Ref. No.: Ex/Met/PC/B/T/313/2024

B.E. Metallurgical Engineering - Third Year - First Semester Examination, 2024

Subject: Plastic Deformation of Metals

Time: Three Hours **Full Marks:** 100

Answer the following Questions (For every question there is one alternative question. Attempt Q1 or Q2, Q3 or Q4, Q5 or Q6 ...; Marks: CO1: 20, CO2:30, CO3: 20, CO4: 20, CO5: 10]

1. (a) Determine the engineering strain ***e,*** the true strain ***ε,*** and the reduction in area ***q*** for each of the following situations : [CO1] 5 x 3 = 15

(i) Extension from L to 1.1 L

(ii) Compression from h to 0.9 h

(iii) Extension from L to 2 L

(iv) Compression from h to 0.5 h

(v) Compression to zero thickness

(b) A wire of 300 mt long elongates by 3 cm when a tensile force of 200 Newton is applied. What is the modulus of elasticity in MPa if the diameter of the wire is 5 mm? [CO1] 5

OR

2. (a) A 24 mm thick plate is decreased in thickness according to the following schedule: 12, 6, 3 mm. Compute the total strain on the basis of initial and final dimensions and summation of the incremental strains, using

(i) conventional strain and [CO1] 3 x 5 = 15

(ii) true strain.

(b) An annealed steel tensile specimen (E = 200 GPa) has a 12 mm diameter and 50 mm gauge length. Maximum load is reached at 7,000 kg (= 68.6 kN), and fracture occurs at 4,500 kg (= 44.1 kN),

(i) What is the deformation when a tensile stress of 100 MPa is applied?

(ii) Why does fracture occurs at a lower load than maximum load? [CO1]

[CO1] 2 x 2.5 = 5

[Turn over

3. (a) What is the role of crystal defects in the plastic deformation of metals? Explain?

(b) Whether dislocations are thermodynamically stable? Justify your answer.

(c) Find the relationship between strain rate and dislocation velocity.

(d) How many atoms per square millimeter are there on a (100) face of a copper crystal. Given: Lattice parameter of copper = 0.36 nm. [CO2] 5 + 5+ 5 + 5 = 20

OR

4 (a) Find the relationship for Critical resolved shear stress for slip on single crystal and comment over the relationship. [CO2] 5 + 3 = 8

(b) Why are the metals in general ductile? What is the reason for brittleness of ceramic materials? [CO2] 4

(c) Justify the role of crystal structure in governing the yield strength of metallic systems. [CO2] 4

(d) What are the reasons for brittleness of Mg as compared to Al? [CO2] 4

5. (a) "Plastic deformation is microscopically heterogeneous" – Justify whether the statement is true or false. [CO2] 5

(b) Why are the stacking faults formed during plastic deformation of FCC materials? [CO2] 5

OR

6. (a) What do you understand by "soft grains" and "hard grains" in polycrystalline single-phase materials? [CO2] 5

(b) Under what deformation conditions twins are formed? Why twins are not observed in aluminium but in copper? [CO2] 5

7. (a) Discuss the discontinuous yielding behaviour observed during tensile testing of annealed low carbon steel. Suggest the remedial measures with proper explanation to overcome such discontinuous yielding behaviour. [CO3] 6 + 4 = 10

(b) Discuss the plastic deformation mechanisms involved in Nickel single crystal. [CO3] 8

(c) What is the burgers vector of Copper? [CO3] 2

OR

8. (a) By giving an example of precipitation hardenable alloy state the processing stages for strengthening the alloy. How can the kinetics of precipitation hardening process be experimentally studied? Draw and explain the nature of shear stress – shear strain curve of the precipitation hardenable alloy under solution annealed, peak aged and overaged conditions. [CO3] 3 + 3 + 6 = 12

(b) What are the mechanisms involved in the plastic deformation of metals at high temperature? Derive the Larsen Miller parameter and state its utility. [CO3] 2+6 = 8

9. (a) Discuss the role of the different factors affecting the fracture behaviour of metals.

(b) Discuss the failure mechanism during tensile loading of a moderately ductile material.

(c) Find the relationship for theoretical fracture stress of metals and comment over this relationship. [CO4] 5 + 7 + 8 = 20

OR

10.(a) State and explain Griffith's theory for brittle fracture? Why the brittle fracture is called 'low energy fracture'? [CO4] 3 + 2 = 5

(b) Discuss the role of second phase morphology and the amount of phases on the fracture behaviour of metals. [CO4] 5

(c) After deriving all the necessary relationships find the condition for equivalence between Griffith's fracture stress and the fracture stress obtained based on stress concentration point of view. [CO4] 10

11. (a) Justify whether plane strain fracture toughness of a material would depend on the test temperature. [CO5] 5

(b) Explain whether there is any benefit of using high fracture toughness material in designing load bearing components. [CO5] 5

OR

12. (a) What is meant by strain energy release rate? What is its importance? [CO5] 5

(b) Explain the "leak before break" criterion in preventing catastrophic fracture. [CO5] 5