3.1 FLUID FLOW

L	T	P
4	-	3

RATIONALE

This subject aims at the basic concepts of fluid flow, measurement techniques involved for the same and equipments used for the transportation of fluids. With this background, students will be able to quantitatively find out material and power requirement for a process.

DETAILED CONTENTS

1. Various types of flow – steady and unsteady, uniform and non-uniform flow, streamline flow, laminar and turbulent flow, rotational and irrotational flow. (7 hrs)

   - Types of fluid: compressible and incompressible fluid, Newtonian and non-Newtonian fluid, properties of fluids.

2. Fluid statics and dynamics, Pascal's law, hydrostatic law, various types of manometers : U tube manometer and differential manometer. (17 hrs)

   - Continuity equation, Bernoullis theorem, flow through pipes and open channels: Hagen poiseulli's equation, friction factor charts, friction losses in pipes, friction loss from sudden enlargement and contraction, effect of roughness in pipes.

   - Simple numerical problems related to the above topics.

3. Flow measurement: flow through venturimeter, orifice meter, flow nozzle, pitot tube, rotameter. (10 hrs)

4. Flow through Fluid Machinery. (30 hrs)

   - Classification of pumps, construction and working of reciprocating pump, centrifugal pump and rotary pump, priming and NPSH, cavitation, power requirement, efficiency of centrifugal pump, specific speed. Blowers and compressors.

   - Pipe and Fittings: Different types of pipes, schedule Number, ID and OD of pipe, colour coding of industrial piping used for transportation of various fluids, different types of valves and fittings: Globe valve, Butterfly valve, Gate valve, Ball valve and Needle valve.

   - Dimensional analysis: Rayleigh's method, Buckingham Pi method, dimensionless numbers and their significance.

LIST OF PRACTICALS

1. Verification of Bernoullis equation
2. Determination of friction loss in flow through pipe
3. Calibration of orifice meter and calculation of Cd, Cv, Cc
4. Calibration of Venturi meter
5. Calibration of Rotameter
6. Determination of discharge coefficient of V-notch
7. Study of constructional feature of centrifugal, gear, reciprocator diaphragm pump, blower and compressors and assembling and disassembling
8. Study of characteristics, curves of centrifugal, reciprocating pump
9. Study of fluidized bed characteristics
10. Calculation of Reynolds number

INSTRUCTIONAL STRATEGY

The students should be imparted theoretical as well as practical knowledge about all the topics supplementing with electronic media.

RECOMMENDED BOOKS

1. Unit Operations of Chemical Engineering by McCabe W.L. & Smith J.C. McGraw Hill.

2. Chemical Engineering Hand Book by Perry K. Chilton.

3. Chemical Engineering Vol.I and II by Coulson and Richardson. Pergamota Press Publications.

4. Introduction to Chemical Engineering by Bedger and Banchero, McGraw Hill Publication.

5. Principles of Unit Operations by Alen Foust, John Willey Publicaiton.

6. Chemical Engineering Fluid Mechanics by K.A. Gavahane, Nirali Publications.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1.	7	10
2.	17	30
3.	10	15
4.	30	45
Total	**64**	**100**

3.2 MECHANICAL OPERATIONS

L	T	P
3	-	3

RATIONALE

This subject will impart knowledge to the students on working of individual mechanical operations and their significance in chemical industries. With this information student can control the operation of equipment and regulate production.

DETAILED CONTENTS

1. Characterization of Solid Particles (8 hrs)

   Particle shape, particle size, mixed particle sizes and size analysis, expressions for specific surface of mixture, average particle size, number of particles in mixture (no derivation).

2. Size Reduction (14 hrs)

   i) Energy and power requirements in crushing, crushing efficiency, mechanical efficiency, expression for power required by machines.

   ii) Crushing laws: Rittinger's law, Bond's law and Kick's law

   iii) Size reduction equipment: classification and names; study of machines: Blake crusher, Jaw crusher, Dodge crusher, Grinding rolls, Roll crusher Impactor, Attrition mill, Ball mill, Fluid energy mill, Colloid mill, Rotary knife cutter, Flow sheet for closed circuit grinding

3. Mechanical Separation (26 hrs)

   i) Screen analysis, Tyler standard screen series, material balances over screen capacity and screen effectiveness, definition and final expression only.

   ii) Screening equipment: Gyrating screens, Stationary screens and Grizzlies vibrating screens

   iii) Filteration: (Qualitative treatment only) classification of filteration, filter media, filter aids, mechanisms of filteration, discontinuous pressure filters, Filter press, Shell and leaf filters; Continuous: Vacuum filters, Rotary drum filters, Centrifugal filters; Suspended batch centrifuges; Clarifying filters.

