

## Faculty of Engineering & Technology

### M.Tech. (Petroleum Processing and Petrochemical Engineering)

#### HIGHER MATHEMATICS

Vector differentiation, scalar field, gradient of a scalar field, vector field, divergence & curves of vector fields, solenoidal angle and irrotational field. Determination of potential function.

Vector integration, line integral, conservation fields, Gauss divergence theorems, Greens theorem and Stokes theorem.

Laplace's transformation, shifting theorems, transforms of derivatives and integrals. Differentiation and Integration of transforms. Inverse transforms, Application with single and system of linear differential equations.

Boundary Value Problems, solution of 2D laplace equation in Cartesian and polar co-ordinates, solution of one dimensional diffusion and wave equation by method of separation of variables.

#### BASIC PRINCIPLES OF CHEMICAL ENGINEERING

Introduction to Chemical Engineering and role of Chemical Engineer, Units and dimensions, stoichiometric and composition relationship, application of thermodynamics and chemical principles in estimation of physical properties, ideal and real gas laws, critical properties, properties of mixtures and solutions, phase equilibria, vapor pressure

Material balance without and with chemical reactions

Energy balance without and with chemical reactions

Combined material and energy balance: Psychrometry, unsteady state material and energy balance, industrial applications.

#### PETROCHEMICAL TECHNOLOGY

History and importance of Petrochemical industry, growth in India, Classification of Petrochemicals, Feedstock of the Petrochemicals, Preparation of feedstock, Primary cracking reaction-ethane cracking, propane cracking, naphtha and gas oil cracking; secondary reactions, recovery and separation of the feed stocks.

Petrochemicals from C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, & aromatics.

Mechanism and back ground of catalytic & non catalytic reactions of hydrocarbons, cracking, reforming, pyrolysis, alkylation.

Polymerization & oligomerization, Isomerization, hydrogenation, hydrodealkylation, disproportionation, nitration.

Methanol, formaldehyde, Ethylene oxide and glycol.

Acrylates, Methyl methacrylate, Acrylic acide, DMT, terephthalic acid

Phenol, acetone, linear alky benzene, caprolactum

Vinyl chloride, styrene, phthalic anhydride, maleic anhydride

Properties, applications and production technologies of the following commodity polymers – polyethylene, LLDPE, HDPE, polypropylene, polystyrene, PVC.

Properties, applications and production technologies of the following engineering and thermoset polymers: ABS plastic, nylon-6, polycarbonate, epoxy resin, unsaturated polyester resin, rubber.

## **FLUID MECHANICS & MECHANICAL OPERATIONS**

S.I. Units and dimensions, Types of Fluids: compressible & incompressible, Newtonian and non Newtonian, Pascal's Law Hydrostatic law, peizometric head, Manometers Buoyancy. Fluid Flow Operation: Pipe and tubes, pipe fittings, Bernoulli's equation application, application to pumps and blowers. Measurement of fluid flow through pipes, orifices meter, venturimeter, pitot tube, Rota meter. Fluid machinery, classification and performance of pumps, selection and specifications.

Particle size analysis, shape factor, sieve analysis cumulative and differential plot, size distribution, equivalent particle diameter, volume surface mean diameter, median diameter surface area and particle populations of a mixture, size estimation in subsive range, particle cut diameter. Ideal and actual screen operation efficiency capacity and effectiveness of screens Industrial screens.

Size reduction: Theory of crushing, laws of combination, power requirement. Types of crushers and grinders, principles and operations of industrial crushers and grinders, close and open grinding. Storage of Solids: characteristics of solid masses, bins, silos, hoppers, Janssen's equation.

Particle Mechanics: Drag From immersed body, Laws of motion of Particles or drops in a fluid, calculation of terminal settling velocity in stokes, Transition and Newton ranges. Particle Separation: Free and hindered settling sedimentation elutriation, settling chambers batch and continuous thickness, floatation cell Characteristics of rotating fluids centrifuges and cyclone separation, Venturi scrubber, Electro-static precipitator

Flow Through Packed Beds: Types of packing, Characteristic of packing, pressure drop in packed beds Kozeny-Carman equation, flooding and loading. Fluidization: General Characteristics of fluidized beds, aggregate and particulate fluidization, calculation of incipient fluidization velocity. Filtration Theory of filtration and washing filter aids, filter media types of filtration plate and frame filter press, rotary drum filter.

