POLYMER CHEMISTRY I

CODE PS 11 **L T P**
3 2 2

RATIONALE

The students will be required to :

(a) Be familiar with basic concept of Chemistry including Physical, Organic and Environmental Chemistry.
(b) Understand usage of different raw materials for manufacture of different polymers.
(c) Be familiar with molecular weight and molecular distribution of different polymers.
(d) Be familiar with structure of polymer molecules.
(e) Have ability to use mathematics as a tool for solving problem of basic chemistry.

CONTENTS

1. Basic concepts of Chemistry

1.1 Physical Chemistry

1.1.1 Concepts of elements, atoms and molecules, atomic structure, atomic number, atomic weight and molecular weight, Concepts of mole, Avogadro number, Periodic table

1.1.2 Electro negativity, Valency, Ionic, covalent bond and hydrogen bond. Intermolecular attraction,

1.1.3. Melting point, boiling point, viscosity and surface tension, Intrinsic and extrinsic properties

1.2 **Organic Chemistry** :

1.2.1 IUPAC nomenclature of organic compound, alkane, alkene, homologous series

1.2.2 Aromatecity

1.3 **Environmental Chemistry**:

1.3.1 Environment pollution, air, water and soil pollution,

1.3.2 Chemical reactions in atmosphere, acid rain, depletion of ozone layer and its effect, green house effect, global warming.

1.3.3 Pollution due to industrial waste

2. **Raw materials**

2.1 Basic raw materials for synthetic rubber manufacturing.

2.1.1 Petroleum

2.1.2 Natural Gas;

2.2 Monomers

2.2.1 Characteristics

2.2.2 Functionality

2.2.3 Types

2.3 Natural Polymers and Their Derivatives

3. **The genesis of Polymers**

3.1 What are polymers? How polymers are made?

3.2 Classification of Polymers,

3.3 Basic concepts of high polymer systems

4. **Molecular Weight and size**

4.1 Average Molecular weight concept

4.1.1 Number average

4.1.2 Weight average molecular weights,

4.1.3 Viscosity Average molecular weight.

4.2 Molecular weight and degree of Polymerization.

4.2.1 Poly-dispersity and Molecular weight distribution in polymers.

4.2.2 The practical significance of polymer molecular weight.

4.2.3 Size of Polymer Molecules

5. **Chemical and Geometrical Structure of Polymer Molecules :**
   - 5.1 Polymer Microstructure concept
     - 5.1.1 Microstructures based on chemical structure,
     - 5.1.2 Microstructures based on geometrical structure

PRACTICALS

1. Determination of melting point of powder material
2. Determination of boiling point of liquid material
3. Determination of viscosity of liquid material by viscometer
4. Measurement of surface tension of liquid material.
5. Element detection of organic compounds
   - 5.1 Nitrogen
   - 5.2 Sulphur
   - 5.3 Halogen
6. Determination of functional group in organic compounds.
   - 6.1 Acid
   - 6.2 Alcohol
   - 6.3 Nitro Groups
   - 6.4 Hydro carbon

7. Determination of softening point of polymeric material.
8. Determination of pH of a solution
9. Acid base titration
10. Redox titration

Reference Books :

1.	Textbook of Polymer Science	Fred W. Billmeyer, Jr.
2.	Polymer Science and Technology of Plastics and Rubber	Prof. P. Ghosh
3.	Polymer Science:	V.R. Gowarikar, N.V. Viswanathan & J. Sridhar
4.	Introduction of Polymer Sc. & Rubber Technology,	Vol I, Ed. By Dr. R. Mukhopadhyay
5.	Qualitative Inorganic Analysis	A.I.Vogel

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POLYMER PHYSICS

CODE PS 12 **L T P**
3 2 2

RATIONAL

The students will be required to:
(a) Be familiar with basic concept of Physics
(b) Have understanding of basic principles involving Rubber like behavior.
(c) Have basic concept of visco-elastic and fundamental of rheology.
(d) Be aware of behavior of Rubber under stress including load-deflection fundamentals
(e) Have ability to use mathematics as a tool for solving problem of basic physics.

CONTENTS

1. **Overview of basic concepts of Physics** :
   - 1.1. Units of measurement, SI units and derived units
   - 1.2 Length, Mass and time measurement,
   - 1.3 Scalar and vector quantities.
   - 1.4 Work, power and energy: kinetic and potential energy, surface energy and surface tension,
   - 1.5 1st law of thermodynamics, Heat, work, internal energy,

1.6 2nd law of thermodynamics, Enthalpy, Entropy and Free Energy,
1.7 Electric potential, Potential difference, Conductors, semi conductors and insulators,
1.8 Ohm's law, Electric resistance, Resistivity,
1.9 Permittivity, Power factor

2. Basic Principles Involved on the Orgin of Rbber Lke Bhaviour and Rbber Elasticity :

2.1 Stress – strain relationship,
2.2 Hooke's law,
2.3 Young's modulus,
2.4 Bulk modulus shear modulus,
2.5 Rigidity

3. Concept of Viscoelasticity and Fundamentals of Rheology :

3.1. Ideal elastic response, pure viscose flow,
3.2 Factors affecting flow behaviour
3.3 Effect of temperature & shear rate; application of the concept of visco-elasticity in rubber processing such as calendar nip swell & extension die swell.

