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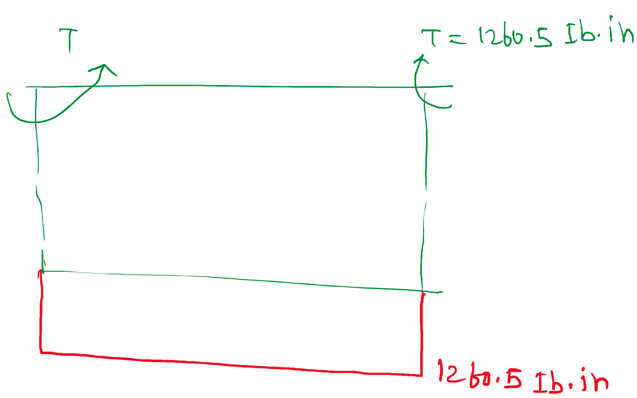
5–34. The gear motor can develop 3 hp when it turns at 150 rev/min. If the allowable shear stress for the shaft is $\tau_{allow} = 12$ ksi, determine the smallest diameter of the shaft to the nearest $\frac{1}{8}$ in. that can be used.

$$T = \frac{P}{\omega}$$

$$P = 3\,hp \times 550 = 1650\ ft\,lb/s$$

$$\omega = 2\pi N = 2\pi \times \frac{150}{60} = 5\pi\ rad/s$$

$$\Rightarrow T = \frac{1650}{5\pi} = 105\ lb\cdot ft \times 12 = 1260.5\ lb\cdot in$$



$$\Downarrow$$

$$T_{max\,abs} = 1260.5\ lb\cdot in$$

Shaft is always designed for absolute maximum Torque

We know

$$\frac{\tau}{R} = \frac{T}{J}$$

$\tau = 12$ ksi [Given] $= 12 \times 10^3$ lb/inch^2

$R = d/2$; $J = \frac{\pi}{2}\left(\frac{d}{2}\right)^4$; $T = T_{max, abs} = 1260.5$ lb·in

$$\Rightarrow \frac{12 \times 10^3}{(d/2)} = \frac{1260.5 \text{ lb.in}}{\frac{\pi}{2}(d/2)^{4\,3}}$$

Solving for d, yields, $d = 0.8118$ inch $= \frac{7}{8}$ inches