18/9/3/20

STAFFORDSHIRE POLYTECHNIC
DEPARTMENT OF MECHANICAL AND COMPUTER AIDED ENGINEERING

Session 1991/92

BEng(HONS) MECHANICAL ENGINEERING - PART 2
BEng(HONS) COMPUTER AIDED ENGINEERING - PART 2

Engineering Materials - BM3MH & BM3CH

Date: ~~Thursday 9th~~ Tuesday 7th January 1992 Examiner: R A Preston
Time: 9.30 am - 11.30 am
Time Allowed: 2 Hours

Answer ALL questions.
All questions carry equal marks.

1. (a) Distinguish between:-

    (i) plain carbon steels;
    (ii) low alloy steels; and
    (iii) high alloy steels

    in terms of their compositions, structure, properties and hardenability, and give examples of the use, or possible use, of such materials in an automobile. Explain your reasons for such choices.

    (15 Marks)

   (b) Cast irons may well be used for the engine block of such an automobile. Give reasons why such a choice may be made, and explain the principle features of a feeding, gating and riser system necessary for production of sound castings.

    (10 marks)

2. (a) Distinguish between

   (i) a solid solution alloy; and
   (ii) an intermetallic compound

   and indicate the requirements of the individual metals which would lead to the formation of each of the above type of phases.

   (10 marks)

(b) Figure Q2(b) shows a hypothetical binary thermal equilibrium diagram of two metals X and Y.

   (i) Identify and label the phase fields.

   (ii) Identify and explain the nature of the single phases shown on the diagram.

   (iii) Describe and explain what structures you might expect to be present immediately below 400°C for an alloy containing 80% Y.

   (iv) Which compositions of alloys on the phase diagram would you expect to be most easily cast?

   (v) Which compositions would you expect to respond to precipitation hardening? Give a brief outline of the thermal treatment to which you would subject the alloy, in order to achieve this effect.

   (vi) Make a sketch which would indicate the expected general mechanical properties of the materials at 0°C as the composition varied from 0 to 100% Y. Assume metal X has higher individual strength than metal Y.

   (vii) Give the full constitution of a slowly cooled alloy containing 25% Y at a temperature of 350°C, and make a sketch of the expected microstructure.

   (15 marks)

3. (a) Sketch diagrams which show clearly the displacement: time behaviour of materials which behave:-

   (i) ideally elastically;
   (ii) anelastically; and
   (iii) ideally viscously.

   when a load is suddently applied at time t = 0 and removed at time t = t.

   (5 marks)

   (b) Sketch an analogue model for anelastic behaviour, derive an expression for the displacement at any time t, and define the retardation time and relaxation time λ, and the relationship between λ, G (the shear modulus) and η (the viscosity coefficient).

   (5 marks)

   (c) Figure Q3(c) represents the shear displacement: time behaviour of a polymer loaded at time t = 0 with a shear stress of 500 N/m^2. By using a suitable analogue model system to simulate the behaviour, determine the appropriate shear moduli, viscosity coefficients and relaxation time. The displacement, γ, at time t = 10 secs is 0.34. Assume relaxation time λ is the same on loading as unloading.

   What general effect would an increase in temperature have on the displacement: time graph?

   (15 marks)

4. (a) Briefly explain the principles of the theory of functionality as applied to polymeric materials, and explain the conditions which promote the formation of thermoplastics, and thermoset materials.

   Distinguish between an addition polymer and a condensation polymer, giving examples of such plastics.

   (5 marks)

   (b) Define T_g, the glass transition temperature, and explain the behaviour of a polymer under stress (i) above and (ii) below T_g.

   (3 marks)

 (Question 4(c) continued over)

(c) Sketch and explain a suitable graph, which demonstrates the differences in mechanical behaviour which exist between:-

(i) amorphous polymers;
(ii) cross-linked polymers;
(iii) crystalline polymers; and
(iv) elastomers

as the temperature is raised from below T_g to above T_m (the melting temperature).

(8 marks)

(d) A continuous aligned fibre composite is required to have a modulus in the direction of the alignment of 100 GN/m^2.

If the values of the modulus of elasticity of the matrix and fibres is 2.5 and 150 GN/m^2 respectively, what is:

(i) The required volume fraction of reinforcement.

(ii) The ratio of the loads carried by the fibres: matrix in the direction of loading.

(iii) The value of the modulus of the composite transverse to the direction of fibres.

(9 marks)

$E_c = 100$

$E_m =$

$V_m = 1 - V_f$

$F_c = F_m + F_f$; $\epsilon_c = \epsilon_m + \epsilon_f$ $\sigma_c = \sigma_m V_m + \sigma_f V_f$

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$E_c = E_m V_m + E_f V_f$ $F_f / F_m = \frac{E_f V_f}{E_m V_m}$

FIGURE Q 3(c) DISPLACEMENT : TIME BEHAVIOUR OF A POLYMER AT $(T_g + 35)°C$