

110 Computational Lab

1) you are to calculate the diameter of a solid shaft which must be made of steel to transmit 20 kW at 200 rpm. For the steel, the ultimate shear stress used is 360 MPa with a factor of safety 8, if this is to be replaced with a hollow shaft, calculate the inside and outside diameter if the ratio of inside to outside diameter is 0.5.

Ans: $D_o = 48.6 \text{ mm}$, $D_i = 25 \text{ mm}$

Given:

$$P = 20 \text{ kW} = 20 \frac{\text{kJ} \cdot \text{s}^{-1}}{\text{s}}$$

$$N = 200 \text{ rpm} = 3.33 \frac{\text{rev}}{\text{s}}$$

$$S_u = 360 \text{ MPa} = 360,000 \frac{\text{N}}{\text{m}^2}$$

$$F_s = 8$$

$$\frac{d_i}{d_o} = 0.5 \Rightarrow d_i = 0.5 d_o$$

$$\frac{S_s}{F_s} = \frac{16 T d_o}{\pi (d_o^3 - d_i^3)}$$

Find Torque:

$$\frac{P}{2\pi N} = \frac{2\pi N T}{2\pi N}$$

$$T = \frac{P}{2\pi N} \Rightarrow \frac{20 \frac{\text{kJ} \cdot \text{m}}{\text{s}}}{2\pi (3.33 \frac{\text{rev}}{\text{s}})}$$

$$T = 0.9558855441 \text{ kJ} \cdot \text{m}$$

Solve for d_o :

$$\frac{S_s}{F_s} = \frac{16 T (d_o)}{\pi (d_o^3 - d_i^3)}$$

$$\frac{360,000 \frac{\text{N}}{\text{m}^2}}{8} = \frac{16 (0.9558855441 \text{ kJ} \cdot \text{m}) (d_o)}{\pi (d_o^3 - (0.5 d_o)^3)} = d_o = 0.0486 \text{ m} \times \frac{1000 \text{ mm}}{1 \text{ m}}$$

$$d_o = 48.685 \text{ mm}$$

Solve for d_i : $d_o = 0.0486 \text{ m}$

$$\frac{S_s}{F_s} = \frac{16 T (d_o)}{\pi (d_o^3 - d_i^3)}$$

$$\frac{360,000 \frac{\text{N}}{\text{m}^2}}{8} = \frac{16 (0.9558855441 \text{ kJ} \cdot \text{m}) (0.0486 \text{ m})}{\pi ((0.0486 \text{ m})^3 - (d_i)^3)}$$

$$d_i = 0.0243 \text{ m}$$

$$d_i = 24.3 \text{ mm}$$

If $d_o = 50 \text{ mm}$:

$$d_i = 0.5 (d_o)$$

$$= 0.5 (50 \text{ mm})$$

$$\rightarrow = 25 \text{ mm}$$

Machine Design Problems And Solutions

William Cawthorne Unwin



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