

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Rubber Engineering)

Semester – II

PROPOSED TEACHING SCHEME

w.e.f. (28/2/2012)

Subject Code	NAME OF SUBJECT	TEACHING SCHEME(HOURS)			CREDITS
		THEORY	TUTORIAL	PRACTICAL	
1720001	Principles of Management	3	0	0	3
1724001	Rubber Bonding & its Technology	3	2	0	4
1724002	Rubber Blends	4	0	0	4
	Major Elective -II	4	0	4	6
	Major Elective -III	3	2	0	4
	Inter Disciplinary Elective II	3	2	0	4
	Total	20	6	4	25

Inter Disciplinary Elective - II

Subject Code	Subject Name
1724007	Weathering of Rubbers

Major Elective -II

Subject Code	Subject Name
1724003	Optimization in Rubber Industries(Synthesis Group)
1724004	Nano Rubber Composites (Product & Process Design Group)

Major Elective - III

Subject Code	Subject Name
1724005	Thermal Analysis of Rubber and Rubbery Materials(Synthesis Group)
1724006	Speciality Elastomers & its Technology (Product & Process Design Group)

GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: **1724001**

Subject Name: **Rubber Bonding & its Technology**

Sr_No	Subject Content
1.	Introduction to Rubber bonding: Types of Bonding, Overview of Bonding Process, Development of Bonding.
2.	Substrate Preparation Methods: Metal Preparation, Pre-treatments of Plastics and Rubbers, Bonding Rubbers to Plastic Substrates, Substrate Preparation for Bonding Using the Wet Blast Process
3.	Rubber to Metal Bonding: Bond System Characteristics, Adhesion, Effective Bond Formation, Post Vulcanisation Bonding, Factors Affecting Bond Integrity, Bond Failure Types, Bond Test Procedures.
4.	Rubber to Metal and Other Substrate Bonding: Substrates and their Preparation, Bonding Agent Preparation, Bonding Agent Application and Use, Post Vulcanisation Bonding, Waterborne Bonding Systems, Bonding Agent Testing, Shelf Life Considerations.
5.	Rubber to Rubber Bonding: Bonding of Unvulcanised Rubbers, Bonding of Vulcanised Rubbers to Unvulcanised Rubbers, Bonding of Vulcanised Rubbers.
6.	Rubber to Metal Bonding Using Metallic Coagents : Introduction, Metallic Coagents, Adhesion to Metals, Adhesion to Fibres and Fabrics.
7.	Failures in Rubber Bonding to Substrates: Incorrect Moulding Procedures, Incorrect Production Quality Testing Procedures, Corrosion in Service, Product Abuse, Factors Affecting Adhesion of Rubbers, Topography of Substrate, Surface Conditions of Adherend, Bonding - Interphase or Interface Considerations, Undesirable Adhesion Occuring Under Service Conditions.

TextBooks:

