Forming of materials

Module -1: Fundamental concepts relevant to metal forming technology

Further reading:

1. Mechanical Metallurgy, George Dieter, David Bacon, S.I. metric Ed., McGraw Hill, 1988.
2. Metal Forming, Mechanics and Metallurgy, Willian F. Hosford, Robert M. Caddell, Third Ed., Cambridge University Press, 2007.
3. Fundamentals of modern manufacturing: materials, processes and systems, Mikell P. Groover, Third Ed., John Wiley and Sons.
4. Manufacturing processes for engineering materials, SeropeKalpakjian, Steven R. Schmid, Fifth Ed., Pearson Education, 2009.

Quiz:

1. Distinguish between crystalline and amorphous materials.

Amorphous – absence of long range order.

2. How does elastic deformation and plastic deformation affect the lattice structure of crystals?

Elastic deformation causes temporary displacements of atoms. Plastic deformation causes permanent displacement of atoms by slipping of planes of atoms against other planes.

3. Give examples for materials that do not have crystalline structure.

Glass, amorphous silica, polyethylene.

4. Which one of the following crystal structure has fewer slip systems, so that the material having that structure is more difficult to deform at room temperature?

a) BCC, b] FCC, c] HCP

c] HCP

5. How many effective number of atoms are there in unit cell of HCP?

2 atoms per unit cell

6. Calculate the packing factor for FCC unit cell.

PF for FCC = $\frac{4\ X\ \frac{4\pi r^3}{3}}{a^3}$ = 0.74, where a = $\frac{4r}{\sqrt{2}}$

7. State Hooke's law.

Within elastic limit, stress is directly proportional to strain.

8. Define work hardening.

Work hardening is the increase in yield stress of a material due to prior working or straining of the material.

9. Define instability in tension.

Instability in uniaxial tensile test refers to the highly localized deformation called necking resulting in a state of triaxial stress.

10. What test is commonly used for determining the strength properties of brittle materials?

Three point bend test.

11. What method of hardness measurement is suitable for very thin sections like foils?

Microhardness test with loads in fraction of a kilogram.

12. Why higher value of m the strain rate sensitivity parameter results in more diffuse neck in tensile loading?

With higher m value, the material gets stretched to a greater length before it fails, thereby delaying necking.

13. What is the dilation of a material with a Poisson's ratio of 0.5?

Zero

14. What is the significance of slip systems?

They are responsible for plastic deformation.

15. A paper clip is made of wire 1.2 mm diameter. If the original material from which the wire is made is a rod, 15 mm in diameter, calculate the longitudinal and diametral engineering and true strains that the wire has undergone.

Solution:

Assuming volume constancy, $lf/lo = (do/df)^2 = 156$.

Longitudinal engg. Strain = (156-1)/1

Diametral strain = ln(1.25/15} = -2.526.

Longitudinal true strain = ln(l/lo) = 5.043

Diametral true strains = -2,526 √

16. A tensile test specimen is made of a material represented by the equation $\sigma = K(\varepsilon + n)^n$. Determine the true strain at which necking will begin. Show that it is possible for an engineering material to exhibit this behavior.

In necking we have $d\sigma/d\varepsilon = \sigma$.

Now applying this condition for this material necking begins when:

$Kn(\varepsilon + n)^{n-1} = K(\varepsilon + n)^n$. Yes it is possible.

17. A torsion test specimen has a radius of 25 mm, wall thickness of 3 mm and gage length of 50 mm. In testing, a torque of 900 N-m results in an angular deflection of 0.3^o. Determine the shear stress, shear strain, and shear modulus assuming the specimen had not yielded.

Solution: Shear stress = $T/2\pi R^2 t$ = 76.39 MPa.

$\gamma = R\alpha/L$ = 0.2618

$\tau/\gamma = G$ = 29179 MPa.