Petrochemicals: Raw materials and principles involved in the production of olefins and aromatics. Acetylene, butadiene and typical intermediates from olefins and aromatics such as ethylene glycol, ethyl benzene, phenol cumene, and DMT.

### **UNIT III**

Agrochemical and Agrichemical Industries:

Chemical processes based on agricultural and silvicultural raw materials; sugar starch, alcohol, cellulose paper vegetable oils soaps, detergents, glycerin.

Pesticides: insecticides fumigants fungicides.

### **UNIT IV**

Organic chemicals: Plastic and rubber chemicals, Dyes and intermediates, Bulk drugs and pharmaceuticals, coal chemicals.

### **UNIT V**

OILS AND FATS: Status and scope, major oil seeds production in India; solvent extraction, energy and solvent requirements, minor oil seeds and other oil bearing materials, Hydrogenation of oils, Corrosion problems and materials of construction.

### **UNIT VI**

Surface coatings: Paints, varnishes lacquers, surfactants, resins.

### **Text/Reference Books**

1. Shrye R.N. and Brink J.A., Chemical Process Industries, McGraw Hill
2. Chemical Technology, I,II,III and IV Indian Institute of Technology, Madras
3. Dryden, Charles E., Outlines of Chemical Technology, affiliated East-West Press Pvt. Ltd. New Delhi.

## **CH 3103      Mass Transfer Operations - I**

### **UNIT I**

Diffusion in fluids - Fick's Law of diffusion equimolecular counter diffusion, diffusion in stationary gas. Maxwell's law of diffusion.

Inter phase mass transfer - Mass transfer equilibrium, diffusion between two phases. Local mass transfer coefficient, Local and average overall mass transfer coefficients. Simultaneous heat and mass transfer.

### **UNIT II**

Material balance – steady state co current and counter current processes stage wise and differential contacts. Number of theoretical stages. Stage efficiency Height of mass transfer units.

### **UNIT III**

Gas Absorption - Equilibrium solubilities of gases. Material balance for transfer of one component. Counter current multistage operations for binary and multi component systems. Continuous contactors, absorption with chemical reaction.

### **UNIT IV**

Liquid-liquid extraction - Calculations with and without reflux for immiscible and partially miscible system.

Leaching - Leaching single and multistage operations based on solvent free co ordinates.

### **UNIT-V**

**ADSORPTION AND ION-EXCHANGE:** Types of adsorption; Nature of adsorption; Freundlich equation; Types of adsorption; Nature of adsorption; Freundlich equation; Stage wise and continuous adsorption. Stage wise and continuous adsorption. Theory of ion – exchange and its application to removal of ionic impurity.

### **UNIT-VI**

Gas-Liquid operations - Sparged vessels (bubble columns), mechanically agitated vessels for a single phase and gas liquid contact. liquid dispersed scrubbers, venturi scrubbers, wetted towers packed towers. Mass transfer coefficients for packed towers co-current flow of gas and liquid end effect and axial mixing.

#### **Texts / References:**

R. E. Treybal, Mass transfer operations, 3ed ed. McGraw Hill, 1980.

A. S. Foust et al. Principles of Unit Operations

J. M. Coulson and J. F. Richardson, “Chemical Engineering”, Vol. 1 ELBS, Pergaman press, 1970

J. M. Coulson and J. F. Richardson, “Chemical Engineering” Vol. 2 ELBS, Pergaman press, 1970

## **CH 3104 Optimization Techniques**

### **UNIT I**

Single-variable optimization algorithms: Optimal problem formulation, Optimization algorithms,

Optimality criteria, Bracketing methods, Region-elimination methods, Point-estimation method, Gradient based methods, Root finding using optimization techniques.

### **UNIT II**

Multi-variable optimization algorithms: Unidirectional search, Direct search methods, Gradient based methods.

