



FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
DEPARTMENT OF POLYMER AND TEXTILE ENGINEERING

2014/2015 HARMATTAN SEMESTER EXAMINATION. PTE 411: POLYMER RHEOLOGY

DATE: 14/04/2015

TIME: 3 HOURS

INSTRUCTIONS: ATTEMPT ANY FIVE QUESTIONS

- Starting from the first principle, derive the mathematical expressions for the analysis of (i) Velocity profile (ii) Volumetric flow rate and (iii) Shear rate, at the wall for a Newtonian fluid flowing through a tube of circular cross-section.
- (a) Derive the rheological equation of Maxwell element as encountered in a creep deformation and creep recovery experiment.
(b) Using five (5) numerical values, describe how stress relaxation behavior could be justified by Maxwell model.
(c) Briefly explain the terms (i) Creep and (ii) Stress-relaxation, in visco-elasticity of polymers.
- Polyethersulfone (PES) is extensively used for the preparation of hollow membrane contactors. In the study, the effect of shear stress and shear rate was experimentally investigated. Data obtained were given as follows:

Shear stress (MPa)	2.0	2.5	3.0	3.5	4.0
Shear rate (S^{-1})	10	15	20	25	30

Use the given data to

- (a) Estimate the coefficient of viscosity and flow behaviour index of the polymer.
(b) If the cylindrical vessel used for the preparation of the PES melt is of uniform cross-section, estimate the shear rate at the wall given that the radius of the vessel is 15 cm and volumetric flow rate is $40 \text{ cm}^3/\text{s}$.
- (a) State Newton's law of flow.
(b) Using appropriate rheograms, differentiate between a Newtonian fluid and Bingham body.
(c) Give three examples, each of the two types of time-dependent fluid.
(d) Calculate the apparent viscosity of a capillary viscometer with length of die 6 cm, diameter of the capillary die, 4 cm, the total pressure drop across the die, 42 Pascal and volumetric flow rate $8 \text{ cm}^3/\text{s}$.
- (a) What are the two broad classifications of rheometers.
(b) State the two common methods of measuring the flow of polymer melts, and list three types of rotational viscometer.
(c) A cone-and-plate viscometer has a cone diameter of 4 cm, the speed of rotation of the cone is 2.0 radian per second and the distance from the cone axis at which the load is applied is 30 cm. If a load of 1000 N is applied, estimate the viscosity of the fluid in the viscometer, given that the cone angle is 0.1 radian.
- (a) Use illustrative hysteresis curves to explain the behavior of time-dependent fluids.
(b) Enumerate two advantages and two disadvantages of cone-and-plate viscometer.
(c) A cup-and-bob viscometer has a bob length of 18 cm and bob diameter of 8 cm. If the diameter of the cup is 12 cm and speed of rotation is 20 radians per second, calculate the viscosity of the fluid in the viscometer, given that the torque exerted on the material is 10 N-cm.