5.1 QUALITY CONTROL AND TESTING OF RUBBER & PLASTICS – I

L	T	P
5	-	4

RATIONALE

It is necessary to test the new materials and the product during various stages of their manufacture to control the quality. The subject provides the essential knowledge and skills for the tests to measure variation and determination of plastic and rubber. This enables the students to take corrective action to be taken in factory to improve the uniformity and serviceability of the finished articles.

DETAILED CONTENTS

1. Over view of various testing methods and organization such as ASTM, BIS, DIN & ISO **(08 hrs)**

2. Test preparation methods: milling, punching, template, cutting from sheets and film products. **(08 hrs)**

3 Amino plastics-introduction ,Urea formaldehyde resin ,.

Melamine formaldehyde resin-introduction, theories of resinification. Melamines phenolic resins, aniline –formaldehyde resins.curing of glycedaple resin

Poly ester resin-introduction , theories of resinification. epoxide resin-introduction, theories of resinification.

Preparation of resin from bis Phenol A.Preparation of Epichlorohydrin.
Application of urea formaldehyde resin, Melamine formaldehyde resin Poly ester resin and Epichlorohydrin **(22 hrs)**

4. Tests for Plastic

(a) Physical properties: Visual burning and heating, specific gravity, water absorption, Moisture content analysis. **(08 hrs)**

(b) Test for readily detectable elements and group analysis **(08 hrs)**

(c) Physical Testing of Plastics: Mechanical properties:
Short term mechanical properties: Tensile strength, impact strength (izod & Charpy) flexural strength, fatigue resistance, compression strength,.

Short term mechanical properties: Creap and stress relaxation **(10 hrs)**

LIST OF PRACTICALS

1- Study and design impact strength (izod and charpy).
2. Study stress and creep relation via curve.
3- Study the Melt Flow Index (MFI).
4- Study flexural strength..
5- Study compressive strength..
6 - Study fatique resistance.

INSTRUCTIONAL STRATEGY

It is a practical oriented subject which should be taught along with practicals like those for mechanical properties and physical characteristics.

RECOMMENDED BOOKS

1. Testing of Plastic by Roger Brown
2. Plastics Testing: Vishu Shah
3. Rubber Technology & Alexander S. Craig, liver & boyd Publsihers
4. Rubber Technology and Manufacture by G.P. Maurya SBP Publishers
5. Polymer Science and Technology, Premamoy Ghosh (2nd Ed.), Tata McGraw

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	08	15
2	08	15
3	22	40
4	08	10
5	08	10
6	10	10
Total	**64**	**100**

5.2 RUBBER AND PLASTIC PROCESSING

L	T	P
6	-	4

RATIONALE

The purpose of this subject is to equip the students with the knowledge of Extrusion Process, Blow Moulding and Calendering Operations. This subject develops the competence of the students in major industrially practical processing techniques.

DETAILED CONTENTS

1. Extrusion Process

   (a) Introduction to extrusion process **(33 hrs)**
   Different types of extrusion (Ram, Single Screw, Twin Screw, Vented Barrel Extruder). General/principle of operation, functions of various parts of extruder (barrel, screw,screen, die, breaker plate, and adopter)

   (b) Types of screws

   For use of different plastics, heating systems and different zones (feed, compression and metering)

   (c) L / D ratio, compression Ratio, and processing output calculation .

   (d) Blown film production, pipe, wire and cable coating , cooling rings, guesseting device, bubble casing, winding equipment, stretching and orientation, effect of variables on product quality.

2. Co – Extrusion Process – Blow moulding **(21 hrs)**

   (a) Principles, process parameters, description of blow moulding machines, types of materials used and limitation of blow mould, and its significance.

(b) Blow moulding of irregular containers.

(c) Decoration of Blow Moulding products

3. Calendaring **(10 hrs)**

Process, material used, advantages of calendaring over extrusion, coating by calendaring.