### **UNIT III**

Constrained optimization algorithms: Kuhn-Tucker conditions, Transformation methods,

### **UNIT IV**

Sensitivity analysis, Direct search for constrained minimization, Linearized search techniques, Feasible direction method, Generalized reduced gradient method, Gradient projection method

### **UNIT V**

Specialized algorithms: Integer programming, Geometric programming.

### **UNIT VI**

Nontraditional optimization algorithms: Genetic algorithms, Simulated annealing, Global optimization.

### **Texts / References:**

Deb K., Optimization for Engineering Design, Algorithms and Examples, Prentice Hall of India, New Delhi 1996

## **CH 3105 Process Equipment Design & Drawing - I**

### Unit 1

Chemical Process Plant Materials: Stress characteristics, materials of construction for process equipment, stainless steel, non ferrous alloys, heat treatment of materials, Indian standard code for steels, polymeric materials, reinforced plastics, packing materials, materials of construction for handling specific chemicals, lining of chemical process equipments, non destructive methods for thickness measurements.

Corrosion Mechanism: theories of corrosion, forms of corrosion.

### Unit 2

Pressure Vessels: vessels subjected to internal pressure and combined loading, cylindrical shell and spherical shell, stresses induced in vessel, vessels subjected to high pressure, high pressure vessel fabrication techniques, optimum proportion of a vessel, optimum vessel size, estimation of equipment weight, criteria for the purchase of new equipments, jacket for reaction vessel, comparison of jacket and coil, closures for vessels, flat plates, formed heads, standard shallow dished heads, torispherical head, elliptical head, hemispherical head, conical head, selecting the most economical head, scale up of process equipments, scale up of fluid flow systems, scale up technique for mixing system.

### Unit 3

Vessel Supports: Design of support for vessels, skirt support, stress due to dead weight, stress due to wind load, stress due to seismic load, skirt bearing plate, base plate radial stress, anchor bolts, base ring, design of bracket or long support, maximum total

compressive load, stiffener and gusset plate, column supports for the brackets, design of saddle supports, stresses induced due to saddles, ring stiffeners, design of tall vessel columns, stresses in the shell of a tall vertical vessel.

#### Unit 4

Flanges and Nozzles: Classification of flanges, types of flanges, design of gaskets, gasket classification, selection of gasket, gasket seating stress and gasket factor, gasket factor, gasket width, bolt load, bolt selection, bolt circle diameter, flange thickness, rating of flange. Nozzles: nozzle reinforcement, design compensation, area for area method, controlled maximum shear stress method, experimental yield method.

#### Unit 5

Storage Tanks: liquefied gases, loss mechanism in storage tanks, optimum proportions of a storage tanks, estimation of volume of storage tanks, horizontal cylindrical tank with flat heads, volume of spherical tank filled upto certain height, partial volume of spherically dished vertical head, volume estimation in partially filled horizontal tank, mechanical design of storage tanks, wind girders, roof of the tank, types of floating roof, self supported conical roof, roof curb angles, mechanical design of horizontal storage tank with saddle supports, spherical storage tank, design consideration of ammonia storage tanks, estimation of nozzle diameter for drain in storage tanks, estimation of time required to drain a tank with piping, storage tank dike, solid materials, cryogenic liquid storage tanks.

#### Unit 6

Agitation: Types of agitators, paddle agitator, anchor agitator, helical ribbon agitator, helical screw agitator, propeller, turbine agitator impeller, flat blade turbine agitator impeller.

Piping: pipe thickness, pipe diameter, condensate piping, pipe diameter for steam, pipe supports, cross country pipeline, design of pipe line for natural gas, pipe line design for transportation of crude oil, pipeline in sea water, pipeline design on fluid dynamics parameters, optimum size of delivery line in pump operation, pipeline for solid transportation.

Valves and relief devices: selection and classification of valves, types of valves, control valves, safety valves, rupture discs, pressure relief system, steam trap valve.

