PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination : Semester I — Academic Year : 2005

Date : 11 October 2005 — Time : 09.00 – 12.00

Subject : 230 - 463 Polymer Technology — Room : A303

Student Name: ..... ID no. : .....

Number of questions : 4

Time : 3 hours

Total marks : 120

Notes are not allowed.

Calculators are allowed.

Two graph papers are provided.

Question	Full Marks	Marks Received
1	30	
2	35	
3	30	
4	25	
Total	120	

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

1. a) Describe emulsion polymerization process for production of styrene butadiene rubber (SBR).

(5 marks)

b) Give the reasons for the differences in transition temperatures for the following pairs of polymers.

b.1) T_g for polypropylene and polyacrylonitrile

b.2) T_g for low molecular weight PP and high molecular weight PP

b.3) T_m for cis-polyisoprene and trans-polyisoprene

b.4) T_m for $-(CH_2CH_2CONH)-_n$ and $-(CH_2CH_2CH_2CONH)-_n$

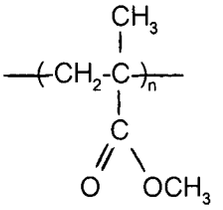
b.5) T_m for polyolefins with side-chain structure $-CH_2CH_3$ and $-CH_2CH(CH_3)_2$

(10 marks)

c) What is the degree of crystallinity of a solid polymer? How can you estimate its value?

(5 marks)

d) Discuss the α–transition and other secondary-transitions occurred by chain motions in polymethyl methacrylate.



(5 marks)

e) Explain the folded chain model for a single crystal.

(5 marks)

Answers to Question 1

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2. a) Explain the Boltzmann Superposition Principle.

(5 marks)

b) Explain the Time-Temperature Superposition Principle and its benefits.

(5 marks)

c) A polystyrene sample was measured for viscosity-average molecular weight. The original stock solution was prepared by dissolving 0.4 gram of the polymer in toluene solvent in a 100 ml volumetric flask. 50 ml of this solution was put into an Ubbelohde viscometer. Efflux times were measured at 25°C. Successive dilutions were made by addition of 20 ml of pure solvent. The efflux time or flow time for pure solvent, (t_0) was 100 seconds. Plot $(1/C)[(t/t_0)-1]$ vs. C. Estimate the intrinsic viscosity,$[\eta]$ at C = 0 and $\bar{M}_v$ of the sample from the experimental data shown below. A graph paper is provided for this estimation.

Note that: $[\eta]=K(\bar{M}_v)^a$ where K = $1x10^{-5}$ l/g and a = 0.73

Concentration,C (g/100ml)	**Efflux time,t (s)**
50ml of stock solution	160
Further dilution by +20 ml solvent	141.9
Further dilution by +20 ml solvent	132.1
Further dilution by +20 ml solvent	126
Further dilution by +20 ml solvent	121.8
Further dilution by +20 ml solvent	118.7

(10 marks)

d) Maxwell model and Kelvin model are combined in series to form a new model called " A Four Parameters Model". The total strain at time t is given by equation

$$\epsilon=\frac{\sigma_0}{E_1}+\frac{\sigma_0 t}{\eta_1}+\frac{\sigma_0}{E_2}\left[1-\exp\left(-\frac{E_2}{\eta_2}\right)t\right]$$

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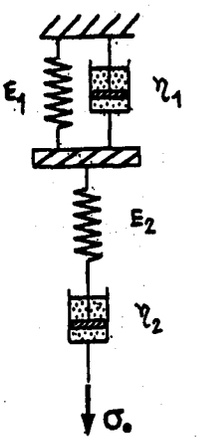

A creep test is performed by applying stress σ_0 at time t_1 and released at time t_2. Sketch strain-time curve of the test.

(10 marks)

e) From the figure shown below, explain the setup and procedure of the test.

Explain the benefits obtained from this experiment.

