PLPC3005 POLYMER RHEOLOGY (3-0-0)

Course Objective:
To provide the student with an understanding of deformation and flow of polymeric materials such as polymeric liquids, suspensions, melts, colloids, foams, gels, etc., and mechanical behaviour of polymeric materials under applied load for short term and long-term flow behavior of polymer melts. Further to perform experimental techniques for measuring the rheological properties and describe the viscoelastic behavior of polymers with respect to their chemical structures.
Syllabus

MODULE - I (06 Hours)
Fundamentals of Rheology
Introduction and basic concept of rheology; viscosity and types of viscosity; classification of fluids – ideal and real, Newtonian and non-Newtonian, compressible and noncompressible fluids; power law model; shear stress; shear strain; shear rate; true strain; true strain rate; shear modulus; bulk modulus; zero shear viscosity; dependence of viscosity with temperature, shear stress, shear rate fluid through channel.

MODULE - II (10 Hours)
Visco-elastic behaviour and Mechanical Models
Viscoelastic behaviour of polymers – stress relaxation, shear thinning, normal stresses in shear flow, creep, hyperelastic deformation, irrecoverable deformation; Mechanical models – stress strain response of spring and dashpot; viscoelastic models – Maxwell model, Kelvin–Voigt model; response to creep and stress relaxation; dynamic mechanical properties – complex modulus, dynamic modulus, loss modulus; Boltzman principle; time temperature super position principle – WLF equation.

MODULE - III (08 Hours)
Measurements of rheological properties
Measurements of rheological properties – sliding plate rheometer, cone and plate rheometer, parallel plate rheometer, capillary rheometers, extensional rheometer, bubble inflation rheometers, compressional rheometer.

MODULE - IV (12 Hours)
Rheology of polymers in processing
Viscoelasticity in amorphous and semi crystalline states; effect of rate of strain, temperature and time on viscoelastic behaviour of polymeric materials; viscoelasticity of polymer melts and flow analysis during – injection moulding, extrusion process – die swell and melt fracture, blow moulding and thermoforming – melt strength, biaxial stretching.

MODULE - V (04 Hours)
Rheology of Filled Polymers
Rheological behaviour of suspensions – dilute and concentrated suspensions of spheres and fibres; effect of orientation of fibres on rheology.

Course outcomes: After the completion of this course, students will be able to:
CO1: Remember: Able to recall the different types of flow behaviour of polymers
CO2: Understand: Able to explain the knowledge in flow behaviour of polymers
CO3: Analyze: Able to describe the viscoelastic behavior of polymers with respect to their chemical structures
CO4: Apply: An ability to calculate the rheological parameters of different types of polymers.
CO5: Evaluate: To construct an idea from the experimental data, which can be used to predict the material response at different temperatures, times, and/or frequencies

Books:

1. B. R. Gupta, Applied Rheology in Polymer Processing, Asian Books, Thailand (2005).
2. Tim Osswald and Natalie Rudolph, Polymer Rheology: Fundamentals and Applications, Hanser Publishers, Munich (2015).
3. Christopher W. Macosko, Rheology: Principles, Measurements and Applications, Wiley-VCH, New York (1993).
4. H. A. Barnes, J. F. Hutton and K. Walters, An Introduction to Rheology, Elsevier, Netherlands (1993).
5. Gebhard Schramm, A Practical Approach to Rheology and Rheometry, Thermo Electron (Karlsruhe) GmbH, Federal Republic of Germany (2004).
6. J. D. Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons, New York (1980).
7. Chang Dae Han, Rheology and Processing of Polymeric Materials Volume I &II, Oxford University Press, New York (2007)