4. Behaviour of Rubber under Stress :

4.1 In tension, compression, shear and torsion,
4.2 Concept of Shape Factor and its significance.

5. Load-deflection Fundamentals of the Design Principles Involved in Products Like :

5.1 Bridge Bearings
5.2 Suspension units.
5.3 Stress relaxation and Creep & their significance.

6. **Glass Transition Temperature :**

6.1 Glass transition temperature, glassy solids and glass transition?
6.2 Factors influencing glass transition temperature.
6.3 Glass transition temperature and molecular weight.
6.4 Glass transition temperature and plasticizers
6.5 Glass transition temperature of copolymers.
6.6 Glass transition temperature and melting point.
6.7 Importance of glass transition temperature.
6.8 Heat distortion temperature.

7. Crystallinity in Polymers :

7.1 Crystalline solids and their behavior towards X-rays.
7.2 Degree of crystallinity,
7.3 Crystallisability.
7.4 Polymer crystallization,
7.5 Crystallites

PRACTICAL

1. Verification of the ohms law.
2. Verification of Series and parallel connection of wire.
3. Determination of refractive index.
4. Determination of velocity of sounds.
5. Determination of density of solid material.
6. Determination of density of liquid material.
7. Verification of hooks law.
8. Determination of strain - train of elastomeric material.
9. Determination of resistivity of polymeric materials.
10. Determination of static and dynamic resistance of P-N diode.

REFERENCE BOOKS :

1. Textbook of Polymer Science — Fred W. Billmeyer, Jr.
2. Polymer Science and Technology of Plastics and Rubber — Prof. P. Ghosh
3. Polymer Science: V.R. Gowarikar — N.V. Viswanathan and J. Sridhar
4. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay

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RUBBER MATERIAL-1

CODE PS 13

L	T	P
3	2	2

RATIONAL

The students will be required to:
(a) Acquire knowledge of various rubber types and grades and their characteristics.
(b) Be familiar with Natural Rubber, Synthetic Rubber, Polymer blends, Thermoplastic rubber, Reclaim rubber, Crumb and Devulcanized Rubber etc.

CONTENTS

1. Latex :
- 1.1 NR latex types and grades;
- 1.2 Preservation,
- 1.3 Concentration ,
- 1.4 Stability,
- 1.5 Gellation,
- 1.6 Coacervation,

2. Natural Rubber :
- 2.1 Source
- 2.2 Production systems for sheet and block rubber
- 2.3 Gradation system
- 2.4 Processing characteristics & Curing systems.

3. Synthetic Rubbers :
- 3.1 SBR
- 3.2 PBR
- 3.3 NBR
- 3.4 CR
- 3.5 IIR
- 3.6 XIIR
- 3.7 EPDM
- 3.8 Comparative properties and applications including high performance application of following synthetic rubbers
  - 3.8.1 FKM
  - 3.8.2 ACM
  - 3.8.3 ECO
  - 3.8.4 CSPE
  - 3.8.5 Silicone
  - 3.8.6 Polysulphide

4. Polymer Blends :
- 4.1 Importance
- 4.2 Applications
- 4.3 Concept of miscibility/ compatibility;
- 4.4 Useful blends
  - 4.4.1 Rubber-plastic
  - 4.4.2 Rubber-rubber e.g. NBR/PVC blends, NR/SBR, NR/PBR etc.

5. Thermoplastic Rubber (TPR) and Thermoplastic Elastomers (TPE) :

5.1 Concept and applications of SBS

5.2 Concept and applications of EVA.

6. Reclaimed, Crumb and Devulcanised Rubbers.

PRACTICAL

1. Determination of total solid and dry rubber in natural rubber latex.
2. Identification of rubber by quality analysis.
3. Determination of volatiles content in rubbers.
4. Determination of ash content in rubber.
5. Determination of rubber content in
   - 5.1 Reclaimed rubber ,
   - 5.2 Crumb rubber
   - 5.3 Devulcanised rubber
6. Determination of sieve residue of powdery material.
   - 6.1 Dry
   - 6.2 Wet
7. Identification of rubber, plastic and fiber.
8. Determination of particles size distribution (40 mesh to 100 mesh)
9. Determination of structure of carbon black by adsorption.
10. Determination of acidities/ alkalinities.