LIST OF PRACTICALS

1. Study of single screw extrusion
2. Study the calendaring process
3. Study of pipe and wire coating
4. Study of blow moulding machine.
5. Study of bag making process.
6. Study of feed ,compression and transmission zone of extruder.
7. Study of blow moulding parameter.

INSTRUCTIONAL STRATEGY

As the subject involves lot of processing, field visit is must to give details about various processing techniques used in rubber as well as plastic industries. Small and simple experiments/practicals will give idea about operational aspect of rubber and plastic industries.

LIST OF RECOMMENDED BOOKS

1. Plastic Engineering Handbook by Michael L. Berins
2. Plastic Extrusion Technology by Griff, Reinhold Book Corporation., London
3. Plastic Processing Data Handbook by DV Rosato
4. Extrusion of Plastics by Fischer, Itiffe London Publication.
5. Blow moulding by Fischer, Itiffe London Publication.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	33	55
2	21	40
3	10	15
Total	**64**	**100**

5.3. COMPOSITE TECHNOLOGY

L	T	P
6	-	4

RATIONALE

This course is designed to enable the students to acquire basic knowledge of reinforced plastics. The acquired knowledge will help the students in identifying the need for reinforcements, types of reinforcements and applications of reinforced plastics. Topics like nano-technology will help the students to keep abreast with the latest technological developments.

DETAILED CONTENTS

1. Introduction to composites . Advantages over virgin materials **(06 hrs)**
   Principle of Composite Reinforcement

2. Classification of Composites (Properties and advantages) **(06 hrs)**

   - Particulate reinforced
   - Fibre reinforced (FRP)
   - Laminates

3. Particulate Reinforced Composites **(16 hrs.)**
   (a) Different types of particulates; carbon black,. High Silica, Mica, graphite fibre , quartz, comparation of high silica and quartz on the basis of property. $CaCO_3$, metallic powder, nano particulates.

   (b) Preparation,and properties of particulate reinforced plastics
   (c) Application of particulate reinforced composites

4. Fibre reinforced plastics **(20 hrs)**

   Properties, composition and advantages of various types of fibers; Carbon, glass fibers (different types) natural fibers (jute, aramid) boron fibers, man made fibers (acrylic, nylon)

   Properties and application of FRPs including

   - Glass fibre reinforced polyesters
   - Glass fibre reinforced epoxies
   - Glass fiber polyurethenes
   - Carbon fibre reinforced epoxies and polyesters
   - Nature fibre reinforced polyesters, polypropylene.

5. Processing techniques like hard lay-up, spray-up, bag moulding, filament winding, etc. **(16 hrs)**

Types of Laminates

- Rigid and flexible laminate
- Plastic – plastic laminates

Preparation and properties and application of following laminates

- Packing material of food materials

Introduction to packaghing , packaging of food material,scope of packaging and fumction of packaging.

LIST OF PRACTICALS

1. Study particulate reinforce composite
2. Study fibre reinforced plastics..
3. Study man made fibre and their articles.
4. Study jute and nylon fibre article and their article.
5. Study jute and acrylic fibre and their articles.
6. Study laminates through packaging material and packaging materials.
7. Study bag moulding technique.
8. Study filament winding technique and the articles who are made by this techniques.

INSTRUCTIONAL STRATEGY

Industrial visit is highly recommended so as to make the student aware of working conditions in the industry as far as composite technology is concerned.

RECOMMENDED BOOKS

1. Handbook of plastics, elastomers and composites Charles A. Harper (Mc Graw Hill Co. New Delhi)

2. Polymer Engineering Composites by Richardson Mcw, Applied Sc. Publisher, London

3. Micro component polymer systems, Miller I.S and Rostane S.

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	06	10
2	06	10
3	16	25
4	20	30
5	16	25
Total	**64**	**100**

5.4 MASS TRANSFER OPERATIONS

L	T	P
6	-	4

RATIONALE

In this subject the basic concepts of mass transfer are covered to enable the students to understand working of various mass transfer equipment like distillation column, gas absorption column, dryers, cooling towers and extraction column etc. which are used in industries for purification of products.