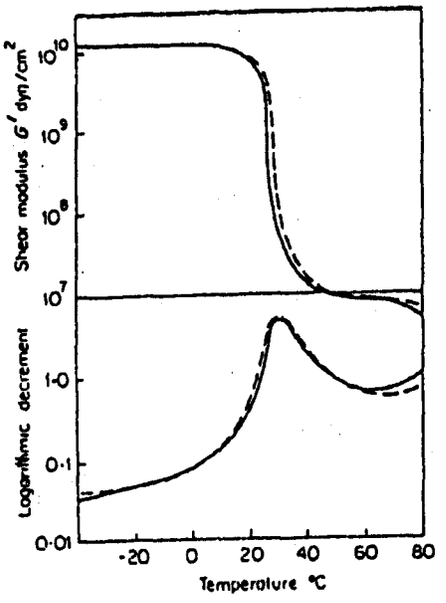

Figure Shear modulus G' and logarithmic decrement for a miscible blend of polyvinyl acetate and polymethyl acrylate —— and a copolymer of vinyl acetate and methyl acrylate – – – (after Nielsen).

(5 marks)

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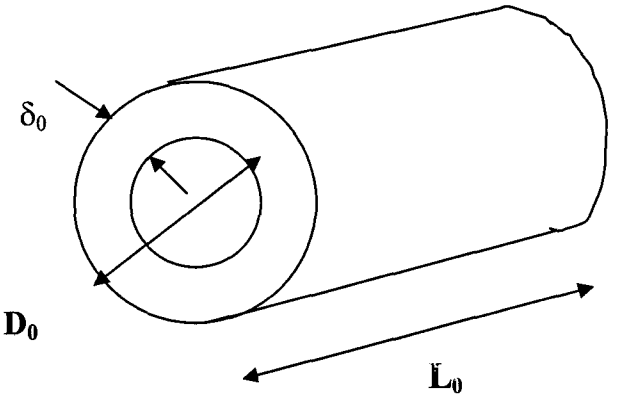
3. In the extrusion process for polymeric pipe, the extruder screw geometry are as follows. The axial flight land width is 2.4 mm, the channel depth is 4.5 mm, the screw diameter is 200 mm, flight helix angle is 17° and the screw length is 1000 mm. The screw speed is 150 rev/min, and the pressure varies linearly over the screw length from the hopper to the die. The leakage flow is negligible.

An annular die with dimensions D_o = 8 mm, L_o = 15.0 mm. and δ_o = 2.0 mm. is fixed to the end of the extruder. The screw metering zone and the annular die temperatures are at 220°C and the melt viscosity and density at this temperature are 200 Ns/m^2 and 1420 kg/m^3 respectively. Calculate the extruder output and die output at pressures 20 and 100 MN/m^2. Plot the characteristic curves for screw and die using Q and P in m^3/s and MN/m^2 respectively. Read the operating point on the graph.

For annular die, the die output is given by

$$Q_d = \frac{\pi D_0 \delta_0^3}{12 L_0} \bullet \frac{\Delta P_d}{\eta}$$



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Output = drag flow + pressure flow + leakage flow

$$\text{output } Q = Q_D + Q_P + Q_L$$

(โดย Q_P และ Q_L มีค่าเป็นลบ มีทิศทางสวนทางกับ Q_D)

$$\text{drag flow } Q_D = \frac{1}{2}\pi^2 D^2 NH \sin\theta \cos\theta$$

$$\text{pressure flow } Q_P = -\frac{\pi DH^3 \sin^2\theta}{12\eta}\frac{dP}{dl}$$

$$\text{leakage flow } Q_L = -\frac{\pi^2 D^2 c^3}{12\eta e}\tan\theta\frac{dP}{dl}$$

N = screw speed, rpm

θ = มุมเกลียว, helix angle

δ หรือ C = ช่องว่างระหว่าง screw กับ barrel ตามแนวรัศมี (radial screw clearance)

e = ความกว้างของ screw land ตามแนวแกน (axial flight land width)

H = ความลึกของฟันเกลียว (flight depth)

D = diameter ภายในของ barrel

η = viscosity ของ polymer melt

s = flight pitch, ระยะฟันเกลียว

(30 marks)

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4. a) Describe the shape of the screw in an extruder for rubber processing.

(5 marks)

b) Suggest the type of polymer used for making 100-cc ice-cream cups. Suggest the polymer processing methods and temperature settings for making these cups.

(5 marks)

c) Describe the dependence of melt viscosity on shear rate and shear stress of real polymers.

(5 marks)

d) What is die swell in extrusion? How does it occur?

(5 marks)

e) A polymer processing company is planning to produce 750 cc water bottles from PET polymer by injection-blow moulding. Give specifications for the injection moulding machine that the company should buy for this project.

(5 marks)

_____ End of Question