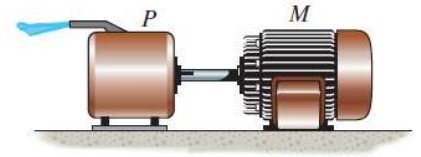


Torsion in Shafts. Question 5-41 Solution

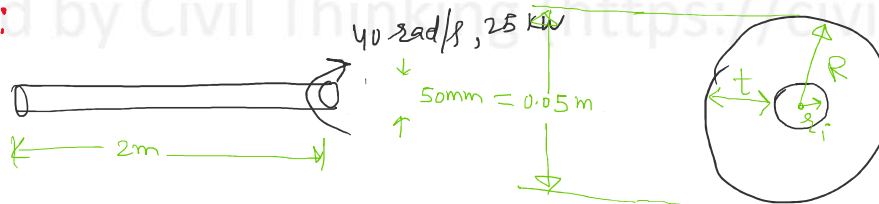
Tuesday, 11 March, 2025 08:07 AM

•5-41. The A-36 steel tubular shaft is 2 m long and has an outer diameter of 50 mm. When it is rotating at 40 rad/s, it transmits 25 kW of power from the motor M to the pump P. Determine the smallest thickness of the tube if the allowable shear stress is $\tau_{\text{allow}} = 80 \text{ MPa}$.

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Given Data:



$$\tau_{\text{allow}} = 80 \text{ MPa} = 80 \times 10^6 \text{ N/m}^2$$

To find: thickness, t

$$\begin{aligned} R &= r_i + t \\ \frac{d_o}{2} &= r_i + t \\ \frac{0.05}{2} &= r_i + t \\ 0.025 &= r_i + t \\ \Rightarrow t &= 0.025 - r_i \end{aligned}$$

Since $t = 0.025 - r_i$ it means once we get the internal radius, r_i of the shaft, we can find thickness, t from it.

We know:

$$\frac{\tau}{R} = \frac{T_{\text{max}}}{J} \Rightarrow \frac{80 \times 10^6 \text{ N/m}^2}{\frac{d_o}{2}} = \frac{T_{\text{max}}}{\frac{\pi}{2} \left[\left(\frac{d_o}{2} \right)^4 - \left(\frac{d_i}{2} \right)^4 \right]} \quad \text{--- ①}$$

$$\frac{d_o}{2} = \frac{50 \text{ mm}}{2} = 0.025 \text{ m} ; \quad \frac{d_i}{2} = r_i$$

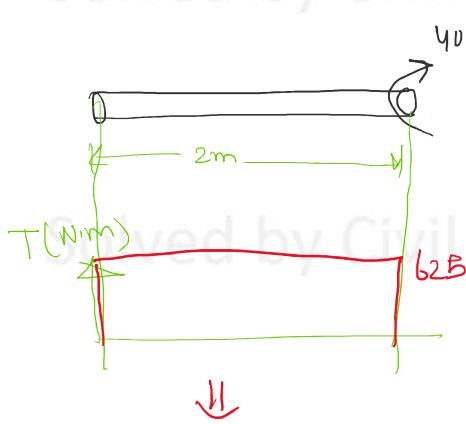
T_{max} will be absolute max. internal torque, since we are designing (finding dimension) the given shaft.

$$40 \text{ rad/s}, 25 \text{ kW}$$

o

$$n \leq \sqrt[3]{1.124}$$

...



40 rad/s, 25 kW

$$T = \frac{P}{\omega} = \frac{25 \times 10^3 \text{ watt}}{40 \text{ rad/s}} = 625 \text{ N}\cdot\text{m}$$

$$T_{\text{max, abs.}} = 625 \text{ N}\cdot\text{m}$$

Substituting it in Equation ①:

$$\frac{80 \times 10^6 \text{ N/m}^2}{\frac{d_o}{2}} = \frac{625 \text{ N}\cdot\text{m}}{\frac{\pi}{2} \left[\left(\frac{d_o}{2} \right)^4 - \left(\frac{d_i}{2} \right)^4 \right]}$$

\swarrow 0.025m \swarrow 2i

Solving the equation, yields $r_i \approx 0.022716 \text{ m}$

$$\text{we found earlier, } t = R - r_i = 0.025 \text{ m} - 0.022716 \text{ m} = 0.002284 \text{ m}$$

$$\Rightarrow \text{thickness of the shaft} \geq 2.28 \text{ mm} \approx 2.5 \text{ mm}$$

Ans. ✓

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