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Rubber Technology Handbook — Werner Hoffmann
3. Introduction of Polymer Sc. & Rubber Technology — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Rubber Technology, Ed. — Maurice Morton
6. BIS Standard for Rubber Testing

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RUBBER TESTING

CODE PS 14 **L T P**
3 2 2

RATIONAL

The students will be required to:

(a) Have knowledge of philosophy of testing of Rubber and /Rubber like material.
(b) Have basic concept of Specification and Standardisation.
(c) Be familiar with different test methods used in rubber Industry.
(d) Have ability to use mathematics as a tool for solving problem related with rubber testing..

CONTENTS

1. **Philosophy of testing** :
   - 1.1 Standard test methods;
   - 1.2 Limitation of test data,
   - 1.3 Precision, accuracy and validity of test methods.
   - 1.4 Quality Assurance a elements of statistical quality control – mean, average, medium, variance, standard deviation .

2. **Specification and standardization**.
   - 2.1 Awareness about BIS and ISO standards on rubber,
   - 2.2 Rubber chemicals and rubber based products.

3. **Testing methods** and their significance with respect to product performance, Stress/Strain properties: Tensile strength, Elongation, Modulus, Hardness, Compression set under constant stress/strain – original and after accelerated ageing conditions.
   - 3.1 Effect of environment and ageing of rubbers; swelling tests, oxidative and thermal ageing, ozone cracking tests.
   - 3.2 Electrical properties of rubber; determination of resistivity and dielectric strength.
   - 3.3 Thermal Properties; Thermal Conductivity, Heat Diffusivity – their importance and measurement.
   - 3.4 Time dependent properties; determination of Creep and Stress relaxation; determination of rebound resilience, effect of temperature on resilience, determination of heat build-up by Goodrich flexometer, effect of temperature frequency and amplitude of vibration on dynamic properties; forced and free vibration machines, determination of loss modulus.

4. **Destructive Tests** -- Tensile and Abrasion resistance tests; crack initiation and crack growth by the De Mattia method and Ross Flexing machine, flexural fatigue failure in rubber fabric composite.

5. **Adhesion/Bond testing** : Peel test, Pull test and Shear test - their significance and limitations.

6. **Thermal Properties**; Thermal Conductivity, Heat Diffusivity – their importance and measurement.

PRACTICAL

1. Determination of Mooney viscosity and moony scorch of rubber compound.
2. Determination of Rheometric properties by Rheometer.
3. Determination of hardness of rubber vulcanizate.
4. Determination of stress – strain property of rubber vulcanizate.
5. Determination of ageing property of rubber vulcanizate
6. Determination of stress strain property of organic and inorganic tyre cord.
7. Determination of textile to rubber adhesion (H-Adhesion)
8. Determination of metal to rubber adhesion (T- Pull Adhesion)
9. Determination of permanent set of rubber vulcanizater
10. Determination of compression set of rubber vulcanizate.

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Vanderbilt's Rubber Technology — Handbook
3. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Physical Testing of Rubber, Ed. — R.P. Brown

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RUBBER ENGINEERING

CODE PS15 **L T P**
3 2 -

RATIONAL

The students will be required to:
(a) Basic concept of elements of Mechanical energy, properties of steam etc.
(b) Be familiar with different air compressors, pumps etc.
(c) Be familiar with transmission, motion of power etc.
(d) Be familiar with different aspects of safety in rubber industry.
(e) Have basic concept of Hydraulic, Heating systems and instrument used in rubber Industry.
(f) Have basic concept of different types of maintenance including lubrication.
(g) Have ability to use mathematics as a tool for solving problem of basic rubber engineering.

CONTENT

1. Basic concept of Engineering

1.1 Elements of mechanical energy: Force, mass, volume, temperature, pressure, work, power, energy, P-V diagram, heat, interchanges of heat, internal energy, enthalpy, efficiency.

1.2 Properties of steam: Enthalpy, enthalpy of water, specific volume of steam, steam tubes, Throttling, Entropy, steam boilers,

1.3 Air compressors

1.4 Pumps : Reciprocating pumps, centrifugal pumps, rotary pumps

1.5 Transmission of motion and power : Power transmission elements, belt drive, chain drive, Pulley, rope drive, friction drive, gear drive and different types of gears

1.6 Press and presswork: Hand press, power press, grinding operations, micro-finishing

2. Power Transmission :

2.1 Principles and operational requirement of

- 2.1.1 Flat Belt
- 2.1.2 V-Belt
- 2.1.3 Toothed Belt
- 2.1.4 Chain Drive
- 2.1.5 Gear Drives

2.2 Main types of gears –

- 2.2.1 Spur
- 2.2.2 Helical
- 2.2.3 Worm.

