



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3152601
Semester –V
Subject Name: Vulcanization

Type of course: Professional Core Course

Prerequisite:

Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	4	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Drawbacks of Raw Rubber, Definition of Vulcanization, Properties of Unvulcanized Compound, Difference between Vulcanized Rubber and Unvulcanized Rubber, Structural Changes observed in Rubber After Vulcanization, Structure of Rubber Vulcanizate.	06
2	Sulphur Vulcanization :- Practical systems for Natural & Synthetic Olefin Rubber-Theory of Sulphur vulcanization.	06
3	Non-sulphur vulcanizing systems for olefin & Non-olefin Rubbers: Metallic oxides, Polyfunctional amines, peroxides for polyacrylates, Silicone Rubbers, Fluorocarbon Rubbers.	06
4	Types of Vulcanizing agents & their effects: 1. Sulphur 2. Sulphur donors 3. Accelerated sulphur vulcanization 4. Peroxides : Introduction, Classification of Peroxides and their Structures, Examples of Peroxides, Efficiency of Peroxides, Chemistry of peroxide cure, Compounding Aspects of peroxide Cure, Advantages of Peroxides cure over sulphur vulcanization, Disadvantages, Reaction mechanism, Peroxide cure of saturated and unsaturated elastomers 5. Metal oxides: Introduction, Reaction mechanism, Suitable examples 6. Phenolic curatives: Introduction, Reaction mechanism, Suitable examples, Vulcanisation by benzoquinone derivatives, bis-maliemides, Vulcanization by triazine accelerators, Urethane cross -linking.	06
5	Relations between Structure and Properties of Vulcanizates: Modulus and Strength, Hardness, Resilience and Heat Buildup, Fatigue Properties, Heat Stability, Swelling, Low Temperature Properties, Abrasion, Compression Set, Aging, Dynamic Properties and Rolling Friction.	06
6	Different Vulcanisation System: Conventional, EV and Semi EV system in rubber, Accelerator system selection &	06



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	adjustment, Vulcanization of rubber blends and filled systems.	
7	Modern Vulcanisation System: Moisture curing, Dynamic Vulcanisation, Shrinkage and Post Vulcanisation reaction	04
8	Vulcanisation techniques: Introduction, Classification of Vulcanization Techniques. Batch Vulcanization Techniques: Moulding, Autoclave, Hot Air Oven Curing, Lead Curing, Moisture Curing, Free Heating: General Comments About Free heating, Difference between hot air and steam vulcanization, Vulcanization Phases During Free Heating, Comparison of Saturated Steam Vulcanization and Super heated Steam, Vulcanization in Air/Steam Mixture, Vulcanization in Water, Cold Vulcanization. Continuous vulcanization : Liquid Curing Method, Fluidized Bed Vulcanization, Continuous Vulcanization in Stem Pipes, Rotocure, Hot Air Tunnel, Comparison of Performance of CV lines. Microwave curing process and equipment, Ultrasonic vulcanization, Electron beam vulcanization, emerging methods of rubber vulcanization.	07
9	The assessment of state of vulcanization: Theoretical study of degree of cross linking. -Practical assessment of state of cure. Determination of state of cure: Methods and techniques: 1. Chemical method, 2. Physical test method, 3. Continuous method, Discussion of methods of measuring cure, Calculation of cure in thick articles, The relation between curing system type & properties (Sulphur - poly olefins Rubbers), Vulcanization process by rheometer curve, Prediction of State of Cure, Cure Simulation Instruments, Prediction of State of Cure by Arrhenius equation.	07

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	15	10	10	10	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

- Rubber Technology & Manufacture by Blow & Hepburn.
- Rubber Processing & Production Organization by Philip K. Freakley
- Rubber Product Manufacture Technology by Anil K. Bhowmick

Course Outcomes:

After learning this course students will be able to:



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Sr. No.	CO statement	Marks % weightage
CO-1	Explain the importance of vulcanization in Rubber	15
CO-2	Differentiate vulcanizing system for olefin & non olefin rubbers	15
CO-3	Relate structure and properties of Vulcanizate	10
CO-4	Classify different vulcanization systems and techniques	15
CO-5	Analyze of state of vulcanization	15

List of Experiments:

Tutorials/Presentation/Practicals based on above topics.

Major Equipment:

Vulcaniser, Semi Hydraulic Press, Rheometer, Mooney Viscometer, Hardness tester etc

List of Open Source Software/learning website:

- <http://digital.csic.es/bitstream>
- <https://www.tut.fi/ms/muo/tyreschool/>
- <http://dyuthi.cusat.ac.in/>
- <http://www.ajer.org/papers/rase-2-2013/Volume-3/BV120130813.pdf>