



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Under Graduate

Branch: Rubber Technology

Subject Code : BE04026041

Subject Name : Rubber Rheology

| | |
|-------------------------|---------------|
| w. e. f. Academic Year: | 2025-26 |
| Semester: | B. E. Sem. -4 |
| Category of the Course: | PCC-07 |

| | |
|----------------------|---|
| Prerequisite: | None |
| Rationale: | The study of rheology in rubber technology involves understanding how materials deform and flow under various forces, integrating concepts like elasticity, viscosity, and viscoelasticity. Topics cover fluid behaviors (Newtonian and non-Newtonian), flow patterns (laminar and turbulent), and rheological models that predict material response. Emphasis is placed on the effect of variables such as temperature, pressure, and molecular structure on rubber flow. Practical aspects include the use of specialized instruments for stress analysis and rheological testing, enabling precise material characterization and quality control. Together, these areas provide a comprehensive foundation for designing, processing, and evaluating rubber materials. |

Course Outcome:

After Completion of the Course, Student will able to:

| No | Course Outcomes |
|----|---|
| 01 | Explain key rheological concepts and fluid behaviors. |
| 02 | Apply rheological models to analyze Newtonian and non-Newtonian fluid flow. |
| 03 | Analyze the influence of temperature, pressure, and molecular structure on polymer and rubber rheology. |
| 04 | Evaluate the suitability of various rheological instruments for fluid characterization. |
| 05 | Design and conduct experiments to study viscoelastic flow behavior. |

Teaching and Examination Scheme:

| Teaching / Learning Scheme (in Hours per semester) | | | | | Total Credits = TH/30 | Assessment Pattern and Marks | | | | | Total Marks |
|---|---|----|------|-----|--------------------------------|------------------------------|-----------|----------------------|---------------|------------|----------------|
| L | T | P | PBL* | TH | | Theory | | Tutorial / Practical | | | |
| | | | | | | 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



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Course Content:

| Unit No. | Content | No. of Hours | % of Weightage |
|----------|---|--------------|----------------|
| 1. | Introduction to Rheology: Definition of Rheology, Rheological Perspective, the importance of non-linearity, Elasticity, Generalized Hook's Law, Moduli of Elasticity, Relation Between Bulk modulus (K) & Young modulus (E), Deviation from perfect elastic behavior, Plasticity and flow, Viscous flow, Components of rheological research: Rheometry, Constitutive equations, Complex flows of elastic liquids, Introduction, Viscosity and Viscosity Nomenclature | 05 | 10 |
| 2. | Rheological Models and Viscoelastic Fluid Behavior: Viscoelasticity, Power law fluid Model, Eyring Model, Bingham Plastic fluid model, Ellis's fluid model, Eyring-Powel model, Reiner-Philipoff model, Meter model, Mechanical Models for Linear Viscoelastic Response: Maxwell Model, The Voight Element, The Four-Parameter Model, Material Response Time — The Deborah Number | 06 | 15 |
| 3. | Fluid Behavior and Rheology: Newton's law, Classification of fluid behavior, non-Newtonian fluid behavior, Time independent fluid behavior, Viscoplastic fluid behavior, Shear-thickening or dilatant fluid behavior, Time-dependent fluid behavior, Visco-elastic fluid behavior | 05 | 15 |
| 4. | Laminar Flow and Boundary Conditions in Fluid Systems: Shell Momentum Balances: Boundary Conditions, Flow of a falling film, Flow through a Circular tube, Flow through an Annulus, Flow between two infinite parallel plates, Adjacent Flow of Two immiscible Fluids. | 06 | 15 |
| 5. | Turbulent Flow Characteristics and Rheological Effects in Fluid Dynamics: Definition of Turbulent flow, difference between laminar & turbulent flow, velocity profile for Newtonian & non-Newtonian fluid flow, flow of Viscoelastic fluids, Turbulence Damping. | 06 | 10 |
| 6. | Stress Analysis and Rheological Characterization of Elastomeric Materials: Stress Tensor and Stress Responses: Stress Tensor: Cauchy Laws of Motion, Stress Responses to Flow, Early Investigations of Flow Properties of Elastomer, Shear Flow Instruments for Rheological Characterization of Elastomers: Sandwich Rheometer: Biconical Rheometer, Shearing Disc (Mooney) Rheometer, General Purpose Viscometer, Gallen Kamp, Plunger and Other Viscometers. | 06 | 15 |
| 7. | Rheological Instruments for Flow and Testing: Oscillatory & Elongation Flow Instruments: Uniaxial Extension: Bubble Inflation Compression Flow Instruments: Parallel Plate Viscometer, Cup and Bob Viscometer, Differential Plastimeter Quality Control | 06 | 10 |