2.3 Comparison of the different forms of power transmission in terms of efficiency and application.

2.4 Safety requirement of drive systems.

2.5 Selection of drive systems for

- 2.5.1 Roll mill
- 2.5.2 Extruder
- 2.5.3 Moulding press
- 2.5.4 Internal mixer
- 2.5.5 Calender

2.5.6 Haul-off system.

3. Hydraulics :

3.1 Major features of following pumps

- 3.1.1 Positive
- 3.1.2 Non-positive pumps
- 3.1.3 Fixed and variable displacement pumps –
- 3.1.4 Gear, Vane and piston pumps

3.2 Advantage and performance of

- 3.2.1 Centrifugal
- 3.2.2 Reciprocating pumps

3.3 Hydraulic accumulator.

3.4 Pressure control valves including simple relief valves

3.5 Pressure reducing valves

3.6 Unloading valves

3.7 Flow control valves

3.8 Directional valves

3.9 Hydraulic circuit for up-stroking compression moulding presses and for a simple screw-ram injection moulding machine with description of functions of components.

4. Heating Systems in Rubber Industry :

4.1 Steam boiler and their basic types

4.2 Dryness factor of steam

4.3 Steam line and steam traps - Functions and basic types and suitability

4.4 Thermic fluid heaters
4.5 Thermic fluid line
4.6 Hot air generators and their applications
4.7 Infrared heating
4.8 Microwave heating and
4.9 Applications and suitability of above.

5. Instruments used for measuring of temperature and pressure

5.1 Thermometers
5.2 Pyrometers
5.3 PD & PID Controller
5.4 Pressure gauges
5.5 Transducers with reference to their application in rubber processing machineries.

6. Safety :

6.1 Occupational Health and Safety in rubber industry.
6.2 Importance of safety
6.3 Analysis of accidents
6.4 General safety devices used machines
6.5 General safety rules in material handling and working in machine
6.6 Knowledge of First Aid
6.7 Artificial respiration
6.8 Fire hazards in rubber industry.
6.9 Operation of fire fighting equipment.

7. Maintenance :

7.1 Objective of maintenance
7.2 Types of maintenance
7.3 Preventive maintenance
7.4 Predictive maintenance
7.5 Breakdown maintenance
7.6 Condition based maintenance
7.7 Total productive maintenance (TPM)

8. Lubrication :

8.1 Objectives of lubrication
8.2 Different methods of lubrications
8.3 Properties
8.4 Types of lubricants

9. AC and DC Motor :

9.1 Basics and their comparison
9.2 Variable frequency drive (VFD)

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Rubber Technology Handbook — Werner Hoffmann
3. Introduction of Polymer Sc. & Rubber Technology — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Rubber Technology, Ed. — Maurice Morton
6. Rubber Processing: An Introduction — Peter S. Johnson

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POLYMER CHEMISTRY II

CODE PS 21 **L T P**
3 2 2

RATIONAL

The students will be required to:

(a) Be familiar with basic concept of polymerization
(b) Have basic concept on different individual polymers
(c) Be aware of different polymer reaction and polymer synthesis.
(d) Have basic understanding of different polymeric materials like elastomers, fibres and plastics
(e) Have ability to use mathematics as a tool for solving problem in polymer chemistry.

CONTENT

1. Chemistry of polymerization :

1.1 Chain polymerization
1.2 Step polymerization.
1.3 Miscellaneous polymerization reactions
1.4 Polymerization techniques.

2. Copolymerisation :

2.1 Free radical copolymerization,
2.2 Ionic copolymerization,
2.3 Copolycondensation.

3. Basic knowledge of Individual polymers

3.1 Polyethylene,
3.2 Polypropylene,
3.3 Polystyrene,
3.4 Polyacrylonitrile,
3.5 Polymethylmethacrylate,
3.6 Polyesters,
3.7 Polycarbonates,
3.8 Polyamides,
3.9 Polyimides,
3.10 Polyurethanes,
3.11 Polyethylene glycols
3.12 Polyvinyl acetate, polyvinyl alcohol, polyvinyl chloride,
3.13 Polytetrafluoroethylene,
3.14 Polyisoprene,
3.15 Polybutadiene,
3.16 Polychloroprene,
3.17 Poysulphides,
3.18 Phenol formaldehyde resins, melamine formaldehyde resins, urea formaldehyde resins, epoxy polymers, cellulose and its derivatives.

4. Polymer Degradation :

4.1 What is polymer degradation?
4.2 Types of degradation
4.3 Thermal degradation
4.4 Mechanical degradation
4.5 Oxiditive degradation

PRACTICAL

1. Determination of water soluble components in accelerator, starch etc.
2. Determination of the components soluble in Acetone - rubber Resin, waxes, plasticizers etc.
3. Determination of the components soluble in alcoholic KOH.
4. Paper and Thin layer chromatography (TLC) separation.(

5. Identification of antioxidant through TLC
6. Determination of aniline point
7. Determination of swelling characteristics of rubber vulcanization in different solvents
8. Identification of different polymers by qualitative test.

