GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Under Graduate

Branch: Rubber Technology

Subject Code : BE05026121

Subject Name : Reclaimed Rubber & its Technology

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	None
Rationale:	This course provides knowledge of waste rubber recycling and reclaim technologies, including devulcanization methods, manufacturing of reclaimed rubber, and material characterization. It focuses on blending reclaimed rubber with natural and synthetic elastomers and studying property improvement using grafting and coupling agents. The course develops understanding of sustainable rubber utilization, waste management, and eco-friendly compounding practices supporting circular economy in the rubber industry.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	Marks % weightage
C01	Differentiate between Recycle Rubber and Reclaimed Rubber	20
C02	Select the proper Devulcanisation technique according to application	20
C03	Explain the different types of reclaimed Rubber and its manufacturing process	20
C04	Analyze the effects of Devulcanised rubber on reclaimed rubber	20
C05	Solve the problems related to compounding, mixing and environment	20

Teaching and Examination Scheme:

Teaching/Learning Scheme in hrs/semester					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Practical			
L	T	P	PBL*	TH	TH/30	ESE (E)	PA (M)	PA (I)	PBL(I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA**

manual.

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction: Difference between Recycle rubber and Reclaim rubber, Tire Reuse and recovery in developing countries, Application of Reclaim rubber	05	15
2.	Devulcanisation Techniques: Introduction, Structure of Sulfur Vulcanized Rubber and the Properties of Sulfur Crosslink's, Thermal Devulcanisation Processes, Mechanical Devulcanisation Processes, Mechanical Devulcanisation in the Presence of Chemical Agents, Ultrasonic Devulcanisation, Microwave Devulcanisation, Microbiological Devulcanisation, Miscellaneous Devulcanisation Processes	06	10
3.	Types and Manufacturing process of Reclaimed Rubber: Whole tire reclaim (WTR), Minimum Staining Reclaim, Drab and Coloured Reclaims, Butyl Reclaim, Production of Whole Tire Reclaim, Digester Process (Neutral or Alkali), Thermal Process, Reclaimator Process, Pan Process, IS 7493 – Specification for Reclaimed Rubber	07	10
4.	Characterisation of Devulcanized Rubber: Chemical Analysis Tests, Quality of Devulcanised Rubber, Determine Processing Properties of Devulcanised Rubber, Physical Properties of Vulcanisates Containing Devulcanised Rubber	07	10
5.	Blends of whole tire reclaim with natural and synthetic rubber: • Natural rubber / Whole tire reclaim blends Preparation of blends, Cure Characteristics, Mechanical Properties, Ageing Resistance • Butadiene rubber / Whole tire reclaim blends Preparation of blends, Cure Characteristics, Mechanical Properties, Ageing Resistance • Styrene butadiene rubber / Whole tyre reclaim blends Preparation of blends, Cure Characteristics, Mechanical Properties, Ageing Resistance • Acrylo nitrile butadiene rubber / Whole tire reclaim blends Preparation of blends, Cure Characteristics, Mechanical Properties, Ageing Resistance	08	15
6.	Effect of grafting Maleic anhydride on to whole tire reclaim: Grafting of Maleic anhydride on reclaimed rubber, NBR/ MA-g- WTR blends, CR/ MA-g WTR blends, SBR/MA-g- WTR blends,	06	10

7.	Effect of coupling agent on whole tire reclaim blends: Effect of silane coupling agent on NBR/WTR blends, Effect of silane coupling agent on CR/WTR blends, Effect of silane coupling agent on SBR/WTR blend	06	10
	Total	45	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
12	12	16	10	10	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Recycling and Re-use of Waste Rubber by Martin Forrest
2. Rubber Recycling Challenges and Developments by Edited by Jin Kuk Kim , Prosenjit Saha, Sabu Thomas, Józef T. Haponiuk, M. K. Aswathi
3. Studies on tue Utilisation of Rubber Reclaim in Elastomers by P.A.NELSON
4. Rubber Products Manufacturing Technology By: Anil K. Bhowmick.

(b) List of Open Source Software/learning website:

- **http://www.seas.columbia.edu/earth/RRC/documents/recycling_rubber.pdf**
- **https://dyuthi.cusat.ac.in/xmlui/bitstream/handle/purl/2191/Dyuthi-T0543.pdf**

List of Experiments:

Tutorials/Presentation/Practicals based on above topics.

Overall SDG Mapping

The course primarily supports **SDG 12** through recycling and sustainable utilization of waste rubber materials. It contributes to **SDG 13** by reducing environmental pollution from discarded tyres and promotes **SDG 9** through innovative devulcanization and reclaim technologies, supporting sustainable and resource-efficient rubber manufacturing practices.

Activities suggested under problem based learning:

Sr No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Online Course	Minimum duration of the course should be 20 h.	Based on assignment submitted and certificate produced.
2.	Virtual /Industry Trip	Duration of hours-5h Report preparation- 5h Total -10 h	Based on report submitted. Report should contain manufacturing process, flow chart.
3.	Assignments	Completion of five independent tasks, each designed for a 3-hour engagement. Total = 15h	Based on assignment submitted.
4.	Case Study Analysis related to subject	Duration of data collection -6 h Report preparation – 4h Total- 10 h	Based on Problem identification, depth of analysis, technical insight, application relevance
5.	Technical Article/Video Reviews related to subject	Duration of Review -6h Report preparation -4h Total-10h	Relevance of content, clarity of summary, insights drawn, conceptual understanding
6.	DIY Experiments	5 hours including report preparation	Based on report submitted. Report should contain experiments performed which have Creativity, relevance to rubber properties, observation documentation, safety awareness.
7.	Course Seminar	Duration -10h	Based on technical Content & Understanding, Analysis, literature review, Quality of report and presentation.
8.	Mini/ Micro Project	Duration -10h	Based on Technical Analysis, literature review, methodology, innovation/sustainability aspect, Quality of report and presentation.
9.	Complex Problem solving	Duration -5h	Evaluation is based on problem complexity & clarity, analytical approach, design/experimental methodology, use of modern tools,

			sustainability considerations, innovation, result validation, and feasibility of solution.
10.	Videos focusing on industrial safety topics relevant to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based report submitted. Report should contain all safety aspects explaining its importance.
11.	Visual presentation of technical content through posters, charts, or PowerPoint slides	Duration = 10 h	Based on quality of poster/chart preparation, creativity, accuracy and effectiveness of presentation skills.

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