#### **Texts / References:**

1. J. M. Coulson, J. F. Richardson and R. K. Sinnott, Chemical Engineering Vol. 6, Pergamon press International Ed., 1989.
2. L. E. Brownell and E. H. Young, Process equipment design, John Wiley and Sons, New York, 1968.
3. M. V. Joshi, Process Equipment Design, McMillan, India, 1976.
4. S. D. Dawande, Process equipment design, volume 1, Dennett & Co publishers.

## **CH 3106 Heat Transfer Equipment Design**

### **Unit 1**

Detailed Process Design of Double Pipe Heat Exchangers

### **Unit II**

Detailed Process Design of Shell and Tube heat exchanger

### **Unit III**

Detailed Process design of condenser

### **Unit IV**

Detailed Process Design of Evaporator

### **Unit V**

Detailed process design of Agitator

### **Unit VI**

Detailed process design of Reboiler

### **Text/Reference books:**

1. J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970
2. D. Q. Kern, "Process Heat Transfer", McGraw Hill, 1950.

### **Practicals**

All above designs will be manually calculated and then verified using Aspen Plus software.

## **CH 3107 Chemical Engineering Operations – III Lab**

### **LIST OF PRACTICALS:**

1. Study of Double Pipe Heat Exchanger
2. Study of Shell and Tube Heat Exchanger
3. Study of Study of emissivity of circular discs with and without black coating.
4. Study of Stefan-Boltzman's constant
5. To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.
6. Study of grinding operation
7. Study of crushing operation

## **CH 3108 Organic Chemical Technology Lab**

### **LIST OF PRACTICALS:**

1. Preparation of adipic acid and its analysis
2. Preparation of benzaldehyde and its analysis
3. Preparation of o- and p- nitrophenol and its analysis

4. Preparation of o- and p- nitrobenzene and its analysis
5. Determination of acid value of an oil
6. Determination of saponification value of an oil
7. Determination of iodine value of an oil
8. Preparation of soap and analysis of soap

### **CH 3109 Process Equipment Design and Drawing – I Lab**

#### **LIST OF PRACTICALS:**

Design and Drawing of following units

1. Symbols for process equipments and instruments.
2. Design of catalyst storage tank.
3. Design of jacketed vessel and storage tank.
4. Design of heads and tube sheet layout.

### **CH 3201 Mass Transfer Operations II**

#### **UNIT I**

**Distillation** - Vapour liquid equilibria, flash vapourisation, batch distillation, differential distillation.

#### **UNIT II**

**Continuous fractionation** - Binary systems, Mc-Cabe.Thiele and Ponchon Savarit method calculations with multiple feeds and withdrawal

#### **UNIT III**

**Humidification** - Vapour liquid equilibrium, enthalpy for pure substances, vapour gas contact operation. Psychrometric charts and measurement of humidity

**Dehumidification and Cooling Tower Design** - Adiabatic and non adiabatic operations evaporative cooling, cooling tower design and dehumidification methods.

#### **UNIT IV**

**Drying** - Drying equilibrium and rate of drying, drying operation batch and continuous number of transfer units.

#### **UNIT V**

**Crystallisation** - Theories of crystallisation nucleation and crystal growth. principles of super saturation. different types of crystallisers.

#### **UNIT-VI**

**Special topics in separation:** Types of membranes for osmosis and dialysis; Mechanism of solute/solvent rejection in the process; Design of R.O. and dialysis units; applications.