8.1 Polyethylene
8.2 Nitrogen containing polymer
8.3 Halogen containing polymer
8.4 Sulphur contacting polymer
8.5 Resinous material

9. Identification of thermo plastic and thermo set materials.

REFERENCE BOOKS :

1. Textbook of Polymer Science — Fred W. Billmeyer, Jr.
2. Polymer Science and Technology of Plastics and Rubber — Prof. P. Ghosh
3. Polymer Science — V.R. Gowarikar, N.V. Viswanathan & J. Sridhar
4. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
5. BIS Testing Standards for Rubber & Rubber like material (Chemical).

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RUBBER PROCESSING TECHNOLOGY

CODE PS 22 **L T P**
3 2 2

RATIONAL

The students will be required to:

(a) Understand the principle of basic rubber processing and rubber products
(b) Be familiar with different rubber machineries like mills, internal mixer, extruder, calendar and moulding operation.
(c) Be aware of safe working practices
(d) Have ability to use mathematics as a tool to solve problems of mixing batch weight, calender gauge weight, extruder die swell, calculation of density of mixed batch, different heating systems and hydraulic process.

CONTENT

1. Storage and handling of materials
Storage life, FIFO, handling and weighing/batching systems

2. Processing and Processability
2.1 Review of methods of determining the processability of a rubber mix by different equipment and their application in process control including description.
2.2 Rapid Plastimeter,
2.3 Mooney Viscometer – viscosity, scorch time
2.3 Rheometer

3. Mixing
3.1 Principles of mixing; distributive & dispersive mixing.
3.2 Description construction and comparison of mixers and compounding equipment -- open mills and internal mixers; mixing energy; mixer geometry and practical mixing techniques including sequence of mixing and evaluation of quality of mixing (e.g. specific gravity and rheograph; trouble shooting of mixing operation; post-mixing operations, handling and storage.

3.3 Latex – Dispersions and Emulsions – their preparation and use of surface active agents in latex compounds, simple latex mix design and latex mixing equipments

4. Extrusion :
4.1 Basic principles involved;
4.2 Types of Extruders – Ram/Screw & their comparison.

4.3 Variations of rubber extruders viz. hot feed, cold feed, pin barrel, vacuum and their comparison, screw design and fee arrangements,
4.4 Extruder head construction – straight head & cross-head; temperature control unit. Die and Die-swell;
4.5 Function and layout of ancillary equipment for standard extrusion operations;
4.6 Trouble shooting of extruder operation.

5. Calendering :

5.1 Construction, Types and function of calendaring machine;
5.2 Calendaring processes; – frictioning, skim coating & sheeting; Roll floating, roll binding and calendar gauze control devices;
5.3 Function and layout of ancillary equipment for standard calendaring operation. Trouble shooting of calendaring operation.
5.4 Other methods of textile coating viz. spreading, dipping – their usefulness, limitation and comparison.

6. Moulding :

6.1 Description and construction of equipment used in Compression moulding, Transfer moulding, and injection moulding – their comparison. Mould shrinkage; Trouble Shooting of moulding operations.
6.2 Hydraulic systems used in moulding presses; Single daylight and multi daylight presses, vacuum system in presses.
6.3 General features of mould design, (a) single impression and (b) multiple impression and construction of a mould, mould clamping and loading and opening arrangements, mould cleaning mould lubricant.
6.4 Methods of blank preparation,
6.5 Various Trimming and Finishing methods.

7. Continuous Vulcanisation Methods :

7.1 General description of methods currently used in industrial practices such as roto-cure, fluidized bed, electron beam and continuous vulcanization by RF, LCM and Hot air, IR and their comparison.

PRACTICALS

1. Calculation of density of compound from the rubber compound formulation.
2. Determination of density of raw compound and cured compound.
3. Mixing of Natural Rubber based compound
4. Mixing of Synthetic Rubber based compound
5. Determination of Rheological property of mixed compound by Rheometer.
6. Curing of rubber compound at different temperature and time.
7. Measurement of properties of cured compound

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Rubber Technology Handbook — Werner Hoffmann
3. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Rubber Technology, Ed. — Maurice Morton
6. Rubber Processing: An Introduction, — Peter S. Johnson

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RUBBER MATERIAL - II

CODE PS 23 **L T P**
3 2 2

RATIONAL

The students will be required to:

(a) Acquire knowledge on various type of rubber compounding materials
(b) Be familiar with different compounding ingredients and their specification standards including safe handling of the materials
(c) Have basis concept about textile materials and their application.
(d) Have ability to use mathematics as a tool for solving problems related to raw material and compounding.

CONTENTS

1. Different Rubber Compounding Materials :

1.1 Functions and uses of different rubber chemicals and processing aids
- 1.1.1 Accelerators
- 1.1.2 Retarders,
- 1.1.3 Peptisers,
- 1.1.4 Tackifiers,
- 1.1.5 Process aids,
- 1.1.6 Activators
- 1.1.7 Softeners,
- 1.1.8 Extenders,
- 1.1.9 Reclaimed rubbers, crumb rubbers, mineral rubbers, rubber substitute (factice) Pigments
- 1.1.10 Blowing agents

1.2 Fillers --- reinforcing, semi – reinforcing and extending fillers, non-black and black fillers – their grades and classification and usage.