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| | Instrumentation: Rotational Rheometers, Capillary Rheometers, Compression Rheometers, Stress Relaxation Instrument. | | |
| 8. | Variable influencing the Rheology of Rubbers: Effect of Temperature, Effect of Pressure, Effect of Molecular weight & Molecular structure, effect of entanglement of molecules & molecular motions. | 05 | 10 |
| Total | | | 100 |

Suggested Specification Table with Marks (Theory):

| Distribution of Theory Marks | | | | | |
|------------------------------|---------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 10 | 10 | 20 | 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 Processing, by James L. White
2. Transport Phenomena, by R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot
3. Rheology applied in Polymer Processing Dr. B.R.Gupta
4. An Introduction to Rheology by H.A.Barnes, J. F. Hutton and K. Walters.
5. Non-Newtonian Flow and Applied Rheology by R.P.Chhabra & J.F.Richardson

(b) Open-source software and website:

- <http://www.eolss.net/>
- <http://www.allsealsinc.com/>
- <http://stbb.nichd.nih.gov/>
- <http://booksite.elsevier.com/>
- <http://www.umbc.edu/>

Suggested Course Practical List: If any

Practical based on above topics.

List of Laboratory/Learning Resources Required:

Suggested Project List:

1. Comparative Study of Elastic and Plastic Behavior in Different Rubber Compounds.



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2. Simulation and Analysis of Viscoelastic Fluid Models Using Real Compound Data.
3. Experimental Classification of Rubber Compounds as Newtonian or Non-Newtonian Fluids.
4. Effect of Tube Geometry on Laminar Flow Characteristics of Polymer Solutions.
5. Comparative Analysis of Turbulent Flow in Newtonian vs. Non-Newtonian Fluids.
6. Stress-Strain Behavior of Elastomers Using Mooney and Biconical Rheometers.
7. Instrumental Comparison of Viscosity Measurements Using Cup & Bob vs. Rotational Rheometers.
8. Effect of Temperature and Molecular Weight on the Viscosity of Rubber Compounds.

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. | Literature review and Concept Mapping | Duration -6h Report preparation- 4h Total-10 h | Based on selection of a topic, creation of concept map, Accuracy, structure, completeness, clarity and coverage of key concepts |



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| 7. | Field Visit to Industrial or Research Setup | Visit- 5h Report preparation-5h Total-10h | Based on report submitted. Report should contain manufacturing process, plant lay out, testing results. |
| 8. | 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. |
| 9. | Peer Teaching Video | 2 video preparation -10 h | Create a 5–10-minute video explaining a rubber technology concept for peers, incorporating visuals. |
| 10. | 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. |
| 11. | Glossary Compilation | Duration -5h | Based on report submitted. Report should contain Accuracy, completeness, formatting, and use of illustrations/examples |
| 12. | 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. |
| 13. | Peer Interaction / Teaching | 5 research paper/ Technical Topics = 20 h | Communication skill, clarity of explanation, concept understanding |
| 14. | 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. |
| 15. | Model-making (working or non-working) focused on technical concepts | Duration -15 h | Based on evaluation from inter-department or external experts. |