Handbook of Rubber Bonding edited by Bryan Crowther, Rapra Technology

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Subject Code: **1724002**

Subject Name: **Rubber Blends**

Sr_No	Subject Content
1.	Rubber-rubber blends: Introduction, morphology, analytical methods for blend characterization, preparation of rubber blends, properties of rubber blends, multiphase elastomers, miscible blends.
2.	NR/NBR Blends: Introduction, NR/BR41, NR/Krynac 34.50 Blends, Improving the Morphology and Properties of NR/NBR Blends with NR/PMMA Graft Copolymers, Improving the Morphology and Properties of NR/NBR Blends with Polychloroprene as the Compatibilizing Agent, NR/NBR Blends – Compounding for Food Contact Applications.
3.	Novel Natural Rubber/Ethylene Propylene Copolymer (EPM) Blends: Introduction, Dynamic Vulcanization, Selection of Dynamic Cure System, Dynamic Vulcanization of NR/EPM Blends, The Sandwich Mix Cycle, Processing Behaviour, Vulcanization of DV Blends, Resistance to Environmental Damage.
4.	Natural Rubber/ENR-25 Blends : Introduction, Designed Experiments, Plasticizer Investigations, Cure Systems, Dynamic: Static Modulus Ratios, Tri-Blends, Improving Resistance to Low Temperature Crystallization in NR/ENR-25 Blends.
5.	NR/EPDM Blends : Solutions to the Basic Problems of Poor Physical Properties of NR/EPDM Blends, Approaches to Improving NR/EPDM Blend Properties, Mixing Procedures, Effect of EPDM Modification on Crosslink Density, Effect of EPDM Modification on Phase Morphology, Interaction of Modified EPDM and Carbon Black, Physical Properties, High Temperature Curing Effects, Modification of Different EPDM Grades, Compounding NR/EPDM Blends for Light-Coloured Applications NR/EPDM Blends for Extruded Profile Weatherstrip.
6.	Blends of carboxylated elastomers with other polymers : Blends of carboxylated and regular nbr, blends of carboxylated nbr with polybutadiene, with epichlorohydrin rubber, with pvc, with regular nbr and pvc, with chlorosulfonated polyethylene, with chlorobutyl rubber, with polychloroprene, with modified natural rubber, with polyacrylic rubber, with polyolefins, blends of carboxylated elastomers with polyamides, blends of carboxylated epdm with polyethylene terephthalate.

TextBooks:

1. Blends of Natural Rubber Novel Techniques for Blending with Speciality Polymers Edited by Andrew .J Tinker and Kevin P. Jones; Publisher: CHAPMAN & HALL
2. Handbook of Elastomers edited by Ani1 K. Bhowmick and Howard I. Stephens

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Subject Code: 1724003

Subject Name: Optimization in Rubber Industries (Major Elective II)

Sr_No	Subject Content
1.	Introduction to Optimization: Basic concept of optimization, formulation of optimization problems, problem dressing, feasible region, Classification of Optimization Problems: single variable- multivariable problems, optimization without constraints - with constraints, Maximization and minimization problems, Convex and concave functions, unimodal-multimodal, single objective-multiobjective optimization.
2.	Analytical Optimization Techniques: Stationary points, Optimization of unconstrained Functions One-dimensional Search, direct substitution, constrained variation, penalty function, Lagrangian Multiplier, Kuhn-Tucker theorem, Simplex Method of Linear Programming, Duals in optimization, Quadratic programming, Geometric Programming.
3.	Numerical Optimization Techniques: General principles of numerical search, region elimination techniques, direction of search, final stage in search, direct search, pattern search, acceleration in direct search, gradient methods, the complex method of Box.
4.	Application of Optimization In Rubber Industries: Design of product mixes, optimization in mould design, product shape-size design, screw design, optimization in Mixing, Extrusion, Curing.
5.	Optimal design and scheduling: Single product batch plants, Multiple product batch plants, Parallel units and intermediate storage, Sizing in batch plants, Inventories, flow shop and jobshop plants, constraints and formulation of design models for optimization, formulations for discrete sizes.
6.	Advanced Optimization Techniques: Genetic Algorithm, Memetic Algorithm, Simulated Annealing, Differential Evolution, Ant Colony Optimization, Particle Swarm Optimization and recent developments.

TextBooks:

1. Optimization Theory and Practice by Gordon S.G. Beveridge and Robert S. Schechter, by Mc-GrawHill Publication.
2. Product and Process Design Principles by Warren D Seider, J. D. Seader, Daniel R Lewin, by John Wiley and Sons, Inc.
3. New optimization techniques in engineering by Godfrey C. Onwubolu and B. V. Babu.

