MS4620 – Polymer Technology

Course Code	MS4620					
Course Title	Polymer Technology					
Pre-requisites	MS2013	Introduction to Polymer Science				
Pre-requisite for	NIL					
No of AUs	3					
Contact Hours	LECTURES	26	Tutorials	13		

Course Aims

MS4620 introduces the fundamental concepts involved in melt rheology, polymer additives, polymer processing, and manufacturing of thermoplastic and thermosetting polymeric products. This subject is offered to fourth year students. Computer aided design fundamentals are incorporated throughout via group project towards the design, modelling, and production of common plastic consumer products.

Intended Learning Outcomes (ILO)

By the end of the course, you should be able to:

1. Determine the relationships between shear modulus and shear viscosity.
2. Apply the concepts of shear deformation in the context of Newtonian fluids.
3. Apply the theory of laminar flow in the context of viscosity and its application in industrial processing.
4. Explain the differences between laminar flow and plug flow.
5. Apply the concepts of Newtonian fluids and Hooke's solids in context to time-dependent viscoelastic materials.
6. Model power law equations to predict Non-Newtonian, laminar flow of polymer melts.
7. Describe how molecular structure, temperature, and other factors can employed to predict and control polymer melt flow.
8. Explain the differences in shear response between Thixotropic and Rheotropic behaviors. Mathematically describe the pressure flow along circular, slit, and annulus cross-sections using the relevant equations.
9. Differentiate between Steady-state testing and Dynamic-state testing.
10. Choose characterization methods to quantitate apparent shear viscosity, zero-shear viscosity, dynamic viscosity, complex viscosity and yield point of various polymer resins.
11. Describe the autooxidation cycle context of polymer processing, degradation, and long-term material properties.

12. Formulate antioxidant additives to prevent premature failure of material properties.
13. Formulate flame retardant additives to prevent or delay ignition of polymer materials. Discuss the factors that prevent the processing of some polymer backbones without additives being incorporated.
14. Describe the application of processing aids, lubricants, and plasticizers, in the contemporary processing of polyvinyl alcohol (PVA).
15. Compare three types of additives used for modifying material properties of plastic based consumer goods.
16. Discuss the fundamental components of a modern extruder and the various extruder designs employed in manufacturing.
17. Explain the functions of the feed, compression, and metering zones within a single screw extruder and how these functions are modified for various polymer feeds.
18. Evaluate polymer melt Total Flow from the individual components of drag flow and pressure flow and their dependent parameters.
19. Prepare the operational settings of a single screw extruder given the appropriate technical data.
20. Explain the solid-to-viscous cycle of plastics resins from nurdle to extruded profiles.
21. Predict how extruder parameters will influence polymer resin material properties at the die exit.
22. Design twin screw extruders for specific compounding of plastic resin formulations.
23. Apply extrusion based processes for the manufacturing of disposable consumer goods. Discuss how single screw extrusion is applied to quickly and efficiently pack molds for high-throughput plastic manufacturing.
24. Explain how shot size, melt path, and plastic solidification is determined and set by the machine operator.
25. Compare and contrast the hydraulic vs. toggle clamping designs.
26. Analyse the mold clamping force required for a given plastic profile.
27. Describe the calendaring process and which plastic products are suitable for this method of manufacturing.
28. Explain the differences of vacuum, pressure, and compression thermoforming and the various consumer products that are suitable for this method of manufacturing.
29. Compare and contrast the concepts of subtractive versus additive manufacturing.
30. Explain the advantages and disadvantages of FDM-based 3D printing in a modern day context.

Course Content

MELT RHEOLOGY: Introduction to Newtonian and non-Newtonian flow behaviours. Factors affecting viscous flow: molecular structures, molecular weight, pressure, temperature,

shear history. Flow through channels: circular cross-section, slits, and annulus. Elastic effects in polymer melt flow: die swell, melt fracture, sharkskin, frozen-in orientation. Measurements of rheological behaviours: cone and plate viscometers, capillary rheometers and melt flow indexer. POLYMER ADDITIVES: Polymer degradation processes: thermal oxidative degradation and photo-degradation. Functions, mechanisms and applications of polymer additives: anti-oxidants, ultra-violet stabilisers, metal deactivators, flame retardants, lubricants and flow promoters, fillers, plasticisers, toughening agents, conductive fillers and colourants, nano-sized fillers and their advantages. POLYMER PROCESSES: Extrusion processes: components of an extruder, types of extruder, analysis of flow profile production, film blowing, extrusion coating. Injection moulding: components of an injection moulding machine, molding cycles. thermoforming, 3D Printing. SOLIDWORKS PLASTICS: Computer aided design fundamentals will be introduced to allow building of common plastic consumer products and perform basic modeling on the designs. Solidworks Plastics is a relatively new software addition that allows modelling of plastic flow injection molding on CAD produced plastic parts.

Reading and References

1. R. J. Crawford, Plastics Engineering, Third edition, Pergamon Press, 1990 [ONLINE]
2. D. H. Morton-Jones, Polymer Processing, Chapman & Hall, 1989.
3. R. Gächter & Müller, Plastics Additives, fifth edition, Hanser Publishers, 1993.
4. Joel R. Fried, Polymer Science and Technology, Prentice Hall PTR, 1995.

Course Policies and Student Responsibilities

(1) CA

Absentees must be supported by a medical certificate or other valid official documents.

Academic Integrity

Good academic work depends on honesty and ethical behavior. Quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honor Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student of NTU, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at the University. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, and collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.