

A pipe with close ends

$t = 10 \text{ mm}$

$d_i = 0.60 \text{ m}$

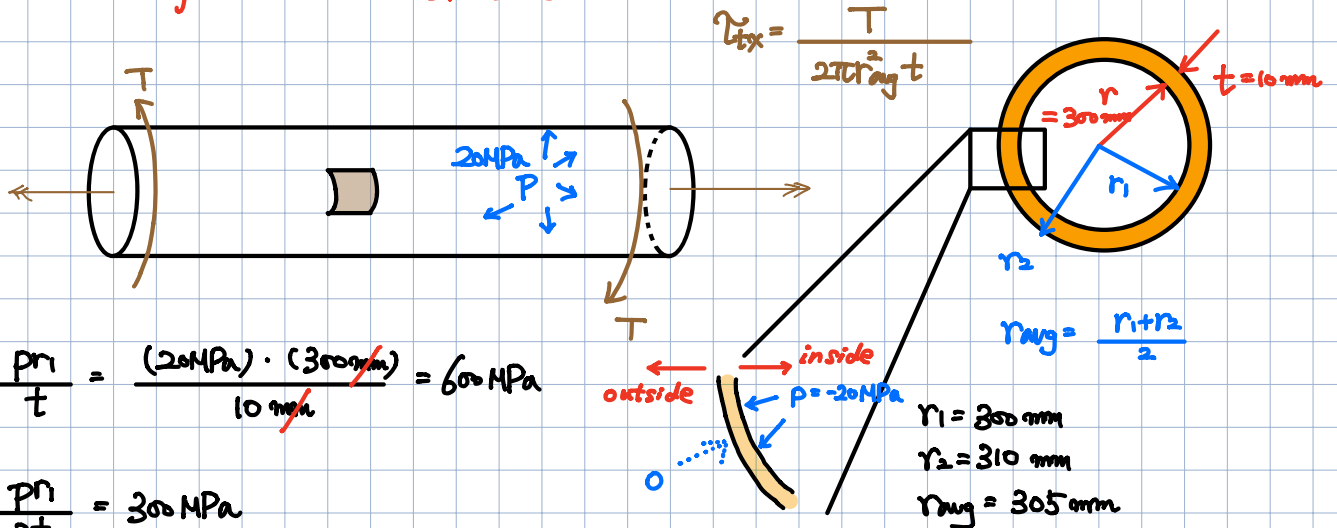
$= 600 \text{ mm}$

$p = 20 \text{ MPa}$ (gas pressure)

torque about its long axis = $1200 \text{ kN}\cdot\text{m}$

Determine the three principal stresses and maximum shear stress.

Step 1. Find your current stress conditions

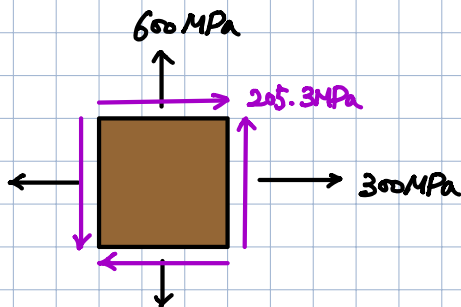


$$\tau_{\text{tor}} = \frac{T}{2\pi r_{\text{avg}}^2 t}$$

$$\sigma_t = \frac{pr_1}{t} = \frac{(20 \text{ MPa}) \cdot (300 \text{ mm})}{10 \text{ mm}} = 600 \text{ MPa}$$

$$\sigma_x = \frac{pr_1}{2t} = 300 \text{ MPa}$$

$$\tau_{\text{tor}} = \frac{T}{2\pi r_{\text{avg}}^2 t} = \frac{1200 \text{ kN}\cdot\text{m} \cdot \frac{1000 \text{ N}}{1 \text{ kN}} \cdot \frac{1000 \text{ mm}}{1 \text{ m}}}{2\pi (305 \text{ mm})^2 \cdot (10 \text{ mm})} = 205.3 \text{ MPa}$$



Step 2. Find your principal stresses

$$\sigma_{1,2} = C \pm R \quad \leftarrow C = \frac{300 + 600}{2} = 450$$

$$R = \sqrt{\left(\frac{300 - 600}{2}\right)^2 + (205.3)^2} = 254.3$$

$$\therefore \sigma_1 = 450 + 254.3 = \underline{704.3 \text{ MPa}} \text{ Ans.}$$

$$\sigma_2 = 450 - 254.3 = \underline{195.7 \text{ MPa}} \text{ Ans.}$$

$$\sigma_3 = 0 \text{ (outside)}$$

$$\sigma_3 = -20 \text{ (inside)}$$

$\sigma_3 = \sigma_r (x)$

$\sigma_3 = 0$

✖

Step 3. Tresca.

$$\tau_{\max} = \text{Max} \left\{ \left| \frac{\sigma_1 - \sigma_2}{2} \right|, \left| \frac{\sigma_2 - \sigma_3}{2} \right|, \left| \frac{\sigma_3 - \sigma_1}{2} \right| \right\}$$
$$= \left| \frac{704.3 - 195.7}{2} \right|, \left| \frac{195.7 - 0}{2} \right|, \left| \frac{0 - 704.3}{2} \right|$$

$$\therefore \tau_{\max} = 352.1 \text{ MPa}$$

Ans.
(outside)

$$\tau_{\max} = \left| \frac{-20 - 704.3}{2} \right|$$
$$= 362.1 \text{ MPa}$$

Ans.

$S_y = 900 \text{ MPa}$ \rightarrow SF = $\frac{900}{352.1}$ (outside) = 2.56 Ans.

or
= $\frac{900}{362.1}$ (inside, conservative) = 2.49 Ans.