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Subject Code: **1724004**

Subject Name: **Nano Rubber Composites (Major Elective II)**

Sr_no	Subject Content
1.	Introduction to Nanocomposites: Various Nanofillers, Rubber Nanocomposites, Future Outlook, Challenges and Opportunities.
2.	Manufacturing Techniques of Rubber Nanocomposites: Introduction, Melt Compounding, Solution Blending, Latex Compounding.
3.	Interface Modification and Characterization: Introduction, Rubber Nanocomposites Without Interface Modification, Interface Modification by Nonreactive Routes, Interface Modification by Reactive Routes, Characterization of Interface Modification.
4.	Natural Rubber Green Nanocomposites: Introduction, Preparation of Polysaccharide Nanocrystals, Processing of Polysaccharide Nanocrystal-Reinforced Rubber Nanocomposites, Morphological Investigation, Swelling Behavior, Dynamic Mechanical Analysis, Tensile Tests, Successive Tensile Tests, Barrier Properties.
5.	Carbon Nanotube Reinforced Rubber Composites: Introduction, Functionalized Carbon Nanotubes, Elastomeric Nanocomposites
6.	Rubber/Clay Nanocomposites-Preparation, Properties and Applications: Introduction, Clays and Their Organophilic Modification, Preparation of Rubber/Clay Nanocomposites, Properties of Rubber/Clay Nanocomposites, Applications.
7.	Nanofillers In Rubber–Rubber Blends : Introduction, Types of Nanofillers, Role of Nanofillers in Reinforcement, Methods to Enhance Polymer–Filler Interaction and Reinforcement, Role of Nanofiller as Compatibilizer, Structure Compatibility Concept of NR-Based Latex Blends, Solubility Parameter and Mixing of Latices, Preparation of Nanocomposites, Rubber Blend Nanocomposites Based on Skim NR Latex and Fresh NR Latex: Preparation, Characterization and Mechanical Properties, Advantages of Nanocomposites and Application of Rubber Nanocomposites.
8.	Aging and Degradation Behavior of Rubber Nanocomposites: Introduction, Types of Fillers Used in Rubber Nanocomposites, Aging of Rubber Nanocomposites, Degradation of Rubber Nanocomposites.
9.	Application of Rubber Nanocomposites: Introduction, Rubber Nanocomposites in Tire Engineering Applications, Rubber Nanocomposite Membranes, Applications of Rubber Nanocomposites in Sporting Goods, Advanced Nanocomposites for Aerospace Applications, Nanorubbers in Medicine and Healthcare.

TextBooks:

Rubber Nanocomposites Preparation, Properties and Applications; edited by Sabu Thomas and Ranimol Stephen

GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: **1724005**

Subject Name: **Thermal Analysis of Rubber and Rubbery Materials**
(Major Elective III)

Sr_No	Subject Content
1.	Instrumental Techniques used for Thermal Analysis of Rubbers and Rubbery Materials: Introduction, Differential Thermal Analysis (DTA) , Differential Scanning Calorimetry (DSC), Derivative Thermogravimetry (DTG), Evolved Gas Analysis (EGA) or Evolved Gas Detection (EGD), Thermomechanical Analysis (TMA) and Thermodilatometry (TD) or Thermodilatometric Analysis (TDA), Parallel Plate Rheometry (PPR), Stress Relaxation Spectrometry, Dynamic Mechanical Analysis (DMA), Torsional Braid Analysis (TBA), Thermally Stimulated Current (TSC), Relaxation Map Analysis (RMA), Differential Photo Calorimetry (DPC), Dielectric Analysis (DEA) or Dielectric Thermal Analysis (DETA).
2.	Applications of DSC and TGA for the Characterisation of Rubbers and Rubbery Materials: Introduction, Differential Scanning Calorimetry of Rubbery Materials, Thermogravimetric Analysis of Rubbery Materials, Thermal Degradation and Stability of Rubbers by TGA, Miscellaneous Applications of TGA.
3.	Micro-thermal Analysis of Rubbery Materials: Introduction, Basic Principles of μ TA, Modes of Micro-thermal Analysis, Micro-thermal Analysis of Rubbery Material, Morphological Investigation in Polymer Blends, Thin Films/Coating on the Substrate, Multilayer Material Characterisation, Thermal Characterisation of Micro-spheres, Powder Particle Characterisation, Characterisation of Micropores, Characterisation of Nanostructured Material.
4.	Thermal Analysis in Understanding Rubbery Matrix and Rubber-Filler Interactions: Introduction, Thermal Analysis and Investigation of Heterogeneous Materials, Structure-Properties Relationships in Particulate Filler/Rubbery Matrix Systems, Description of the Shape and Space Distribution of Filler Particles, Filler-to-Matrix and Filler-to-Filler Interactions as Investigated by Thermal Analysis, Thermogravimetry, DTA and DSC.
5.	Thermal Analysis of Rubber Products: Introduction, Thermal Analysis of Rubber Based Vibration Control Devices, Thermal Analysis of Rubber Seals, Thermal Analysis of Rubber-Based Cable Sheathing Compounds, Thermal Analysis of Rubber Based Adhesives, Thermal Analysis of Rubber Based Insulators, Thermal Analysis of Thermal Interface Materials (TIM), Thermal Analysis of Automobile Tyres.

