

Solution Manual 3rd Ed. Metal Forming: Mechanics and Metallurgy
Chapter 1

Determine the principal stresses for the stress state

$$\sigma_x = \begin{vmatrix} 10 & -3 & 4 \\ -3 & 5 & 2 \\ 4 & 2 & 7 \end{vmatrix}$$

Solution: $I_1 = 10+5+7=32$, $I_2 = -(50+35+70) + 9 + 4 + 16 = -126$, $I_3 = 350 - 48 - 40 - 80 - 63 = 119$; $\sigma^3 - 22\sigma^2 - 126\sigma - 119 = 0$. A trial and error solution gives $\sigma = 13.04$. Factoring out 13.04, $\sigma^2 - 8.96\sigma + 9.16 = 0$. Solving: $\sigma_1 = 13.04$, $\sigma_2 = 7.785$, $\sigma_3 = 1.175$.

1-2 A 5-cm. diameter solid shaft is simultaneously subjected to an axial load of 80 kN and a torque of 400 Nm.

- Determine the principal stresses at the surface assuming elastic behavior.
- Find the largest shear stress.

Solution: a. The shear stress, τ , at a radius, r , is $\tau = \tau_s r/R$ where τ_s is the shear stress at the surface R is the radius of the rod. The torque, T , is given by $T = \int 2\pi r^2 dr = (2\pi \tau_s /R) \int r^3 dr = \pi \tau_s R^3/2$. Solving for τ_s , $\tau_s = 2T/(\pi R^3) = 2(400\text{N})/(\pi 0.025^3) = 16 \text{ MPa}$

The axial stress is $.08\text{MN}/(\pi 0.025^2) = 4.07 \text{ MPa}$

$$\sigma_1, \sigma_2 = 4.07/2 \pm [(4.07/2)^2 + (16/2)^2]^{1/2} = 1.029, -0.622 \text{ MPa}$$

b. the largest shear stress is $(1.229 + 0.622)/2 = 0.925 \text{ MPa}$

A long thin-wall tube, capped on both ends is subjected to internal pressure. During elastic loading, does the tube length increase, decrease or remain constant?

Solution: Let y = hoop direction, x = axial direction, and z = radial direction. -

$$e_x = e_z = (1/E)[\sigma - \nu(\sigma_3 + \sigma_1)] = (1/E)[\sigma_2 - \nu(2\sigma_2)] = (\sigma_2/E)(1-2\nu)$$

Since $\nu < 1/2$ for metals, $e_x = e_z$ is positive and the tube lengthens.

4 A solid 2-cm. diameter rod is subjected to a tensile force of 40 kN. An identical rod is subjected to a fluid pressure of 35 MPa and then to a tensile force of 40 kN. Which rod experiences the largest shear stress?

Solution: The shear stresses in both are identical because a hydrostatic pressure has no shear component.

1-5 Consider a long thin-wall, 5 cm in diameter tube, with a wall thickness of 0.25 mm that is capped on both ends. Find the three principal stresses when it is loaded under a tensile force of 40 N and an internal pressure of 200 kPa.

Solution: $\sigma_x = PD/4t + F/(\pi Dt) = 12.2 \text{ MPa}$

$$\sigma_y = PD/2t = 2.0 \text{ MPa}$$

$$\sigma_z = 0$$

Metal Forming Solution Manual

**Helmi A. Youssef, Hassan A. El-
Hofy, Mahmoud H. Ahmed**



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