



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Plastics Engineering

Subject Code: ME02084051

Subject Name: Polymer Rheology and Kinetics

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

Prerequisite:	Plastic Materials
Rationale:	Nil

Course Outcome:

After Completion of the Course Student will able to:

No	Course Outcomes
01	After learning the course the students should be able to: 1. Know the fundamentals in polymerization reactor design, with the knowledge of kinetics 2. Understand Rheology of Plastic Materials and apply the same
02	Understand Principles of Kinetics and applications

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR		C	Theory		Tutorial/ Practical	
			ESE (E)		PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No.of Hours	%of Weightage
1.	<u>RHEOLOGY OF PLASTIC MATERIALS</u> A.INTRODUCTION : Introduction to Rheological Principles, Definition & importance of Rheology, types of fluids, Non Newtonian fluids, time-dependent fluids, time independent fluids, viscous elastic fluids, Pseudoplastic fluids, Dilatant fluids, Bingham plastic fluids. Introduction to tensors, stress tensors and strain	7	10



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	tensors, Basic equations of fluid mechanics - Continually equation, Couchy equation, Navier – stokes equation. Normal stress difference and Weissenberg's effect		
2	B. VISCOELASTIC BEHAVIOUR : Stress relaxation, relaxation modulus, creep compliance dynamic modulus, dynamic compliance, dynamic viscosity, Mechanical models – Maxwell model, Voigt – Kelvin model, Zener model, Boltzmann Principle of Superposition. Time-temperature correspondence, time temperature superposition, WLF equation, Glass-transition and theories of glass transition - free volume theory, thermodynamic theory and kinetic theory. Molecular theories – Rouse theory, Doi – Edward theory, Curtis – bird model.	7	15
3	C. PARAMETERS INFLUENCING RHEOLOGY : Effect of pressure on viscosity. Effect of temperature, activation energy, effect of molecular weight and molecular weight distribution on viscosity, molecular at dependence of zero shear viscosity, effect of crosslinking, crystallinity branching, copolymerization, effect of fillers, fiber filled polymer melts, effect of plasticizers, shear rate dependence of viscosity.	10	15
4	D.MELT FLOW ANALYSIS : Laminar flow through circular c/s, annulus, slit, parallel plates, irregular profiles. Flow analysis using power law, turbulent flow analysis, turbulence dumpling. Rheological models for extensional viscosity. Transition between laminar & turbulent flow, Ryan Johnson criterion, Application of Ryan Johnson criterion to power low fluids, extensional flow and rheological models for extensional viscosity. Flow in coni cylindrical dies – pressure drop due to shear, pressure drop due to extensional flow and pressure drop at die entry, flow in wedge shaped die. Swelling due to shear stresses and swelling due to tensile stresses E. RHEOMETRY : Basic concept of constant stress & constant strain, Different types of Rheometers–Cone and plate Rheometer, Concentric cylinder rheometer, parallel disk rheometer, concentric rotating disk rheometer, controlled stress rotational Rheometer, Torque Rheometers – Extruder type.	9	35
5.	PLASTIC REACTION ENGINEERING <ul style="list-style-type: none"> • Elements of Polymer Reaction Engineering • Introduction to Kinetics of homogenous Reaction • Interpretation of Batch Reactor Data 	15	25



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	<ul style="list-style-type: none">• Single Ideal Reactor• Mechanism and kinetics of polymerization• Polymerization Reaction Engineering• Reactors for various commodity plastics• Reactors for different polymerization technique		
	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
15	15	20	10	5	5

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

References/Suggested Learning Resources:

Books:

TEXTBOOKS:

1. Octave lewenspiel-Chemical Reaction Engineering 2nd Ed.
2. J.A.Brydson, Flow properties of Polymer Melts, life books, London.
3. Anil Kumar and Santosh gupta-fundamentals of polymer science engineering, tata McGraw hill publishing company

Reference Books:-

1. Polymer Reaction engineering by K.H.Reichert
2. P.N.Cogswell, Polymer Melt Rheology, A guide for Industrial Practice, George Godwin.
3. Richard C. Progelhof and James L. Throne, Polymer Engineering Principles, Hanser Publishers, New York, 1993.
4. John M. Dealy and Kurt F. Wissburn, Melt rheology and its role in plastics processing, Chapman, London, 1995.
5. R.S. Lenk, Polymer Rheology, Applied Science, London,
6. R.J. Crawford, Plastics Engineering, Butterworth – Heinemann, Oxford, 1998.
7. J.D. Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons, New York,
8. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York



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)Open source software and website:

1) <https://nptel.ac.in/>

2) <https://www.bpf.co.uk/>

Suggested Course Practical List: : As per the above syllabus topics

List of Laboratory/Learning Resources Required:Rheometer
