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Program: M.Sc. (ME)/M.Sc.TE /Ph.D. (ME) Date: 8 December 2023 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination **Winter Semester: 2022-2023**

Course Number: ME 6105 **Full Marks: 150**

Course Title: Mechanical Behavior of Materials **Time: 3 hours**

Answer all the 6 (six) questions below. The distribution of marks is given in brackets. The necessary tables and formulas are given in the last page.

Q1. (a) i) A tensile test was conducted on a mild steel specimen at strain rate 0.1 s^{-1}. The following Figure 1 shows the modelled plastic stress-strain behavior (flow curve) of the specimen, which is based on the power-law (Equation 1), **[20]**

$$\sigma(\varepsilon_p) = b\varepsilon_p{}^n \quad (1)$$

Assume the values of stress and strain at different points from Figure 1 and draw a necessary graph to find the strength coefficient, b, and the strain hardening exponent, n.

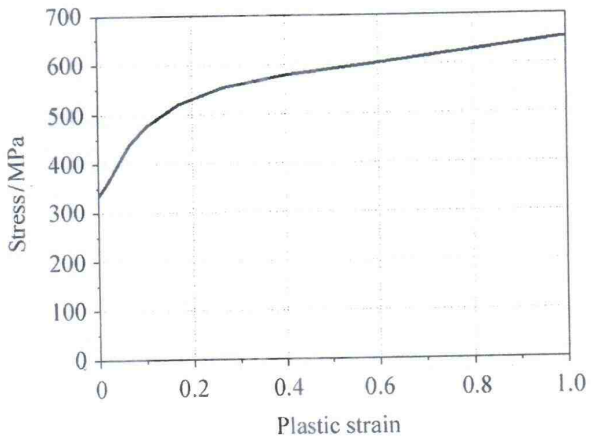

Figure 1. For Problem 1a

ii) Now, strain rate effect is considered in modelling the flow curve using the following Symon-Cowper model (Equation 2).

$$\sigma = (a + b\varepsilon_p{}^n)\left(1 + \left(\frac{\dot{\varepsilon}}{c}\right)^{1/P}\right) \quad (2)$$

where, a is the reference yield stress. What will be the true stress value at 50% of plastic strain. Assume, the strain rate constants C = 45 s^{-1} and P = 5.1.

(b) Write a short note on superplasticity. **[5]**

Q2. (a) A section of a 25 mm diameter solid shaft shown in Figure 2 below is drawn from AISI 1080 (quenched and tempered at 800^{O}C) carbon steel for which the ultimate tensile strength becomes 615 MPa. During service, the shaft encounters a bending moment that varies from –8 to 40 Nm. For a reliability of 98.5% and no thermal or miscellaneous effects, determine the safety factor using the Goodman line. Assume that the fatigue stress concentration factor = 1 due to the unnotched shaft. **[25]**

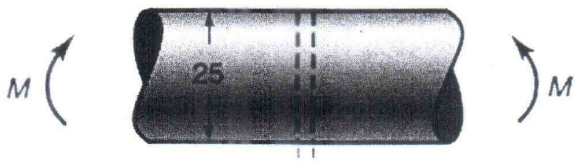

Figure 2. For Problem 2a.

Q3. (a) Show the Westergaard representation for different failure theories. **[5]**

(b) Compare the Relaxation modulus vs Temperature curves for the thermoplastic, thermosetting and elastomer polymers. What are the differences among these polymer types? **[10]**

(c) Describe the plastic deformation behavior of semicrystalline polymers. **[10]**

Q4. (a) An aligned short-fiber composite has 35 vol.% carbon fibers of length 1.5 mm and diameter of 0.07 mm in polypropylene matrix. The tensile strength of the fibres is 3.5 GPa at maximum 2.2% strain. The shear strength of the fibre-matrix interface is 20.5 MPa. **[15]**

(i) Calculate the critical fibre length.

(ii) If the stress on the matrix at the failure strain of the fibre is 45 MPa, calculate the longitudinal tensile strength of the composite.

(b) Briefly discuss any two types of joining phenomena at the fibre-matrix interface with necessary figures. **[5]**

(c) Discuss the advantages and application of any one of the following composites. **[5]**

i) Glass-fibre reinforced polymer composite

ii) Carbon-fibre reinforced polymer composite.

Q5. (a) What are the methods suitable for engineering an alloy for optimal strength? Describe any two methods. **[13]**

(b) A particular metal has an average grain diameter of 0.35 mm. The material starting stress for the dislocation movement is 70 MNm^{-2}. The Hall-Petch material constant is 0.74 $MNm^{-3/2}$. To what does the average grain diameter has to be reduced in order to double the strength of the material. **[12]**

Q6. (a) Describe (any three): i) Nabarro-Herring creep, ii) Coble creep, iii) Displacement creep, iv) Haper-Dorn creep. **[15]**

(b) What is the steady-state creep rate of a crystalline alloy that is undergoing a high-temperature creep at a temperature of $190^{O}C$ due to a 185 Pa stress. The alloy has a grain size of 60 micrometers, and an activation energy of 95 KJ/mol. The material constant A for this alloy is $A = 3.2x10^{-6}\ m^5K/N$. The molar gas constant is 8.314 $Jmol^{-1}K^{-1}$. Assume the stress constant as 3.2. [10]