SYLLABUS
FOR
POST GRADUATE DIPLOMA COURSE
OF
INDIAN RUBBER INSTITUTE

PGD-IRI

NO OF PAPERS : 4 (Each Paper has Two Parts)

MARKS IN EACH PAPER : 100

PAPER I : POLYMER SCIENCE
Part "A" POLYMER CHEMISTRY
Part "B" POLYMER PHYSICS

PAPER II : RUBBER PROCESSING TECHNOLOGY AND PROCESS ENGINEERING
Part "A" RUBBER PROCESSING TECHNOLOGY
Part "B" PROCESS ENGINEERING

PAPER III : RUBBER MATERIALS, RUBBER COMPOUNDING & REINFORCEMENT
Part "A" RUBBER MATERIALS
Part "B" RUBBER COMPOUNDING & REINFORCEMENT

PAPER IV : RUBBER PRODUCTS MANUFACTURING AND THEIR EVALUATION
Part "A" RUBBER PRODUCT MANUFACTURING
Part "B" RUBBER PRODUCT EVALUATION

PAPER I PGD-IRI

POLYMER SCIENCE

This Paper consists of two parts – Part A : Polymer Chemistry and Part B : Polymer Physics. Out of total five numbers of questions to be answered at least three numbers must be from either Part.

The student will be required to :

(a) be familiar with Raw Materials and sources of Monomers
(b) have understanding on Structure – Property relationship
(c) have basic concept on Polymerisation – Mechanism & Techniques
(d) be aware about properties of Polymers and Physics of Vulcanised Rubber
(e) have ability to use mathematics as a tool for solving problems related to molecular weight of Polymers, shape factor, transmissibility etc.

PART A POLYMER CHEMISTRY

1. Raw materials

Concept of the basic starting materials of synthetic polymers, viz. petroleum and natural gas; brief outline of refinery process.

Monomers – their characteristics, functionality and types; outline of their manufacturing process. Natural polymers and their derivatives.

2. Structure-Property Relationship

Size and shape of molecules. Concept of Polymers, macromolecules and elastomers.

Classification of polymers – linear, branched, graft, crosslinked, thermosets and thermoplastics, homo -, hetero -, co - & ter- polymers.

molecular forces and bonds in polymers; relation between rubbers, plastics & fibres interpreted in terms of bond strengths, interchain forces and rotational energy barriers; concept of cohesive energy density and solubility parameter and their significance in polymer properties and in processing.

Configuration of polymers – isomerism and tacticity in polymers and their effect on polymer properties.

Crystallinity in polymers -- concept of spherulities & fibrils; factors affecting crystalisability of polymers and effect of Crystallinity on polymer properties; crystallization of polymers by cooling & stretching - concept of orientating a drawing & their significance.

Glass transition temperature – factors affecting tg; significance of tg in polymer properties and processing. Outline of measurement of tg.

3. Polymerisation -- degree of polymerization, development of the ideas of molecular mass averages, molecular weight distribution and their relevance to mechanical properties and flow behaviour; outline of molecular weight measuring methods.

Polymerisation – mechanism; basic types and criteria for polymerization – chain

and step growth (addition and condensation); extent of reaction & degree of polymerisation (DP), Control of DP; Corother's equation, Three dimensional polymerization; cross-linking and gel point.
Concept of Free Radical, Ionic, Coordination polymerization; initiation, Propagation, transfer & termination; effect of initiator, modifier, short stop & Inhibitors; effect of temperature & solvents; effect of catalysts.
types of monomers that can be polymerized through different mechanisms.

Importance and significance of stereo-regular polymers & their practical importance
Ring opening polymerization and its practical importance
Principles of polymerization techniques – mass, suspension, emulsion and solution ; their suitability for producing important commercial polymers

Comparison between batch and continuous polymerization processes.

PART B POLYMER PHYSICS

1. Rubber Physics Basic principles involved on the origin of rubber like behaviour and rubber Elasticity – Maxwell & Weight model
Concept of viscoelasticity and fundamentals of rheology – ideal elastic response, pure viscose flow, factors affecting flow behaviour; flow behaviour of Newtonian and non-Newtonian materials
Power law equation and its significance
Stress/strain behaviour of rubber as compared to plastics, fibres and metals

1. Rubber Engineering
Poisson's ratio, stored energy and energy loss – hysteresis and its significance. Behaviour of rubber under stress – in tension, compression, shear and torsion, concept of Shape Factor and its significance. Load-deflection and Transmissibility. Fundamentals of the design principles involved in products like Bridge Bearings, Suspension units Stress relaxation and Creep & their significance.

PAPER II (PGD-IRI)

RUBBER PROCESSING TECHNOLOGY AND PROCESS ENGINEERING

This Paper consists of two parts – Part A Rubber Processing Technology and Part B Engineering. Out of total five numbers of questions to be answered, maximum three numbers from each Part are to be answered.