1.3 Curing Systems :
- 1.3.1 conventional, semi – EV and EV systems,
- 1.3.2 Classification of accelerators, provide, metal oxide and resin curing systems and their applications.
- 1.3.3 Principles of Mix Design and selection and application of polymers such as NR, SBR, PBR, NBR CR and IIR with suspect to ageing and weathering, heat resistance, oil and solvent resistance, abrasion resistance, resilience, hysteresis , heat build-up ozone resistance, low compression set, high tensile strength, low/high hardness and modulus, flex cracking resistance, flame resistance, low temperature flexibility, electrical insulation, conducting and antistatic properties --- cost efficiency.

2. Concept of waste as generated during different processing stages and avenue for their re-use and cost optimization.

3. Reinforcing Materials :

3.1 Definition of fibres, yarn, cord, twist, count, denier, tex, types of textile weaves and their application in different rubber products;

3.2 Structure and comparative properties of cotton, rayon, polyamide, polyester, aramid, glass and steel wire and their applications in rubber products.

3.3 Textile to rubber bonding systems – Dry and RFL.

PRACTICAL

1. Determination of purity of accelerator by melting point and ash analysis.
2. Determination of purity of materials by measurement of melting/ boiling/ softening point
3. Evaluation of different reinforcing filler in rubber compounds.
4. Evaluation of different type of Non reinforcing filler in rubber compounds

5. Evaluation of different type of accelerator in rubber compounds
6. Evaluation of different type of anti oxidant in rubber compounds
7. Evaluation of different type of processing aid in rubber compounds
8. Characterization of different type of reinforcing textile materials.

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Rubber Technology Handbook — Werner Hoffmann
3. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Rubber Technology, Ed. — Maurice Morton

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RUBBER COMPOUNDING

CODE PS 24 **L T P**
3 2 2

RATIONAL

The students will be required to:
(a) Knowledge on principle of compounding.
(b) Be familiar with compounding of latex properties, solid rubber etc.
(c) Have ability to use mathematics as a tool to solve problems of related to volume cost and cost calculation of compounds and those related to raw material tests.

CONTENTS

1. **Principles of compounding :**
   - 1.1 Compounding Ingredients
   - 1.2 Mix Design to meet Processing and Vulcanisate properties

2. **Compounding of latex products**
   - 2.1 Rubber band,
   - 2.2 Elastic thread,
   - 2.3 Nipples,
   - 2.4 Hand gloves and surgical gloves,
   - 2.5 Condoms,
   - 2.6 Latex foam, etc.

3. **Compounding of solid rubbers**
   - 3.1 Tyres,
   - 3.2 Tubes,
   - 3.3 Flaps,
   - 3.4 Conveyor belts,
   - 3.5 Power transmission belts,
   - 3.6 Hoses,
   - 3.7 Footwear,
   - 3.8 Cables,
   - 3.9 Moulded and extruded rubber goods
   - 3.10 Adhesives

PRACTICALS

1. Design of the Rubber Compound to meet specific properties.
1.1 Stress-Strain property (TS, M 300, EB, SH, TEAR Strength)
1.2 Set properties (Tension set, Compression set)
1.3 Flex to fatigue (De-Mattia flex)

1.4 Swell Index (Oil resistance, Solvent resistance)
1.5 Aging properties (Hot air, Steam, Ozone)
1.6 Abrasion resistance
1.7 Heat resistance

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Rubber Technology Handbook — Werner Hoffmann
3. Introduction of Polymer Sc. & Rubber Technology — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan
5. Rubber Technology, Ed. — Maurice Morton

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RUBBER PRODUCT DESIGN AND DEVELOPMENT

CODE PS 25 **L T P**
3 2 -

RATIONAL

The students will be required to:
(a) Acquire knowledge of basic concept of Product Design and development.
(b) Be familiar with mould manufacturing equipment.
(c) Have basic concept of mould design - compression, transfer and injection mould
(d) Have knowledge of materials for moulding.

CONTENTS

1. Mould Manufacturing Equipment
- 1.1 Centre lathe,
- 1.2 Milling machines,
- 1.3 Die sinking machines,
- 1.4 Shaping and planning machines,
- 1.5 Drilling and boring machines,
- 1.6 Hobbing press,
- 1.7 Grinding equipment,
- 1.8 Heat treatment equipment,
- 1.9 Finishing and measuring equipment,
- 1.10 General tolerances and financial investment requirement.

