GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: Under Graduate
Branch: Rubber Technology
Subject Code : BE04026011
Subject Name : Rubber Compounding Materials

w. e. f. Academic Year:	2025-26
Semester:	B. E. Sem. -4
Category of the Course:	PCC-04

Prerequisite:	None
Rationale:	This subject provides essential knowledge of organic and inorganic materials, their roles in rubber compounding, and the functional use of rubber additives and antidegradants to enhance performance and durability. It covers the selection and function of compounding materials, along with the principles and calculations involved in compounding (cost, volume, specific gravity). The course also addresses environmental requirements and regulatory considerations, promoting safe and sustainable practices. A detailed understanding of carbon black and its impact on vulcanizate properties is included. Overall, the subject builds scientific and technical skills needed for efficient rubber formulation, processing, and product development.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Differentiate between the roles of organic and inorganic materials in rubber formulations based on their properties.
02	Analyze the functions and classification of rubber additives and anti-degradants in rubber processing.
03	Identify compounding materials and formulate rubber recipes as per requirements.
04	Calculate cost, volume, and specific gravity of compounds and analyze the impact of compounding variations on processing and end use properties.
05	Evaluate carbon black properties and their effect on rubber performance.

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

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

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

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Organic Materials: Hydrocarbons, Unsaturated Hydrocarbons, Aromatic Hydrocarbons, Phenols, Alcohols, Fatty Acids, Amines, Rubber Chemicals, Organic Peroxides, Resins, Quantitative Analysis of Organic Compound.	05	10
2.	Inorganic Materials: Calcium & Magnesium, Copper & Zinc, Compounds of Aluminum, Silicone and Ozone, Other Inorganic Compounds used in Rubber Industries, Sulfur etc.	05	10
3.	Rubber Additives: Basic Principles, Introduction, Classification of Additives, Recurring Theories, Synergism, Toxicity.	05	10
4.	Antidegradants: Introduction, Autoxidation of Hydrocarbon Polymers, Chain-Braking Antioxidants, Amine & Phenolic Antioxidants, Antiozonants, Prevention of Ozone Attack, Use of Waxes & Saturated Polymer for Ozone Protection.	05	10
5.	Compounding Materials: Plasticizers, Process aids & Factices, Accelerators, Blowing Agents, Bonding Agents, Other Compounding Aids, Peptisers, Colors & Pigments, Special Purpose Additives, Non-Black Fillers etc.	10	20
6.	Principles of Compounding: Introduction, the ingredients & formulation of a mix, compounding to meet processing requirements, Compounding of Vulcanizate properties, Compounding for Bonding to non-rubber substrates.	05	15
7.	Art of compounding: Calculation of compound cost of a recipe, Calculation of compound volume of a recipe, Calculation of compound specific gravity of a recipe, formulation of mix, Processing requirements.	05	10
8.	Carbon Black: Introduction, Properties, Rubber compounding aspects, Furnace process, Thermal process channel or impingement process, Lamp black process, Particles size, Structure, Particle porosity, Classification. Effect of properties of carbon black on properties of rubber Vulcanizates.	05	15
	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. Rubber Engg. by IRI
2. Rubber Technology Handbook, by Hofmann
3. Science & Technology of Rubber, by J. Mark, B. Erman, F. Eirich
4. Rubbery Materials & their Compounds, by J. A. Brydson
5. Rubber Technology & manufacture, by C. M. Blow
6. Rubber Product Mfg. Technology, by Anil K. Bhowmick

(b) Open source software and website:

1. **www.britannica.com/EBchecked/topic/511800/rubber/289657/Additives**
2. **www.ndsseals.com/rubber-ingredients.html**
3. rubbertrainer.blog.com/2012/09/24/compounding-ingredients
4. **https://rubbertech.wordpress.com/2013/07/.../basic-rubber-compounding**
5.

Suggested Course Practical List: If any

Practical based on above topics.

List of Laboratory/Learning Resources Required:

Suggested Project List:

1. **Comparative Analysis of Phenolic and Amine-based Antioxidants in Rubber Compounds**
2. Quantitative Analysis of Organic Peroxides in Rubber Formulations.
3. Effect of Zinc Oxide vs. Magnesium Oxide on Cure Characteristics of Natural Rubber.
4. Role of Sulfur and Aluminum Compounds in Crosslinking Density of Vulcanizates.
5. Classification and Synergistic Effects of Rubber Additives on Tensile Properties.
6. Toxicity and Environmental Impact Assessment of Common Rubber Additives.
7. Evaluation of Additive Efficiency Using Recurring Theory in Rubber Compounding.

8. Mechanism and Prevention of Autoxidation in Unsaturated Rubber Blends.
9. Performance Comparison of Non-black Fillers in Colored Rubber Compounds.
10. Assessment of REACH-compliance for Rubber Compounding Ingredients.
11. Green Alternatives to Hazardous Rubber Chemicals in Compounding.
12. Design of a Compound Mix to Achieve Target Vulcanizate Properties.
13. Cost Estimation and Optimization of Rubber Recipes for Sealing Applications.
14. Structure and Particle Size Analysis of Carbon Black Using Microscopy Techniques.
15. Comparative Study of Carbon Black Production Methods and Their Influence on Rubber Properties.

Suggested Activities for Students: If any

List of suggested activities for 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.	Self-Learning Through Assignment Creation related to subject	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.	Industry Interaction (Webinar/Interview/Quiz)	Total-10 h	Based on certificate produced for participation in webinar, interview, quiz and based on report submitted. Report should contain key takeaways.

7.	Peer Teaching Video	2 video preparation - 10 h	Create a 5–10-minute video explaining a rubber technology concept for peers, incorporating visuals.
8.	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.
9.	Glossary Compilation	Duration -5h	Based on report submitted. Report should contain Accuracy, completeness, formatting, and use of illustrations/examples
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.	Peer Interaction / Teaching	5 research paper/ Technical Topics = 20 h	Communication skill, clarity of explanation, concept understanding
12.	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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