Total number of printed pages – 7

B. Tech
CPMT 6307

Sixth Semester Examination – 2008

DEFORMATION BEHAVIOUR OF MATERIALS

Full Marks – 70

Time : 3 Hours

Answer Question No. ***1*** *which is compulsory and any* ***five*** *from the rest.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2 ×10

   (i) What is Hall-Petch relation ?

   (ii) What is the phenomenon of strain hardening ?

   (iii) Explain the Bauschinger effect.

   (iv) How do the stacking faults affect cross slipping in a material ?

   (v) Explain cross slip and double cross slip with suitable sketches.

   (vi) What is a Tresca criterion of yielding ?

   (vii) What is the difference between plane stress and plane strain condition ?

   (viii) Compare the strain energy of an edge dislocation with that of a screw dislocation for a metal having Poisson ratio = 1/3.

   (ix) Draw and explain the different types of stress strain diagram of different materials.

(x) What are the differences between slip and twinning ?

2. (a) Prove that the following dislocation reaction is vectorically correct.

$$(a/2)\,[10\bar{1}] \rightarrow (a/6)\,[21\bar{1}] + (a/6)\,[11\bar{2}]$$

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(b) Show that the above reaction results in a decrease in strain energy. 4

(c) Determine the critical reserved shear stress for an iron crystal which deforms by simultaneous slip on $(110)[\bar{1}1\bar{1}]$, $(\bar{1}10)[111]$, and $(\bar{1}11)[11\bar{1}]$ when the tensile stress along $[010]$ is 95.2 MPa.

4

3. (a) Estimate the strain energy of an edge dislocation where dislocation outer radius (r) = 10 mm, dislocation core radius (r_0) = 1 nm, G = 50 GPa, b = 0.25 nm and ν =1/3. Express the result in electron volts per atomic plane. How much energy (electron volts) is required to produce 1 cm of dislocation line ? 5

(b) Show that more than one-half the strain energy resides outside the core of the dislocation in the region r = 10^{-4} to 1 cm.

5

4. (a) What is the mechanism of precipitation hardening ? Describe the different stages of precipitation during aging time of A1 – 4.5 Cu alloy. 6

(b) Boron fibers having elastic modulus (E_f) = 380 GPa are made into a unidirectional composite with an aluminum matrix, E_m = 60 GPa. What is the modulus parallel to the fibers for 10 and 60 volume percentages ? 4

5. Derive the equations of compatibility :

(a) $$\frac{\partial^2 \varepsilon_{xx}}{\partial y^2} + \frac{\partial^2 \varepsilon_{yy}}{\partial x^2} = \frac{\partial^2 \gamma_{xx}}{\partial x \partial y}$$ 5

(b) $$\frac{\partial}{\partial z}\left(\frac{\partial \gamma_{zy}}{\partial x} + \frac{\partial \gamma_{zx}}{\partial y} - \frac{\partial \gamma_{xy}}{\partial z}\right) = 2\frac{\partial^2 \varepsilon_{zz}}{\partial x \partial z}$$ 5

6. (a) Derive the following Energy distortion theory (Von-Mises) of yielding / failure.

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \geq 2\sigma_{ys}$$

5

(b) For the following state of stress, determine the principal stresses and their directions :

$$[\tau_{1f}] = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$ 5

7. (a) Describe the generalized stress-strain diagram for FCC single crystal and explain the deformation behaviour in the different stages. 6

(b) How does the above diagram differ for BCC and HCP materials ? 4

8. (a) Describe the yield point phenomenon for mild steel. 4

(b) Derive the theoretical shear strength of metal from required assumptions. How is the presence of dislocations responsible for the variations of theoretical shear strength to observed shear strength ?

6