2. Moulded articles – Design Considerations to Simplify Manufacture
- 2.1 Undercuts, Tolerances, Draft, Wall thickness, Ribs etc.
- 2.2 Flow of material in mould,
- 2.3 Scoring of cores, Knife edges, Inserts etc.
- 2.4 Decorative Finish in the mould, Finish of moulded articles, Surface finish etc.
- 2.5 Parting line on the mould, gate location,
- 2.6 Mould inserts, ejection of article, special features in the mould, threads,
- 2.7 Coring of holes, post-moulding machining operations, post-moulding assembly operations

3. Materials for Mould Construction :
- 3.1 Steel for cavities and punches,
- 3.2 Steel for hobs and hobbling,
- 3.3 Steel for bolsters or shoes,
- 3.4 Steel for ejector or knock out pins,
- 3.5 Steel for guide pins and bushings,
- 3.6 Size of moulded parts,
- 3.7 Steel for screws and dowels,
- 3.8 Steel for bucking plates for pins,

3.9 Steel for sprue bushings,
3.10 Finish requirements of mould steels

4. Mould Design :

4.1 Material,
4.2 Moulding machines,
4.3 Moulding area available,
4.4 Clamping pressure,
4.5 Daylight or opening between the platens, Shot capacity,
4.6 Single or multi-cavity mould,
4.7 Other considerations

REFERENCE BOOKS :

1. An introduction to the design and manufacture of mould for Rubber and Plastics Industry : L. J. Shehan
2. Rubber Technology and Manufacturing C.M. Blow
3. Vanderbilt's Rubber Technology Handbook
4. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed. By Dr. R. Mukhopadhyay
5. Rubber Engineering, Ed. K.S. Logonathan

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RUBBER PRODUCT MANUFACTURING

CODE PS31 **L T P**
6 2 4

RATIONAL

The students will be required to:

(a) Knowledge about manufacturing outline of major rubber products involving the material, components, their functions, building and curing

(b) Have basic concepts on design, construction and comparative advantages and disadvantages

(c) Have ability to use mathematics as a tool for solving problem related to product design calculation.

CONTENTS

1. **Tyres and Tubes** :
   - 1.1 Cycle tyres, passenger car tyres and truck tyres;
   - 1.2 Tyre sizing and marking;
   - 1.3 Different types of tyre constructions – bias, radial & tubeless tyres – their basic features and characteristics;
   - 1.4 Different components of tyres and their functioning;
   - 1.5 Selection criteria of different reinforcement materials;
   - 1.6 Method of tyre building &curing; post curing treatments.

2. **Industrial Rubber Products**
   - 2.1 **Belting** –
     - 2.1.1 Conveyor, Transmission, V-Belt & Timing Belt – types, grades functions, construction
     - 2.1.2 Selection of materials,
     - 2.1.3 Mix design, building and curing.
   - 2.2 **Hose --**
     - 2.2.1 Types and grades;
     - 2.2.2 Construction – hand-made, circular woven, braided and spiral; their advantages; disadvantage and applicability;
     - 2.2.3 Design features, neutral angle and bursting pressure calculation; selection of reinforcing materials and mix design,
     - 2.2.4 Production flow chart and curing methods.
   - 2.3 **Footwear** -- Sole manufacturing – microcellular, Unit Sole and Resin Rubber Sole; hand-built footwear & DVP/DIP.
   - 2.4 **Cables** -- Types/grades -- Construction, insulation and sheath, materials selection, mix design, building and curing.

3. **Latex Products** : Dipped Goods – balloons, gloves, latex thread, foam and Carpet Backing

4. **Miscellaneous Rubber Products** :
   - 4.1 Coated Fabrics and calendered sheeting.
   - 4.2 Moulded items like seals, gaskets, auto components etc.
   - 4.3 Rubber to Metal bonded components -- engine mounting, rubber roller.
   - 4.4 Extruded items like tubing, weather strip etc.

5. **Adhesives** -- Solvent based and aqueous systems.

PRACTICAL

1. Visit and study the manufacturing process at rubber industry (minimum 2 industry) and illustrative documentation of the process studied.
   - 1.1 Tyre and Tube Industry
   - 1.2 Moulded and Extruded items
   - 1.3 Retreading units
   - 1.4 Footwear industry
   - 1.5 Auto Rubber Components

1.6 Belting industry
1.7 Hose industry
1.8 Latex industry

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Vanderbilt's Rubber Technology Handbook
3. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan

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RUBBER PRODUCT TESTING AND EVALUATION

CODE PS32 **L T P**
6 4 4

RATIONAL

The students will be required to:
(a) Acquire knowledge about testing of different rubber products like tyre, tube, belts, footwear, hoses and cables.
(d) Have ability to solve problems of related to Product testing and evaluation.

CONTENT

1. **Testing of Tyres** :
1.1 Pulley wheel and plunger testing for endurance.
1.2 Pulley wheel testing for mileage and temperature build up.
1.3 Measurement of stiffness,
1.4 Rolling resistance.
1.5 Ply to ply adhesion, sidewall to ply adhesion. Breaker / belt to ply adhesion.

2. **Testing of Tubes** : Air permeability testing, growth , set and swelling.