DETAILED CONTENTS

1-Mass transfer **(20 Periods)**

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, Maxwell law of diffusion, diffusivity, diffusion in the gas phase-Equimolecular counter diffusion and nondiffusing diffusion, diffusion in the liquid phase-Equimolecular counter diffusion and nondiffusing diffusion., Mass Transfer Coefficient. Film theory and penetration theory of Mass Transfer,

2- Gas Absorption **(20 periods)**

Condition of equilibrium between liquid and gas, mechanism of absorption two film theory. Diffusion of a gas through a stagnant gas, diffusion in liquid phase, rate of absorption, relation between film and overall coefficients, rate of absorption in terms of mole fraction, factors affecting transfer coefficients.

Packed Tower

Properties of tower packing, types of packing, Channeling ,Minimum liquid gas ratio Loading and Flooding Capacity of packed tower Material balance and design equation, height of column based on conditions in gas film and liquid film, height of column based on overall coefficient, the operating line and graphical integration for height of column. Concept of transfer unit. H.E.T.P. for packed column of distillation, relation of H.T.U. to H.E.T.P... Derivation of the following relations

I. $$\frac{1}{K_G a} = \frac{1}{k_G.a} + \frac{m}{k_L.a}$$

II. $$\frac{1}{K_L a} = \frac{1}{k_L.a} + \frac{m}{k_G.a}$$

3. **Distillation** **(30 Periods)**

a) Various distillation methods

i) Equilibrium or flash distillation
ii) Differential distillation
iii) Batch distillation
iv) Vacuum and Steam distillation
v) Azeotropic and Extractive distillation.

b) Types of distillation columns

i) Perforated plate or sieve plate column

ii) Bubble cap plate column
iii) Packed column and fractionating column accessories.

c) Boiling point diagrams

Raoult's law; Henry's law, Relative volatility, constant boiling mixtures, equilibrium diagram and construction of equilibrium diagram, Fractionating column calculation-Heat & material balance, Reflux ratio, equilibrium plate, Location of feed plate. Sub cooled reflux; effect of reflux ratio, Total reflux, Minimum reflux ratio Entrainment; McCabe Thiele diagram-section above and below feed plate; Intersection of operating line. Location of q-line, derivation of q line, optimum reflux ratio, calculation of no. of equilibrium plates by Mc-Cable Thiele diagram. Overall plate efficiency.

4. Extraction (08 Periods)

i) Applications of this extraction
ii) Choice of solvent
iii) Steps of extraction operation
iv) Solid Liquid extraction, construction and description of
- Moving solid bed Basket type oil seed extractor or Boll man extractor
- Rotocel extractor

v) Liquid extractor; description and construction of
- Mixer settler extraction system
- Spray and packed extraction tower

5. Humidification (10 Periods)

Definition and calculation of

i) Humidity
ii) Percentage humidity
iii) Relative humidity
iv) Humid volume
v) Humid heat
vi) Enthalpy and its calculation
vii) Dry bulb and wet bulb-temp
viii) Adiabatic saturation temperature
ix) Use of humidity chart. Dew point, simple numerical problem using humidity chart, construction and description of cooling towers (Natural and induced draft)

6. Drying (08 Periods)

General drying behavior-Critical moisture content, equilibrium moisture contents, description and construction of dryer.

i) Tray dryer
ii) Screen conveyor dryer
iii) Rotary dryer.