## **Texts / References:**

- R. E. Treybal, Mass transfer operations, 3ed ed. McGraw Hill, 1980.  
J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergamon press, 1970  
J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970

## **MH 3202 Chemical Reaction Engineering – I**

### **UNIT I**

**Mole Balances** - Definition of the rate of reaction, General mole balance equation, Batch Reactors, Continuous-flow reactors, Industrial reactors

### **UNIT II**

**Conversion and Reactor Sizing** - Definition of conversion, Design equations, Applications of the design equations for continuous-flow reactors, Reactors in series

### **UNIT III**

**Rate-Law and Stoichiometry** - Basic definitions, Approach to reactor sizing and design, Stoichiometric table, Expressing concentrations in terms other than conversion, Reactions with phase change

### **UNIT IV**

**Isothermal Reactor Design** - Design structure for isothermal reactors, Scale up of liquid-phase batch reactor data to the design of a CSTR, Tubular reactors, Recycle reactors

### **UNIT V**

**Collection and Analysis of Rate Data** - Batch reactor data, Method of initial rates, Method of half-life, Differential reactors, Least square analysis

### **UNIT VI**

**Catalysis and Catalytic Reactors** - Catalysts, Steps in a catalytic reaction, Synthesizing a rate law, mechanism and rate-limiting step, Design of Reactors for gas-solid reactions, Heterogeneous data analysis for reactor design

## **Texts / References:**

- H. S. Fogler, "Elements of Chemical Reaction Engineering", 3<sup>rd</sup> Ed, New Delhi-Prentice Hall, 2001  
O. Levenspiel, "Chemical Reaction Engineering" Willey Eastern, 3<sup>rd</sup> Ed., 2000  
J. M. Smith, "Chemical Engineering Kinetics", 3<sup>rd</sup> Ed., McGraw- Hill, 1988

## **CH 3203 Process Instrumentation and Control - I**

### **Instrumentation:**

#### **UNIT I**

Introduction to measurements. Elements of measuring systems and their functions. Signal transmission. Transmitters electronic pneumatic etc.

#### **UNIT II**

Fundamentals of Measuring Devices:

Temperature Measurement : Temperature scales Mercury in glass thermometer, Bimetallic thermometer, pressure spring thermometer, Thermoelectric temperature measurements, thermocouples, thermal well and potentiometers, Resistance thermometer and pyrometers.

#### **UNIT III**

Pressure Measurement : Manometers, Pressure and vacuum gages.

### **Control:**

#### **UNIT IV**

**Introduction:** Block diagrams, closed loop and open loop control systems, Basic control actions.

**Open loop response of simple systems:** Dynamics of first order systems using transfer functions; Various first order response such as, a thermometer bulb. General response to step, ramp, impulse, and sinusoidal inputs; Concentration and temperature responses of a stirred tank;

#### **UNIT V**

Linearization of liquid level systems; Response of a pressure system, second order systems, the manometer; Response of interacting and non interacting systems.

#### **UNIT VI**

**Transient response of control systems:** Servo and regulated operation, General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action.

### **Text / References:**

1. D. P. Eckman, Industrial Instrumentation, Wiley Eastern, 1989.
2. J. P. Bentley, Principles of Measurement Systems, 2<sup>nd</sup> ed. Longman London, 1988.
3. J. W. Dally, W. F. Riley and K. G. McConnell, Instrumentation , Engineering Measurements, John Wiley and Sons, Singapore, 1984.

4. D. R. Coughanowr, Process system analysis and control, 2<sup>nd</sup> ed, McGraw Hill, 1991.
5. P. Harriott, Process Control, Reprint of text, ed. Tata McGraw Hill, 1983.
6. G. Stephanopoulos, Chemical Process Control: An introduction to theory and practice, Prentice Hall, New Jersey, 1984.

## **CH 3204 ENERGY ENGINEERING**

### **Unit 1**

Energy crisis in the world and position in India

**Solid Fuels:** Principal solid fuel-coal, origin, composition and classification of coal, origin, composition and classification of coals, analysis and properties of coal, characteristics and distribution of Indian coals, coal preparation, Storage of coal, coal carbonization, briquetting, gasification and liquefaction of solid fuels.

### **Unit 2**

#### **Liquid Fuels:**

Petroleum and Related Products:

**A** Introduction: Origin, occurrence and reserves, reserves, Production and consumption, classification and characteristics of Petroleum properties and characteristics, petroleum refining in India.