## **REACTION KINETICS AND REACTOR DESIGN**

Rate of Reaction , elementary and non-elementary reactions molecularity and order of reaction, thermodynamics formulations of rates, mechanism of reaction, Temperature dependency from thermodynamics, arrhenius, collision and activated complex theories,

Integral and differential methods for analyzing kinetics data, interpretation of constant volume batch reactor data for zero, first second and third order reactions, half life period, irreversible reactions in parallel and series, auto catalytic reaction, shifting order reactions enzyme catalyzed and surface catalyzed reactions. Interpretation of variable volume batch reactor data for zero, first and second order reactions.

Design equations for batch, plug flow, back mix, flow and semi batch reactors for isothermal, adiabatic reactions holding time and space time for flow system Design of batch plug flow and mixed flow reactors for first and second order single reactions. Optimum reactor size plug flow reactors in series / parallel Equal and different size of mixed reactors in series and finding the best system for a given conversion recycle reactor

Multiple reactions, independent, parallel and series reactions; mixed reactions, instantaneous and over all fractional yield, choice of reactors for simple and complex reactions and multiple reactor system; Introduction to thermal stability of reactors; temperature and pressure effects and optimal temperature progression for first order reactions. Introduction to Residence time Distribution of fluid in Vessel.

## **CHEMICAL ENGINEERING THERMODYNAMICS**

The scope of thermodynamics, dimensions and units, measures of amount or size, force, temperature, pressure, work, energy and heat.

The first law of thermodynamics and other basic concepts, Joules' experiment, internal energy, the first law of thermodynamics, energy balance for closed systems, thermodynamic state and state functions, equilibrium, the phase rule, the reversible process, constant volume and constant pressure process, enthalpy, heat capacity.

The second law of thermodynamics, statements of the second law, heat engines, thermodynamic temperature scales, entropy, entropy changes of an ideal gas, mathematical statement of the second law, entropy balance for open systems, calculation of ideal work, the third law of thermodynamics.

Refrigeration and Liquefaction: the Carnot refrigerator, the vapour – compression cycle, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction process. Vapour-Liquid Equilibrium: The nature of equilibrium, the phase rule-Duchem's theorem, VLE –Quantitative behaviour, VLE by modified Raoult's Law, VLE from k-value correlations.

Solution thermodynamics: theory, fundamental property relation, the chemical potential and phase equilibria, partial properties, ideal-gas mixtures, fugacity and fugacity coefficients, pure species, species in solution, generalized correlations for the fugacity coefficient, the ideal solution, excess properties. Application ; liquid phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing, heat effects of mixing processes.

Chemical Reaction Equilibria: The reaction coordinate, application of equilibrium criteria to chemical reactions, the standard Gibbs. Energy change and the equilibrium constant, effect of temperature on the equilibrium constants, relation of equilibrium constants to composition, equilibrium conversions for single reactions, phase rule and Duhem's theorem for reacting systems.

## **PROCESS DEVELOPMENT AND EQUIPMENT DESIGN**

Principles of process synthesis: reaction path synthesis, species allocation, separation task selection, task integration.

Diagrams for understanding chemical processes: Block Flow Diagram, Process Flow Diagram, Piping & Instrumentation Diagram. Structure and synthesis of process flow diagrams.

Chemical product design, tracing chemicals through the process flow diagram, understanding process conditions.

Introduction to design codes, design of cylindrical and spherical shells, design of storage tanks, designs of tall vertical vessels, selection and design of flanges and supports for equipment.

## **CRUDE OIL AND PETROLEUM PRODUCTS**

Origin and formation of Petroleum, Reserves and deposits, Indian Petroleum Industry, Composition of crude Oils, ultimate and chemical composition, non-hydrocarbons in petroleum, Asphaltenes and Resins, classification of petroleum, evaluation of crude oil, Bench mark crudes.

Characterization of crude oils : TBP and ASTM distillation, Classification by chemical composition, Correlation Index, Density, API gravity, Viscosity, UOP characterization factor, etc. Physical & Thermal properties of petroleum, ASTM, TBP, EFV distillation curves.

Distillation: Pretreatment, Electric desalting, atmospheric and vacuum distillation, petroleum products and their quality control tests.

Value addition of petrochemicals from feedstock to consumer end products, chemical reactions of hydrocarbons like Decomposition (Thermal & Catalytic), Halogenations, Isomerization, Hydrogenation, Alkylation, Nitration, Sulfonation, etc. with chemistry and reaction mechanism. Fuel Additives and blending, Euro & Bharat standards.

## **PETROLEUM ENGINEERING**

Overview & Structure of Petroleum Industry, Origin and occurrence of oil & gas, migration and accumulation of oil and gas, source and reservoir rocks, physical properties of oil bearing rocks, carbonate reservoirs, fracture, anticlines etc, types of reserves fluids, rocks and fluid properties.