   iv) Separation based on the motion of particles through fluids; Gravity classifiers, Sorting classifier; Thickeners: Batch sedimentation, rate of sedimentation; centrifugal settling process: Cyclone, Hydro-cyclone, Tabular centrifuge, Disk centrifuge, Nozzle discharge centrifuge

v) Mixing of solids and pastes, Change can mixer, Double motion paste mixers, Two arm Kneader, Kneader and disperser blades

LIST OF PRACTICALS

1. To find the sieve analysis of a given sample of solid particles by sieve shaker
2. To determine the grindability of solids by ball-mill
3. To determine the crushing efficiency by a roll crusher using a sample of solid particles
4. To find the rate of filtration with the help of filter press
5. To perform an experiment on rotary vacuum filter and find rate of filtration
6. To perform an experiment on a cyclone separator and find collection efficiency
7. To perform an experiment on mixers for liquid-liquid mixing and find rate of mixing
8. To perform an experiment on mixer for solid-liquid mixing and find rate of mixing
9. To perform and experiment on separation of solid particles using a sedimentation tank

INSTRUCTIONAL STRATEGY

Adequate competency needs to be developed by giving sufficient practical knowledge to mechanical operation (characterization of solid particles, size reduction, energy requirement and mechanical separation). A field visit may be conducted to expose the working of various conveyers and filtration equipment in industries.

RECOMMENDED BOOKS

1. Chemical Engineering, Vol. I and II by Coulson and Richardson, Pergamon Press Publication
2. Unit Operation of Chemical Engineering by McCabe and Smith; McGraw Hill Publication
3. Introduction to Chemical Technology by Badger and Banchero, McGraw Hill Publication
4. Fluid Mechanics and Its Applications by Gupta and Gupta, Wiley Eastern Publication
5. Principles of Unit Operations by Alen Foust, John Wiley Publication
6. Unit Operations-I, by KA Gavahane, Nirali Publication
7. Unit Operations by Chattoupadhay.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1.	8	20
2.	14	30
3.	26	50
Total	**48**	**100**

3.3 CHEMICAL PROCESS CALCULATIONS

L	T	P
4	-	-

RATIONALE

This subject provides the knowledge of material and energy requirements for a process and with this knowledge raw material requirement for a given process can be calculated.

DETAILED CONTENTS

1. Definition of Chemical Engineering with brief history, future and career opportunities for chemical engineers. (4 hrs)

2. Difference between Unit Operations and Unit Processes. (6 hrs)

3. Units and dimensions, inter conversion of units of pressure, volume, force, work, energy, viscosity, temperature, specific gravity and heat in S1, CGS, MKS and simple numerical problems. (10 hrs)

4. Boyle's law, Charle's Law, Ideal gas equation, Dalton's law, Amagat's law, Relation between Vol% = Mole% = Press%, Average molecular weight of gas mixture, Density of gas mixture and simple numerical problems. (6 hrs)

5. Concept of mole, gm moles, gm atoms, mole fraction and concentration of solution in different ways like molarity, molality and normality, mass%, mass fraction, volume%, volume fraction. (6 hrs)

6. Definition and meaning of material balance, basic steps to be followed in the material balance calculation, numerical problem based on material balance without chemical reaction; unit operations like distillation, drying, evaporation, meaning of by bass, recycle and purge system of material balance. (12 hrs)

7. Definition and meaning of energy balance, standard heat of reaction, and formation, sensible heat, latent heat, heat capacity at constant pressure, relation between Cp and Cv, standard heat of reaction: heat of formation and heat of combustion, Hess's law of constant heat summation. (10 hrs)

8. Definition of combustion, heat of combustion, air requirement (theoretical air, excess air and theoretical oxygen requirement). (10 hrs)

INSTRUCTIONAL STRATEGY

Emphasis should be laid on problem solving in all the area of material and energy balance. Simple practicals relating to wet bulb temperature, dry bulb temperature and humidification chart should be done. Students should be encouraged to make flow sheets for various processes. This will help the students to understand the subject better and solve intricate problems in various areas.

RECOMMENDED BOOKS

1. Solved Example in Chemical Engineering by G.K. Roy, Khanna publication.

2. Chemical Process Principles by Hougen and Watson, Wiley International Edition.

3. Stoichiometry by Bhatt and Vohra,Tata McGraw Hill Publicaiton.

4. Basic Principles and Calculations in Chemical Engineering Himmelblaw, Prentice Hall Publication.

5. Stoichiometry by K.A. Gavhane, Nirali Publishers

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1.	4	5
2.	6	10
3.	10	15
4.	6	10
5	6	10
6	12	20
7	10	15
8	10	15
Total	**64**	**100**

3.4 PULPING PROCESSES

L	T	P
4	-	3

RATIONALE

Students will be given the idea of various processes to convert raw material to pulp. The status of Indian Industries in relation to pulp making should be imparted to them. The use of pulp for various types of papermaking should also be emphasized

DETAILED CONTENTS

1. Raw Material (10 hrs)

   Introduction to paper on network of cellulosic fibrers. Brief study of fibrous raw materials and their classification, their sources and availability in the context of Indian paper industry.