**B.** Refining Unit Process: Cracking, thermal cracking, catalytic cracking, hydrocracking, reforming thermal and catalytic reforming, alkylation, and polymerization, Isomerization.

### **Unit 3**

**C.** Petroleum Products - Naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oils, fuel oils, lubricants, petroleum waxes. Petroleum coke.

**D** Testing of petroleum products:

(i) Physical test: Density and specific gravity, viscosity.

(ii) Chemical test: Organic and inorganic constituents.

(iii) Flammability Test: Flash point, volatility.

(iv) Knock Rating Test: For Gasoline Octane Number.

### **Unit 4**

**Gaseous Fuels:** Types, natural gas, methane from coal mines, producer, water carburetor water, coal, blast furnace and refinery gases, gases from biomass, LPG, gasification of coal and oil, purification of gaseous fuels. Combustion Process and Appliances; Stoichiometry and heat balance calculations, nature and types of combustion processes, mechanism of combustion reaction, spontaneous ignition temperature, gas and oil burners, coal burning equipment's, fluidized bed combustion.

### **Unit 5**

#### **Additional Sources of Energy:**

Nuclear energy: - Nuclear reactions, fuel materials, moderators and structural materials, reactors. Energy by bio-processes-bio-gas Solar Energy - Photovoltaic cells, solar collectors, wind, tidal and geothermal energy.

## **Unit 6**

Furnaces: General classification and description of different types of furnaces with special reference to furnaces used in ceramic, petroleum and pharmaceutical industries.

### **Books Recommended**

1. Samir Sarkar Fuels and combustion, orient longman
2. O.P. Gupta Elements of Fuels, furnaces and Refractories
3. Wilson, P.J., Wells, G.H. Coke, cake and coal chemicals, McGraw Hill
4. Griswold, J. Fuels, combustion and Furnaces, McGraw Hill
5. Francis, W. Fuels and fuel Technology, Vol. I and II Pergamon Press
6. McNeil D Coal combustion products, peragaman Press
7. Haslam, R.T. Russal, R.P Fuels and their combustion, McGraw Hill
7. Brame, J.S. and King, J.C Fuels-solid liquid and Gaseous, St. Martin Press

## **CH 3205 Plant Utilities and Safety**

### **Utilities**

#### **UNIT I**

Identification of common plant utilities: water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and fire fighting.

#### **UNIT II**

Steam generation by boilers: Types of boilers and their operation, Steam generation by utilizing process waste heat using thermic fluids, Distribution of steam in a plant.

#### **UNIT III**

Principles of refrigeration: Creation of low temperature using various refrigerants. Creation of low pressure/vacuum by pumps and ejectors.

### **Safety**

#### **Unit IV**

Safety in Chemical Processes: Introduction, Chemical Process classification, Process design and safety parameters. Safety parameters in the process design of phenol from cumene, safety in polyvinyl chloride plant.

Chemicals and their Hazards: Introduction, Acetonitrile, acetyl chloride, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol, acetaldehyde, ethylene oxide, butane, n-hexane, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, monochloro benzene, oleum, carbon monoxide.

#### **Unit V**

Hazards in Chemical Process plants: Introduction, Hazards, Hazard code and explosive limit, electrical safety in chemical process plants, static electricity hazards, pressure vessel hazards, LEL and UEL of various compounds, explosive hazard, flammable liquid hazards, protection to storage tanks, fire zone location, fireball, fireball hazard.

Safety in handling gases, liquids and solids: Introduction, safety in handling of gases, chlorine hazards, chlorine leakage management, safety in handling of fluorine, important safety considerations in ammonia storage, flammable solids storage, flammable liquid storage, handling of LNG, requirements to be fulfilled for storing hydrocarbons or chemicals, fail safe concept, transportation of hazardous chemicals, Hazardous in plastics processing.