The student will be required to :

(a) Have understanding of the principles of the basic processing operations and processability;

(b) be familiar with the features of design and construction f machinery used, including ancillary equipment (e.g. feed and take-off systems, drive systems, temperature and pressure measuring devices);

(c) be aware of the safe working practices;

(d) have ability to use mathematics as a tool for solving problems relating to hydraulic presses, heating system, mixing batch weight, calendar coating weight, extrusion die swell and Rheographs.

PART "A" RUBBER PROCESSING TECHNOLOGY

1. Storage and handling of materials

   Storage life, FIFO, handling and weighing/batching systems

2. Processing and Processability

   Review of methods of determining the processability of a rubber mix, using Mooney Viscometer, Rapid Plastimeter, Rheometer and Procesability tests-- including description of such equipments.

3. Mixing

   Principles of Mixing; distributive, laminar & dispersive mixing.

   Description construction and comparision of mixers and compounding equipment -- open mills and internal mixers; mixing energy; mixer geometry and flow mechanism, practical mixing techniques including sequence of mixing and evaluation of quality of mixing; trouble shooting of mixing operation;. post-mixing operations, handling and storage.

4. Extrusion

Basic principles involved; types of Extruders – Ram & Screw & their comparison. Variations of rubber extruders viz hot feed, cold feed, pin barrel,. vaccum and their comparison, screw design and fee arrangements, extruder head construction – straight head & cross-head; temperature control unit. Die and Die-swell; Function and layout of ancillary equipment for standard extrusion operations; trouble shooting of extruder operation.

5. Calendering

Construction, types and function of calendaring machine; calendaring processes; – fractioning, skim coating & sheeting; Roll floating, roll binding and calendar gauze control devices; Function and layout of ancilliary equipment for standard calendaring operation. Trouble shooting of calendaring operation. Other methods of textile coating viz. spreading, dipping – their usefulness, limitation and comparison.

6. Moulding

Description and construction of equipment used in Compression moulding, Transfer moulding, and injection moulding – their comparison.Mould shrinkage; Trouble Shooting of moulding operations.

Hydraulic systems used in moulding presses; Single daylight and multidaylight presses, vaccum system in presses.

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. Methods of blank preparation, Various Trimming and Finishing methods.

7. Continous Vulcanisation methods.

General description of methods currently used in industrial practices such as continuous vulcanization by RF, LCM and Hot air, IR and their comparison

PART "B" PROCESS ENGINEERING

1. Safety

Human aspect and Machine aspects – safety methods used in bale cutting, mixing extrusion, calendaring, moulding presses and in autoclaVes.

2. Mechanics

Work, POWER, Energy, Torque, concept of efficiency.

3. Power Transmission

Principles and operational requirement of Flat Belt, V-belt, Toothed Belt & Chain drives. Main types of gears – spur, helical & worm. Comparison of the different forms of power transmission in term of efficiency and limit of application; safety requirement of drive systems.

Selection of drive systems for a roll mill, extruder, moulding press, internal mixer, a calendar and haul-off system.

4. Hydraulics

Major features of pumps including positive and non-positive displacement pumps, fixed and variable displacement pumps – gear, vane & piston pumps; hydraulic accumulator.

Pressure control valves including simple relief valves, pressure reducing valves, unloading valves, flow control valves and direction al valves.

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

5. Heating systems used in rubber industry – steam boiler and their basic types; dryness factor of steam, steam line and steam traps – their functions and basic types and suitability; thermic fluid heaters and thermic fluid line; hot air generators and their applications; infra red heating, microwave heating and their applications and suitability.

6. Instruments used for measurement and control of temperature and pressure; thermometers, pyrometers, PD & PID controller, pressure gauges and transducers with reference to their application in rubber processing macheineries.

PAPER - III PGD-IRI

RUBBER MATERIALS, RUBBER COMPOUNDING & REINFORCEMENT

PART "A" RUBBER MATERIALS

1. Natural Rubber -- source, production systems for sheet and block rubber, gradation system, processing characteristics & curing systems.

2. Latex --- NR latex types and grades; preservation, concentration , stability, gellation, coacervation,; Dispersions and Emulsions – their preparation and use of surface active agents in latex compounds simple latex mix design.

3. General Purpose Synthetic Rubbers such as SBR, PBR, NBR, CR, IIR, EPDM -- their structure, grades, curing systems, comparative properties and applicatuions.

4. Special Purpose Synthetic Rubbers - FKM, ACM, ECO, CSPE, Polysulphide & Halo Butyl – their structure, grades, general compounding, comparative properties and applications.

5. Polymer Blends --- their importance and applications, concept of miscibility/ compatibility; useful blends – rubber-plastic, rubber-rubber e.g. NBR/PVC blends, NR/SBR, NR/PBR etc.

