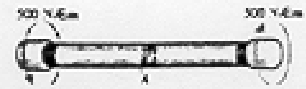
*9–84. The pipe has an inner radius of 25 mm and an outer radius of 27 mm. If it is subjected to an internal pressure of 8 MPa and a torsional moment of 500 N · m, determine the principal stresses and the maximum in-plane shear stress at point A, which lies on the pipe's outer surface.



Section Properties :

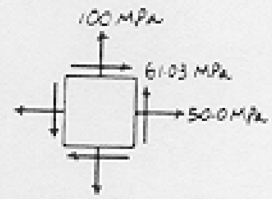
$$A = \pi\left(0.027^2 - 0.025^2\right) = 0.104\pi\left(10^{-3}\right)\ \text{m}^2$$
$$J = \frac{\pi}{2}\left(0.027^4 - 0.025^4\right) = 70.408\pi\left(10^{-9}\right)\ \text{m}^4$$

Normal Stress : Since $\frac{r}{t} = \frac{25}{2} = 12.5 > 10$, the thin wall analysis for cylindrical pipe is valid.

$$\sigma_{long} = \frac{pr}{2t} = \frac{8(25)}{2(2)} = 50.0\ \text{MPa}$$
$$\sigma_{hoop} = \frac{pr}{t} = \frac{8(25)}{2} = 100\ \text{MPa}$$

Shear Stress : Applying the torsion formula,

$$\tau = \frac{Tc}{J} = \frac{500(0.027)}{70.408\pi(10^{-9})} = 61.03\ \text{MPa}$$

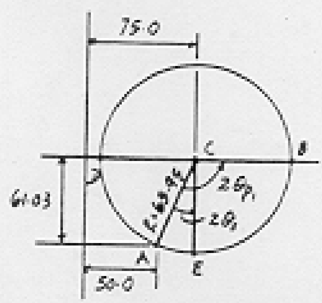


Construction of the Circle : In accordance with the sign convention, $\sigma_x = 50.0$ MPa, $\sigma_y = 100$ MPa, and $\tau_{xy} = 61.03$ MPa. Hence,

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2} = \frac{50.0 + 100}{2} = 75.0\ \text{MPa}$$

The coordinates for reference points A and C are

$$A(50.0,\ 61.03) \qquad C(75.0,\ 0)$$



The radius of the circle is $R = \sqrt{(75.0 - 50.0)^2 + 61.03^2} = 65.95\ \text{MPa}$

In-Plane Principal Stress : The coordinates of points B and D represent σ_1 and σ_2, respectively.

$$\sigma_1 = 75.0 + 65.95 = 141\ \text{MPa} \qquad \textbf{Ans}$$
$$\sigma_2 = 75 - 65.95 = 9.05\ \text{MPa} \qquad \textbf{Ans}$$

Maximum In-Plane Shear Stress : Represented by the coordinate of point E on the circle.

$$\tau_{\substack{max \\ in\text{-}plane}} = R = 66.0\ \text{MPa} \qquad \textbf{Ans}$$