#### Unit VI

Combating Chemical Fires: Classification of fires, control of high vapour pressure fire, fire fighting foams, foam for fire protection, Foam characteristics, gaseous agent extinguishing system, automatic sprinkler system, chemical extinguishing powders, natural gas fire control.

Portable fire extinguishers: Soda-acid extinguishers, carbon dioxide extinguisher, dry chemical fire extinguisher, general safety precautions for maintenance of fire extinguishers.

Safety Checklist: safety studies for chemical plants, safety checklist during startup, safety checklist during shutdown mode, safety checklist for installation, safety needs during construction. Protective devices.

#### **Text / Reference:**

1. D. A. Wingham, Theory and practice of Heat engines, ELBS cambridge University press, 1970.
2. J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall 1970.
3. S.D.Dawande, Chemical Hazards and safety, Dennet & Co publishers, 2007

### **CH 3206 Process Equipment Design and Drawing – II**

#### Unit 1

Detailed Design of Absorption towers

#### Unit 2

Detailed design of Distillation Columns

#### Unit 3

Detailed Design of Reactors

#### Unit 4

Detailed Design of Cooling towers and Dryers

#### Unit 5

Detailed Design of Pumps and Ejectors

#### Unit 6

P& I Diagrams of typical process plants

### **Laboratory**

In the laboratory hours students are expected to complete design calculations and drawing of the equipments which they have been given as assignments. They will also make use of Auto Plant software for preparing P&I diagrams.

### **Text/Reference Books:**

- R. E. Treybal, Mass transfer operations, 3ed ed. McGraw Hill, 1980.  
J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergamon press, 1970  
J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970  
H. S. Fogler, "Elements of Chemical Reaction Engineering", 3<sup>rd</sup> Ed, New Delhi-Prentice Hall, 2001  
O. Levenspiel, "Chemical Reaction Engineering" Willey Eastern, 3<sup>rd</sup> Ed., 2000  
J. M. Coulson, J. F. Richardson and R. K. Sinnott, Chemical Engineering Vol. 6, Pregman press International Ed., 1989.  
L. E. Brownell and E. H. Young, Process equipment design, John Wiley and Sons, New York, 1968.  
M. V. Joshi, Process Equipment Design , McMillan, India, 1976.

### **CH 3207 Mass Transfer Operations – I Lab**

#### **LIST OF PRACTICALS:**

1. To determine the diffusivity of acetone in air
2. To determine the diffusivity of carbon tetra chloride in air
3. To study the absorption with chemical reaction in packed bed
4. To study multistage cross-current leaching operation for calcium carbonate, sodium hydroxide water system.
5. To draw equilibrium solubility diagram for an acetic acid, benzene, water.
6. To study counter-current single stage extraction process for water(A), acetic acid(B) and benzene(C) system
7. To study liquid-liquid extraction in packed bed (HTU/NTU)
8. To study the physical absorption in packed bed (HTU/NTU)

### **CH 3208 Seminar**

Each student is expected to collect information on recent advances in Chemical Engineering by regularly referring to national and international journals and reference books. At the end of the semester he/she is required prepare a report as per the guide

lines prescribed by the Department. Each student will be assigned a guide for this seminar course.

### **CH 3209 Industrial Training**

#### **GUIDE LINES:**

Each student is expected to spend FOUR weeks in any one factory/project/workshop at the end of sixth semester (during summer vacation). Here he/she shall observe layout, working and use of various machinery, plants, design, instruments, process etc. under the general supervision of the foreman/artisan/engineer of the factory etc.

The student shall submit the report in a systematic technical format about the major field of the factory, particularly about the section/department where he/she has received the training giving details of equipment, machinery, materials, process etc. with their detailed specifications, use etc. The report shall be checked and evaluated by the concerned teacher and appropriate grade (PP or NP) shall be awarded.