TextBooks:

Thermal Analysis of Rubbers and Rubbery Materials: Editors: Namita Roy Choudhury & Prajna P De and Naba K. Dutta.

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Subject Code: 1724006

Subject Name: Speciality Elastomers & its Technology (Major Elective III)

Sr_No	Subject Content
1.	Modified natural rubber: Hydrogenated natural rubber, chlorinated natural rubber, hydrohalogenated natural rubber, cyclized natural rubber, resin-modified natural rubber, poly(methylmethacrylate)-grafted natural rubber, enpcaf-modified natural rubber, liquid natural rubber.
2.	Chemical modification of synthetic elastomers : Hydrogenation, cyclization, isomerization, halogenation and hydrohalogenation and recent developments.
3.	Short fiber-filled rubber composites : introduction to rubber composites, methods for the analysis of fiber orientation, mixing effects.
4.	Tetrafluoroethylene-propylene rubber: Introduction, manufacturing, polymer structure and fundamental properties, compounding and vulcanization, vulcanizate properties and applications.
5.	Carboxylated rubber : Introduction, preparation of carboxylic rubbers, composition of carboxylated emulsion polyfvlrs, vulcanization of carboxylated rubbers, scorch, and bin storage stability of carboxylic elastomers, compounding ingredients for carboxylated elastomers, physical properties, applications for carboxylated elastomers.
6.	Acrylic-based elastomers : Introduction, basic structure, methods of production, compounding techniques, processing characteristics, vulcanization methods, physical properties, applications.
7.	Crosslinked polyethylene : Introduction, basic structure, compounding and mixing of polyethylene, processing, physical properties of crosslinked polyethylene, applications of crosslinked polyethylene.

TextBooks:

Handbook of Elastomers edited by Ani1 K. Bhowmick and Howard I. Stephens

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Subject Code: 1724007

Subject Name: Weathering of Rubbers (Interdisciplinary II)

Sr_No	Subject Content
1.	Assessment of life of Rubber: Introduction, The Problems, The Choice of Approaches, Degradation Agents, Degradation Mechanisms, Time Dependent Limitations, Critical Factors, Parameters to Monitor Degradation, Preparation of Test Pieces, Uncertainty and Application of Statistics.
2.	Product tests and experience: simulating service, principles of product testing.
3.	Accelerated tests: introduction, purpose, methods, fundamental problems, designing an accelerated test programme.
4.	Effect of Temperature: Low temperature, Properties at service temperature, Thermal expansion, Heat ageing
5.	Effect of Liquids and Gases: General procedures, Standard liquids, Water, Effect of Gases, Exposure to ozone, Evaluation of cracking
6.	Weathering and Fatigue: Introduction, Heat build-up tests, Flex cracking and cut growth tests, Tests in tension, Non-standard methods
7.	Abrasion: Introduction, Types of abrasion test, Abrasion test conditions, Abrasion test apparatus, Expression of abrasion test results.
8.	Other Degradation Agents and Service Conditions: Biological attack, Ionising radiation, Electrical stress, Temperature, Solar irradiation.
9.	Prediction Techniques: Introduction, Standardised procedures, Models for change of parameter with time, Environmental degradation tests, Arrhenius relationship, Time/temperature shift, Artificial weathering, Ionising radiation, Effect of liquids, Effect of gases, Creep and stress relaxation, Set, Fatigue, Abrasion, Dynamic conditions.

TextBooks:

Practical Guide to the Assessment of the Useful Life of Rubbers by Roger P. Brown; Rapra Technology Limited.