NOTE: - At least one question from each topic

LIST OF PRACTICALS

1. To study the rate of drying in a vacuum dryer
2. To determine the pounds of volatile compounds distilled per unit pounds of steam distilled in a steam distillation operation
3. To determine rate of setting of crystals in a crystallizer
4. To study the rate of drying in rotary dryer
5. To determine drying rate for a wet materials
6. To determine drying rate for a wet material in a tray dryer
7. To study packed tower in various industries
8. To study various extractors in solvent extraction plant
9. To study a spray pond in a sugar and other industries for cooling system
10. To find out the drying characteristics of given sample and draw drying rate curve by infra-red moisture meter and rapid moisture meter
11. To study sketch and operation of strip chart recorder and directing pen recorder

INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of column (packed/tray) and different types of packings/trays used in the column. This will also make the students aware of auxiliary equipment/manholes/supports used for the columns. Along with the theoretical part, emphasis should be given to problem solving and practices especially for distillation column, absorption and humidification.

RECOMMENDED BOOKS

1. Mass Transfer Operations by Trybal
2. Unit Operation by McCabe and Smith
3. Mass Transfer I & II by Bhattacharya
4. Mass Transfer by Gavhane
5. Mass Transfer by Badger

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time period Allotted	Marks Allotted (%)
1	20	15
2	20	15
3	30	35
4	08	10
5	10	15
6	08	10
Total	**96**	**100**

5.5 POLYMER SCIENCE

L	T	P
5	-	-

RATIONALE

This specialized subject is taught in view of the growing employment potential in the field of polymers. This subject deals with polymerization techniques and important industrial polymers which will enable the diploma holder in chemical engineering to join polymer industry.

DETAILED CONTENTS

1. **Introduction** **(10 periods)**
   Monomer, polymer, functionality and structure of polymer, classification of polymers
2. **Chemistry of Polymerization** (20 periods)
   Introduction, chain polymerization, step polymerization, polymerization techniques
3. **Molecular Weight and Size** **(20 periods)**
   Average molecular weight, number – average and weight - average molecular weights, viscosity - average molecular weight , molecular weight and degree of polymerization, size of polymer molecules, methods for average molecular weight determination – end group analysis vapour pressure osmometry..
4. **Kinetics of Polymerization** **(15 periods)**
   Introduction, free radical chain polymerization, cationic polymerization, anionic polymerization, polycondensation
5. **Glass Transition Temperature** **(15 periods)**
   Glass transition temperature, factors affecting the glass transition temperature, glass transition temperature and molecular weight, glass transition temperature and plasticizers, glass transition temperature of co - polymers, glass transition temperature and melting point.

INSTRUCTIONAL STRATEGY

Extension lectures by experts from polymer industry can enrich the students with better inputs regarding various types of techniques and latest developments in polymer industry. Also field visits must be encouraged to provide practical inputs and inputs regarding operational aspects of machinery used in polymer industry.

RECOMMENDED BOOKS

1. Polymer Science and Engineering by Gowarikar
2. Polymer Science and Engineering by Fried
3. Polymer Science and Engineering by Anil Kher and SK Gupta
4. Polymer Science and Engineering by Ghosh

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	10	10
2	20	20
3	20	30
4	15	20
5	15	20
Total	**80**	**100**

5.6 REACTION ENGINEERING

L	T	P
5	-	-

RATIONALE

It is a core subject of chemical engineering and is essential for understanding the kinetics of various types of reaction vessels and the performance of reactive system used in industry.

DETAILED CONTENTS

1. Introduction: (5 periods)

What is reaction engineering? Chemical kinetics & their dynamics classification of chemical reactions. Based on (i) Phases involved, (ii) Catalytic and non-catalytic reactions, (iii) Molecularity of a reaction, (iv) Heat effect, (v) based on order of reactions, (vi) reversible and irreversible reactions.