2. Introduction (12 hrs)

   i) Introduction to pulp and paper making with block diagram
   ii) Definition of pulping
   iii) Morphological analysis of fiber
   iv) Brief description of cellulose, hemi cellulose, lignin and extratives

3. Raw Material Preparation (12 hrs)

   i) Importance
   ii) Brief study of debarking: physical debarking (drum, disk and hydraulic and mechanical de-barker) chemical debarking
   iii) Chipping: definition, purpose and equipment (description of drum and disk chipper)
   iv) Chip screening: different types of screens (vibrating and gyratory)
   v) Chip storage: open and close

4. Pulping Process (16 hrs)

   i) Basic definition and standard terms used in pulp and paper industries Active Alkali (AA), Total Alkali (TA), Total titrable alkali, effective alkali, white liquor, black liquor and green liquor, sulphidity, causticity and causticizing efficiency

ii) Types of pulping:

(a) Chemical pulping: alkaline pulping (soda and sulphate pulping process), Acidic pulping (very brief review)
(b) Mechanical pulping: Stone ground wood, process description and factors affecting stone ground wood
(c) Semi-Chemical pulping: Brief description of process (excluding types of semi-chemical pulping)
(d) Scope and significance of bio-pulping, anthraquinon pulping, extended delignification etc.

5. Pulping Equipment (12 hrs)

Different types of digestors: Continuous digestors (Kamyar & Pandia), batch digestors (Rotary and Stationary), Outlines of secondary fibre pulping, Simple calculations based on yield, Consistency and other chest capacity.

LIST OF PRACTICALS

1. Determination of moisture content in bamboo/wood/bagasse pulp
2. Determination of basic and bulk density of chips
3. Preparation and analysis of sulfate cooking liquor
4. Determination of alcohol benzene solubility of pulp
5. Determination of Hollocellulose content
6. Determination of Ash conent of raw materials/pulp
7. Determination of hot water solubility of pulp
8. Determination of cold water solubility of pulp
9. Determination of one per cent NaOH solubility of pulp
10. Determination of $KMnO_4$ number of unbleached pulp
11. Determination of kappa number of unbleached pulp
12. Cooking of given raw material (soda process)
13. Cooking of given raw materials (sulphate process)

INSTRUCTIONAL STRATEGY

Pulping process is fundamental to Pulp and Paper industry. It is important to have good understanding about various pulping processes. Since this is an important core subject of pulp and paper Technology. It is very essential for the teacher to make the students very clear about the various raw materials preparation and pulping processes. Industrial visit will make the students familiar with different types of pulping equipments.

RECOMMENDED BOOKS

1. Pulp and Paper Chemistry and Chemical Technology Vol. 1 by JP Casey
2. Pulp and Paper Making by Libbey
3. Handbook for Pulp and Paper Technologies by GA Smook

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (hrs)	Marks Allotted (%)
1	12	15
2	12	20
3	12	20
4	16	25
5	12	20
Total	**64**	**100**

3.5 PULP WASHING AND CLEANING

L	T	P
4	-	-

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 (06 hrs)

   General Principle and objectives of washing

2. Brown Stock Washing (20 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

3. High Efficiency Washing (20 hrs)

   - 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

4. Screening (18 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

INSTRUCTIONAL STRATEGY

Pulp washing, screening and cleaning are fundamental processes after pulping section. It is important to have good understanding about washing, screening and cleaning of pulp. Since this is an important core subject of Pulp and Paper Technology, it is very essential for the teacher to make the students very clear about the above processes.

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

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (hrs)	Marks Allotted (%)
1	06	10
2	20	35
3	20	30
4	18	25
Total	**64**	**100**

3.6 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 (10 hrs)

   Bleachability and its measurement, simple numerical problems based on bleachability

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 ECF, TCF (Total Chlorine Free) bleaching and use of sulphamic acid, ozone bleaching (10 hrs)

4. Preparation of bleaching chemicals, like calcium hypochlorite, chlorine dioxide (12 hrs)

   Important equipment used in bleach plant like agitator, tower, chlorine mixer, and washer

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

INSTRUCTIONAL STRATEGY

Pulp bleaching is basic process in pulp and paper industry. It is important to have good understanding about pulp bleaching.

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

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (hrs)	Marks Allotted (%)
1	10	20
2	12	25
3	10	20
4	12	25
5	04	10
Total	**48**	**100**