6. Thermoplastic Rubber (TPR) and Thermoplastic Elastomers (TPE) - their concept and applications of SBS and EVA.

6. Industrial Plastics – PVC, PE, PP, PF Resin, Polyester, Polyamide – their structure, grades, comparative properties & applications

PART "B" RUBBER COMPOUNDING & REINFORCEMENT

7. Principles of compounding, Compounding Ingredients and Mix Design to meet processing and vulcanisate properties.

a. Functions and uses of accelerators, setarders, peptisers, tackifiers, process aids, activators, softeners, extenders, reclaimed rubbers, crumb rubbers, mineral rubbers, rubber substitute (factice), pigments, blowing agents.

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

c. Curing Systems -- conventional, semi – EV and EV systems, classification of accelerators, provide, metal oxide and resin curing systems and their applications. 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.

7. Textiles -- definition of fibres, yarn, cord, twist, count, denier, tex, types of textile weaves and their application in different rubber products; structure and comparative properties of cotton, rayon, polyamide, polyester, aramid, glass and steel wire and their applications in rubber products. Textile to rubber bonding systems – Dry and RFL.

8. Specification, Standards and Testing of Raw Materials.

Plasticity and Viscosity Test of dry rubbers and latices; sieve residue test, heat loss, ash content acetone extract test for dry rubbers; their significance; total solids, dry rubber content, pH, VFA content, KoH member, mechanical and chemical stability test for latex and their significance; sieve residue test, Sp.Gr. bulk density, heat loss, ash content, pH of water extract, aniline point, melting point/softening point test for compounding ingredients and their significance.

9. Storage, Handling and Hazardous nature of compounding materials, oils and solvents and safety measures involved.

PAPER - IV

RUBBER PRODUCT MANUFACTURING AND THEIR ELALUATION

This Paper consists of two parts ; Part A Rubber Product Manufacturing and Part B Rubber Product Evaluation. Out of total five number of questions to be answered , atleast two numbers are required to be answered from each Part

The students will be required to :

(a) have knowledge about manufacturing outline of major rubber products involving the material, components, their functions, building and curing.
(b) be familiar on design construction and comparative advantages/disadvantages.
© be familiar with MIX design.
(e) have ability to use mathematics as a tool to solve problems related to design parameter on products like Hose, expansion/shrinkage in cellular products etc.

PART A RUBBER PRODUCT MANUFACTURING

1 : Tyres and Tubes –cycle tyres, passeneger car tyres and truck tyres; tyre sizing and marking; different types of tyre constructions – bias, belted bias, radial & tubeless tyres – their basic features and characteristics; different components of tyres and their functioning; manufacturing techniques – principles of compound design, selection criteria of different reinforcement materials; method of tyre building & curing; post curing treatments.

2. Industrial Rubber Products
:
(a) Belting – Conveyor, Transmission, V-Belt & Timing Belt – types, grades functions, construction, selection of materials, mix design, building and curing.
(b) Hose -- Types and grades; construction – hand-made, circular woven, braided and spiral; their advantages; disadvantage and applicability; design features, neutral angle and bursting pressure calculation; selection of reinforcing materials and mix design, production flow chart and curing methods.
(c) Footwear -- Sole manufacturing – microcellular, Unit Sole and Resin Rubber Sole; hand-built footwear & DVP/DIP.
(d) Cables -- Types/grades -- Construction, insulation and sheath, materials selection, mix design, building and curing.

3. Latex Products : Dipped Goods – ballons, prophylatices and gloves; latex Thread and Foam and Carpet Backing

4 : Miscellaneous Rubber Products :

(a) Coated Fabrics and calendered sheeting.
(b) Moulded items like seals, gaskets, auto components etc.
(c) Rubber to Metal bonded components -- engine mounting, rubber roller.
(d) Extruded items like tubing, weather strip etc.
e) Adhesives -- solvent based and aqueous systems.

PART – "B' RUBBER PRODUCT EVALUATION

The student will be required to :

(a) be aware of Philosophy of Testing.

(b) be familiar with SPECN, STDS and Quality Management systems.

(c) have knowledge about the following test methods and their application in the rubber products covered in Part 'A' above.

(d) have ability to use mathematics as a tool to solve problems related to testing such as tensile strength, resilience, resistivity, swelling etc.

1. Philosophy of testing : Standard test methods; limitation of test data, precision, accuracy and validity of test methods. Quality Assurance a elements of statistical quality control – mean, average, medium, variance, standard deviation .

2. Specification and standardization. Awareness about BIS and ISO standards on rubber, 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.

(a) Effect of environment and ageing of rubbers; swelling tests, oxidative and thermal ageing, ozone cracking tests.

(b) Electrical properties of rubber; determination of resistivity and diaelectric strength.

(c) 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.

(d) Destructive tests -- Tens 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.

(e) Adhesion/Bond testing -- peel test, Pull test and shear test -- their m significance and limitations.

(f) Thermal Properties; Thermal Conductivity, Heat Diffusivity – their importance and measurement.