2. Homogeneous Reactions: (20 periods)

Rate of chemical reaction, factors affecting the rate of reaction. Concentration dependent term of a rate equation. Rate constant, Elementary and non-elementary reaction. Difference between elementary and non-elementary reactions. Molecularity of a reaction, order of a reaction. Difference between molecularity & order of reaction. Representation of an elementary & non-elementary reaction. Temperature dependent term of a rate of equation, Temperature dependency from Arrhenius law, collision theory & thermodynamics. Activation energy & its significance, activation energy & temperature dependency. Simple numerical problems,

3. Interpretation of constant volume batch reactor data: (35 periods)

Kinetic run, kinetic data or rate data, integral method of analyses of rate of data, differential method of analysis of rate of data. Integral V/s differential method, Constant volume batch reactor, conversion, relation of concentration and conversion for constant volume batch reactor.

Find out the concentration of component B, C & D in

(a) Chemical reaction of the type $aA+bB \rightarrow cC+dD$ and for

(b) For flow systems.

Analysis of total pressure data obtained in a constant volume system, use of ideal gas law. To calculate C_{Ao}.

Integral method of analysis of rate data; integrated rate expression for different order of reactions:

(A) Irreversible unimolecular type first order reactions:

i. Integrated rate equation or expression for the first order reaction in terms of concentration, relation between half-life and rate constant.

ii. Integrated rate equation or expression for the first order reaction in terms of conversion

(B) Irreversible bimolecular type second order reaction:

i. Integrated rate equation or expression for the second order reaction in terms of concentration. Relation between half-life and rate constant and concentration.

ii. Integrated rate equation or expression for the second order reaction in term of conversion.

iii. Integrated rate equation for second order reaction with $C_{Ao} \neq C_{Bo}$ in terms of concentration.

iv. Integrated rate equation or expression for second order reaction with C_{Ao}

$\neq C_{Bo}$. In term of conversion.

(C) **Zero order reaction**: zero order reaction in terms of concentration & Conversion. Characteristics of zero order reaction.

(D) Empirical rate equation of n^{th} order. Determination of overall order of irreversible reaction from half-life, Irreversible reaction in parallel/series & homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions: Reversible reactions of unimolecular type first order reactions, reversible unimolecular type second order reactions.

(E) **Differential method of analysis of data** :

I) Step by step procedure for analysis of the complete rate equation by differential method.

II) Variable volume batch reactor: - Unimolecular type general reaction expression in which the volume is a liner function of conversion of a reactant. An integrated rate expression for first order reaction for variable volume system. Integrated rate expression for zero order reaction for a variable volume system.

Bimolecular type reactions: integrated rate expression for first & second order reactions. Simple numerical problems.

4. Ideal Reactors: (20 periods)

Classification of reactors based on

a. Shape & size
   i. Tank reactors
   ii. Tubular reactors
b. Based on mode of operation
   i. Batch reactors
   ii. Semi batch reactors
   iii. Continuous flow reactors

Application, advantages, disadvantages and comparison of reactors.

Relation between C_A & X_A. Ideal batch reactor: - Performance/design equation for batch reactor for constant volume/constant density and for variable volume/density reaction system. The performance measures of flow reactors: - Space time and space velocity. Steady state mixed flow reactors (CSTR):- The performance equation for constant and variable volume/density reaction system. Steady state plug flow reactor: - Performance equation for plug flow reactor for first order reaction in case of constant density and variable density system. Holding time and space time for flow reactors.

INSTRUCTIONAL STRATEGY

Simple models can be made to show batch reactors, plug flow reactors and continuous reactors. Emphasis should be laid on problem solving / numerical solving for rate constants and temperature dependence of rate constant.

RECOMMENDED BOOKS

1. Chemical Reaction Engineering by Levenspiel, Job Wiley Publications
2. Chemical Engineering Kinetics by Smith, McGraw Hill Publication
3. Elements of Chemical Reaction engineering by Fogler, Prentice Hall of India
4. Reaction Kinetics for Chemical Engineering by Wales, McGraw Hill Publication
5. Chemical Reactin Theory – An Introduction by Denbigh and Turner, Cambridge University Press Publication

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	05	10
2	12	20
3	35	50
4	20	20
Total	**80**	**100**