Oil & gas exploration methods, direct oil finding methods, geological and geophysical methods, basics principles of oil field development planning

Introduction to drilling operations, planning of drilling programme, drilling equipment, basics of drilling mud functions, well completion fundamentals.

Production principles, types of reservoir drives, primary oil recovery, secondary oil recovery, enhanced oil recovery methods.

## **PETROLEUM REFINING PROCESSES**

Thermal conversion processes like Visbreaking, Delayed Coking, Fluid coking, Flexicoking,.

Catalytic conversion processes - fluid catalytic cracking, RFCC, DCC, Hydrocracking, Hydrotreating processes.

Reforming, hydrogen production, Alkylation, Polymerization, Isomerisation.

Evaluation of crude for LOBS, Production of lubes and waxes.

## **HEAT TRANSFER OPERATIONS**

Steady State heat conduction in one dimension: heat conduction through plane wall, composite wall, single layer cylinder, multi layer cylinder, sphere, Fourier's Law of conduction and thermal conductivity, critical thickness of insulation, overall heat transfer coefficients. Forced Convection: forced convection past planar surface, inside cylindrical pipes and tubes and in non-circular sections, forced convection for external flow normal to tubes, tube banks.

Heat Transfer by Free Convection: Governing equation for free convection, working correlations for free convection, analytical solution of free convection past vertical plane surfaces. Heat Transfer in Boiling and Condensing: working correlations of film condensation, dropwise condensation, heat transfer for boiling of a liquid, working correlations for pool boiling, forced convection boiling.

Heat transfer by radiation: basic definition, laws of radiation, black body, gray body, shape factors. Heat Exchangers: Various types, general characteristics, overall heat transfer coefficient of heat exchanger, heat exchanger mean temperature difference, heat exchanger effectiveness and number of transfer units, performance of heat exchanger and design of heat exchanger.

Evaporation and Evaporators: types of evaporators, their construction and operation, evaporator auxiliaries, principles of evaporation, single effect evaporator, multiple effect evaporator, modes of feed supply to the evaporator, evaporator selection, effect of boiling point on multiple effect Evaporator.

## **PLANT DESIGN AND ECONOMICS**

Introduction, Process Design development, General design considerations, Cost and asset accounting, Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment.

Organizations for presenting capital investments, estimates by compartmentalization, estimation of total product of cost direction, production costs, fixed charges, plant overhead costs, financing, Interest and investment cost, type interest, nominal and effective interest rates, continuous interest, present worth and discount annuities, cost due interest on investment, source of capital.

Taxes and insurances, type of taxes: federal income taxes, insurance-types of insurance, self insurance, Depreciation: types of depreciation, services life, salvage value, present value, methods for determining depreciation, single unit and group depreciation.

Profitability: alternative investments and replacements, profitability standards, discounted cash flow, capitalized cost, pay out period ,alternative investments, analysis with small investments, increments and replacements.

## **POLYMER SCIENCE AND TECHNOLOGY**

Classification of polymers, , Linear branched and cross – linked polymers, Molecular weights of polymers, Polydispersity and Mol. Wt. distribution in polymers, Random, alternate, block and graft co – polymers, polymer characterization techniques, polymer degradation.

Kinetics of chain & Step polymerization, techniques of molecular weight control, Initiators, Chain transfer agents, Inhibitors. Techniques of polymerization Bulk, Solution, Suspension & Emulsion polymerization.

Introduction to polymer rheology, Newtons law of viscosity, viscometris plots, rheometers, rheological models, theory of viscoelasticity, Tg, Heat distortion temperature.

Basic concept of polymer processing: Compounding methods, Extrusion molding, Injection molding, Blow molding, Rotational molding. Introduction to fiber reinforced plastics.

## **PROCESS DYNAMICS AND CONTROL**

Process Control systems, Basic Concepts in Process Control., Process variables, control configurations & physical elements of a control System, Block diagrams, Dynamic Modeling of processes, Linearization of Non-linear systems,

Response of first order system, Response of first order system in series (Interacting and non- interacting systems) , Second order system, Dynamic Response of second order system Transportation

Closed loop transfer functions, Modes of control action, Classification of Controllers, Transient response of some simple control systems. Stability analysis of control systems, Root locus Method, Controller Tuning, Frequency response analysis, Bode diagrams, control system design by frequency response, Bode stability criterion, Nyquist plots.

Introduction to Advance Control Systems, Control systems with multiple loops, feed forward and Ratio Control systems. Process Control using Digital Computers, Reconstruction of continuous signals from their discrete-time values, conversion of continuous to discrete time models, Z- transforms.