3. **Testing of power transmission belt and conveyor belt** : Drum friction test

4. **Testing of Footwear**:
4.1 Taber abrasion testing,
4.2 Compression set measurement

5. **Testing of Hoses**:
5.1 Leakage test,
5.2 Bursting strength,
5.3 Impulse test,
5.4 Oil resistance,
5.5 Flame resistance etc.

6. **Testing of Cables** : Permittivity, resistivity, die electric strength

7. **Testing of Moulded and Extruded Rubber Goods** : Compression set, swelling, ageing

PRACTICAL

1. **Testing of the Different Component of Tyres :**
1.1 Sample preparation
1.2 Stress-Strain property of tread, side wall compound.
1.3 Abrasion resistance of tread compound
1.4 Adhesion properties (Ply – Ply, Rubber – Ply)
1.5 Aging Property

2. Testing of Different Components of Tube :

- 2.1 Stress-Strain property
- 2.2 Aging property
- 2.3 Tension set
- 2.4 Swelling Index
- 2.5 Valve adhesion

3. Testing of Flaps :

- 3.1 Stress-Strain property
- 3.2 Aging property

4. Testing of any One of the Following Rbber Products :

- 4.1 Belting
- 4.2 Seals
- 4.3 Hoses
- 4.4 Cabels
- 4.5 Footwear

REFERENCE BOOKS :

1. Rubber Technology and Manufacturing — C.M. Blow
2. Vanderbilt's Rubber Technology Handbook
3. Introduction of Polymer Sc. & Rubber Technology, — Vol I, Ed. By Dr. R. Mukhopadhyay
4. Rubber Engineering, Ed. — K.S. Logonathan

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INDUSTRIAL MANAGEMNENT & COMMUNICATION SKILL

CODE PS33 **L T P**
6 2 2

RATIONAL

The students will be required to:

(a) Acquire basic knowledge about Industrial Management & Communication skills.
(b) Be familiar with different process control and quality control systems
(c) Be familiar with plant lay out and operational methods
(d) Be familiar with economics of manufacturing operation, process management etc.
(e) Be familiar with different quality management systems

CONTENT

1. Process Control & Quality Control :

- 1.1 Interaction of process control and quality Control
- 1.2 Specifications
- 1.3 Process Capability studies
- 1.4 Process Monitoring

2. Plant lay out and Operation Methods :

- 2.1 General considerations
- 2.2 Transport and storage in manufacture
- 2.3 Handling methods and operations at work stations
- 2.4 Planning and allocating space
- 2.5 Lay out synthesis and evaluation
- 2.6 Installing and commissioning a lay out.

3. Company philosophy, Organization and Strategy :

3.1 Philosophy
3.2 Company Organisation
3.3 Market Research
3.4 Company Development.

4. The Economics of Manufacturing Operations :

4.1 The flow of cash through a company,
4.2 Cost identification and analysis methods
4.3 Standard costs
4.4 Business Plans and Budgets
4.5 Budgetory Controls.

5. Production Management :

5.1 Production Planning
5.2 Purchasing
5.3 Inventory Control
5.4 Implementing the Production Plan.

6. Quality Management Systems :

6.1 Quality Data
6.2 Statistical Process Control
6.3 Quality Costs
6.4 Quality Audit
6.5 Quality Policy & Objectives
6.6 Inspection
6.7 Certification
6.8 Accreditation.
6.9 Basic concepts of ISO 9000, QS 9000, ISO 14000, OHSAS 18000, TS 16949 and TPM.

PRACTICALS

1. Group discussion/ Brain storming/ mock drill on the following :-

1.1 Different quality management system (ISO 9000, ISO 14000, OHASAS 18000, EnMS 50000)
1.2 Safety (Men Machine Material)
1.3 Environmental impact assessment
1.4 Risk Management

2. Preliminary plant lay out of Rubber Industry using Auto Cad.

REFERENCE BOOKS :

1. Rubber Processing and Production Organisation — Philip K. Freakly
2. Total Quality Management — D.H. Besterfield, C. Besterfield, G.H. Besterfield and M. Besterfield

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VIDYA BHAWAN POLYTECHNIC COLLEGE, UDAIPUR
TIME TABLE
POST DIPLOMA I Year POLYMER SCIENCE & RUBBER TECHNOLOGY

First Semester

Lecture / Day	I 8:00-9:00	II 9:00-10:00	III 10:00-11:00	RECESS 11:00-12:00	IV 12:00-1:00	V 1:00-2:00	VI 2:00-3:00
Monday	PS-11	← PS-13(T) →			PS-14	PS-11(T)	
Tuesday	PS-11	← PS-12(T) →			← PS-14(T) →		PS-15
Wednesday	← PS-13(P) →		PS-12		PS-15	← PS-11(P) →	
Thursday	← PS-14(P) →		PS-13		PS-11	PS-14	PS-15
Friday	← PS-15(T) →		PS-13		PS-12	PS-13	PS-14
Saturday	← PS-12(P) →		PS-12		← PS-16 →		