Question #80243

It is desired to transmit 90 kW by means of a solid circular shaft rotating at 3.5 rad/s. the allowable shearing stress it 45 MPa. Find the required shaft diameter.

Answer:

The torque *T* applied to the shaft is the ratio of transmitted power *P* to the rotating velocity ω:

$$T = \frac{P}{\omega}, \tag{1}$$

Substitute into (1):

$$T = \frac{90{,}000}{3.5} = 25{,}714 \text{ Nm}.$$

The shear stress in the shaft is given by:

$$\tau = \frac{Td}{2J}, \tag{2}$$

where *d* is diameter of the shaft,

J is the second are moment, which is given by:

$$J = \frac{\pi d^4}{32} \tag{3}$$

for a circular shaft.

Let us substitute (3) in (2) and derive equation for *d*:

$$\tau = \frac{Td}{2 \cdot \frac{\pi d^4}{32}} = \frac{16T}{\pi d^3},$$

$$d = \sqrt[3]{\frac{16T}{\pi\tau}} \tag{4}$$

Now, substitute into (4):

$$d = \sqrt[3]{\frac{16 \cdot 25{,}714}{\pi \cdot 45 \cdot 10^6}} = 0.1428 \text{ m} = 143.8 \text{ mm}.$$

Thus, the diameter of the shaft should be more than 143.8 mm