## **TRANSPORT PHENOMENA**

General Introduction to Transport Processes: analysis of momentum transport process, principle of shell balance, laminar, rectilinear steady flow of incompressible fluids in conduits and thin layer. Flow of falling film, flow between parallel plates, flow through circular pipes, capillary flow viscometer, flow through annular, adjacent flow of two immiscible fluids.

Analysis of thermal transport processes: Fouriers law of heat conduction, steady one dimensional heat conduction without and with internal heat source, conduction through plane wall, hollow cylinder, composite wall, multilayer cylinder, overall heat transfer coefficient, critical thickness of insulation, heat conduction with internal electrical/nuclear/viscous and chemical heat.

Analysis of species transport processes: Definition of concentration, velocity, flux in multi species system, Fick's Law of diffusion, continuity equation for binary system and transport of species through annulus.

Macroscopic Analysis of momentum, heat and species transport: Macroscopic mass balance, momentum balance, mechanical energy balance, use of macroscopic balance equations, power requirement for pipeline flow, efflux time of tank. Interphase transport of momentum/ heat/ species in turbulent flow: definition of friction factor, heat transfer coefficient, binary species transfer coefficient, interphase momentum/ heat/ species transport in circular tubes.

## **MASS TRANSFER OPERATIONS**

General Introduction: Mass transfer operations and its classifications, Diffusion mass transfer, Mass transfer coefficient, Mass transfer models, Mass transfer with chemical reactions

Gas Absorption Operations: Equilibrium, Choice of solvents, co-solvents, co-current and counter current operations, packed bed and staged columns.

Humidification Operations: Psychrometry, Adiabatic humidification and dehumidification operations, Packed bed columns, Humidification equipments. Drying: Fundamentals, drying curves, equipment for drying

Equipment for Gas-Liquid Operations: Sparged vessels, mechanically agitated vessels.

## **NATURAL GAS PROCESSING**

Natural Gas-origin and occurrence, properties of natural gases, phase behavior of Natural Gas systems, vapor liquid equilibrium calculations.

Natural gas- liquid separation, separation principles, separation equipment, low temperature separation.

Water-hydrocarbon phase behaviour, measurement of water content in Natural gases, Hydrate formation and prevention of hydrates, Gas dehydration- types of processes.

Acid gases in natural gas, acid gas treatment, types of processes. Natural gas storage, Natural gas liquids removal, Transportation of Natural Gas, LNG chain.

## **INDUSTRIAL INSTRUMENTATION**

Classification of measuring instruments, dynamic and static characteristic, introduction to various process variables, introduction to modern techniques for temperature, pressure, flow, motion, level measurement, etc.

Introduction to analog transducers, digital transducers, A to D and D to A conversion, intermediate elements, amplifiers, compensator, filters, data transmission.

Application of digital computation in large-scale industries/complexes, input output structure, interfacing techniques, Human Machine interface, touch screen system.

Introduction to Programmable Logic Controller (PLC), Structure, ROM, EPROM and EEPROM. Input/output cards, Introduction to PLC programming, introduction to DCS system, modern methods of instrumental analysis.

## **FERTILIZER TECHNOLOGY**

Sulphuric Acid, Nitric Acid, and phosphoric acid, Biofertilizers , case studies.

Macro- and micro nutrients, fertilizer Grades, Various fertilizers and their demand and production in India, Synthesis gas with reference to various feed stocks and technologies.

Nitrogenous fertilizers , Nitrogen , Hydrogen , Ammonia Synthesis , Urea , Ammonium Sulphate, Ammonium Nitrate , Calcium Ammonium Nitrate.

Phosphatic fertilizers, super phosphate , Triple super phosphate, Mono and diammonium phosphate , Nitro phosphate , Mixed Fertilizers ,.

## **SEPARATION PROCESSES**

Introduction to separation processes, Phase equilibrium thermodynamics, Flash calculation, Distillation: Flash distillation, Differential distillation & Steam distillation; Binary distillation, Multi stage tray towers; McCabe & Thiele method, Ponchon & Savarit method, Continuous contact system (packed towers).

Multi-component distillation, Adsorption: Adsorption Equilibrium, Fixed bed adsorption column, Ion exchange method

Liquid-Liquid Extraction: Extraction Equilibrium, Extractive solvent, Extraction equipment, Multistage cross current and counter current operations, Liquid-solid leaching operation.

Membrane Separation Processes: Types of membrane process, liquid and gas permeation membrane process, types of membrane, Applications