ENGG*2120 Materials Science Fall 2011

Assignment: Chapter 6 with Answer

1. A specimen of aluminum (elastic modulus is 69 GPa) having a rectangular cross section 10 mm × 12.7 mm is pulled in tension with 35,500 N force, producing only elastic deformation. Calculate the resulting strain.

Answer:

This problem calls for us to calculate the elastic strain that results for an aluminum specimen stressed in tension. The cross-sectional area is just (10 mm) × (12.7 mm) = 127 mm^2; also, the elastic modulus for Al is given in as 69 GPa (or 69 × 10^9 N/m^2). Combining Equations 6.1 and 6.5 from the book and solving for the strain yields

$$\varepsilon = \frac{\sigma}{E} = \frac{F}{A_0 E} = \frac{35,500 \text{ N}}{\left(1.27 \times 10^{-4} \text{ m}^2\right)\left(69 \times 10^9 \text{ N/m}^2\right)} = 4.1 \times 10^{-3}$$

2. How is yield strength measured from stress-strain graph?

Answer:

For metals that experience elastic-plastic transition, the point of yielding may be determined as initial departure from linearity of the stress-strain curve and is called the proportional limit. The position of this point is difficult to measure precisely from the stress strain graph. As a consequence, a convention has been established wherein a straight line is constructed parallel to the elastic portion of the stress-strain curve at a specified strain offset of 0.002. The stress corresponding to the intersection of this line and the stress-strain curve as it bends over in the plastic region is defined as the yield strength, σ_y.

3. Define ductility and explain why knowledge of ductility of materials is important.

Answer:

Ductility is the measure of degree of plastic deformation that has been sustained at fracture. Ductility is expressed quantitatively as either percent elongation or percent reduction in area.

Ductility, as percent elongation:

$$\%EL = \frac{L_f - L_o}{L_o} \times 100$$

Where,

L_f is fracture length

L_0 is original gauge length

Ductility, as percent reduction in area:

$$\%RA = \frac{A_o - A_f}{A_o} \times 100$$

Where,

A_0 is original cross sectional area

A_f is cross sectional area at point of fracture

Knowledge of the ductility of materials is important for two reasons. First, it indicates to a designer the degree to which a structure will deform plastically before fracture. Second, it specifies the degree of allowable deformation during fabrication operation.

4. Briefly explain plastic deformation from atomic perspective.

Answer:

From atomic perspective, plastic deformation corresponds to the breaking of bonds with original atom neighbors and then re-forming bonds with new neighbors as large number of atoms or molecules move relative to one another; upon removal of the stress they do not return to their original positions. The mechanism of this deformation is different for crystalline and amorphous materials. For crystalline solids, deformation is accompanied by slip. Plastic deformations in non crystalline solids as well as liquids occur by viscous flow mechanism.

5. A cylindrical specimen of a brass alloy 7.5 mm in diameter and 90.0 mm long is pulled in tension with a force of 6000 N; the force is subsequently released and material undergoes complete elastic recovery. Compute the stress when the load again is increased to 16,500 N.

Answer:

σ = Force / Area

Where Force = 16500 N

d= 7.5mm

Area = $\Pi\ (d/2)^2$

$$\sigma = \frac{16{,}500\ \text{N}}{\pi\left(\frac{7.5\times10^{-3}m}{2}\right)^2} = 373\ \text{MPa}$$

6. Determine the value of Poisson's ratio for a metallic bar of length 30 cm, breadth 4 cm and thickness 4 cm, when the bar is subjected to an axial compressive load of 400 KN. The decrease in length is given as 0.075 cm and increase in breadth is 0.003 cm.

Answer: Poisson's ratio = lateral strain / longitudinal strain

Where,

Lateral strain=change in breadth / original breadth = $\frac{\delta b}{b}$ = 0.003/4 = 0.00075

Longitudinal strain= change in length / original length = $\frac{\delta L}{L}$ = 0.075/30 =0.0025

Poisson's ratio = 0.00075/0.0025 = 0.3