Deformation Behaviour of Materials

(MT 403)

Time: 3 hrs ***Full Marks: 70***

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1. Briefly explain the fallowings:
   (a) Influence of *hydrostatic stress* in plastic deformation with an example.
   (b) Effects of *misfit strain* and *electron/atom ratio* in solid solution strengthening.
   (c) Role of *stacking fault energy* in plastic deformation.
   (d) Concept of *critical volume fraction of fiber* in fiber strengthening.

[2Yz x 4]

2. Discuss the fallowings with the help of appropriate schematic diagram(s):
   (a) *Polygonization.*
   (b) Different stages of *strain-hardening* in a FCC single crystal.
   (c) Movement of yogs produced by intersection of two *screw dislocations.*

[2+4+4]

   (a) Discuss the generalized theory of *yield drop.* Explain how this theory also validated the *'dislocation locking by interstitial atoms'* theory for *yield-point phenomenon* observed in ' annealed mild steel.
   (b) What is *stretcher strain* defect? How it can be controlled?

[(3+3)+{2+2)]

   (a) State *Hall-Petch* relationship.
   (b) Derive *Hall-Petch* relationship on the basis of *dislocation pile-up theory.*
   (c) The yield strength of a polycrystalline material increases from 120 MPa to 220 MPa, on decreasing the grain diameter from 0.04 mm to 0.01 mm. Find the yield stress of this material for a grain size of ASTM 9.

[2+4+4]

   (a) State the dislocation reaction proposed by *W.H. Lomer* in FCC crystal and comment on mobility of the product dislocation.
   (b) Discuss how the *Lomer dislocation reaction* has been modified by *A.H. Cottrell* and its significance in strain-hardening.
   (c) Explain why {001} planes are cleavage planes in BCC crystal.

[{2+1)+(2+2)+3]

6. (a) Discuss the (i) dislocation cutting and (ii) dislocation by pass (Orowan's mechanism) mechanisms of *precipitation hardening* with suitable sketches. Outline the criteria for transition of one mechanism to another.

   (b) Find out the yield stress of an AI-4.5%Cu alloy, if the average spacing of Cu_2AI particles is 11.5 nm. Given *G* = 27.6 GPa, 6 = 0.25 nm.

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7. (a) . Discuss how the concept of dislocation is able to explain the discrepancy between the observed and theoretical shear strength of materials.

   (b) Discuss the *Ashby's* concept of *geometrically necessary dislocations.*

   (c) State and explain the requirement of *minimum number of independent slip systems* for an arbitrary change of shape.

[4+3+3]

8. Differentiate the following with the help of appropriate schematic diagrams (any TWO):

   (a) *Slip* and *Twining*

   (b) *Climb* and *Cross-slip*

   (c) *Edge* and *Screw dislocation*

[5x2]

9. (a) Define *plane-strain* condition. Prove that both *Tresca* and *von Mises'* yield criteria are equivalent in *plane-strain* condition.

   (b) Prove that Poisson ratio is 0.5 for plastic materials.

[(1+5J+41

10. (a) Calculate the strain energy (in eV) per atom of the screw dislocation line if the Burgers vector is 2.5^°. Given, G = 4.11 x 10^{11} dynes/cm^2.

    (b) Calculate the length of *Burgers vector* in copper. Copper is FCC with lattice parameter of 3.6151 *A°.*

    (c) Calculate the elastic modulus of WC-Co composite in the longitudinal and transverse direction. Given E_{co} = 207 GPa, Ewe = 690 GPa and Vco = 40%

[3+3+4]

11. Answers the following questions:

    (a) Discuss the construction of *Mohr's circle* for determination of principal strains in 3D.

    (b) Discuss the mechanism of *Frank-Read source* of dislocation multiplication.

[5x2]