Torsion in Shafts. Question 5-52 Solution

Saturday, 15 March, 2025 06:45 AM

*5-52. The engine of the helicopter is delivering 600 hp to the rotor shaft AB when the blade is rotating at 1200 rev/min. Determine to the nearest 1/8 in. the diameter of the shaft AB if the allowable shear stress is T_{allow} =10.5 ksi and the vibrations limit the angle of twist of the shaft to 0.05 rad. The shaft is 2 ft long and made from L2 steel.

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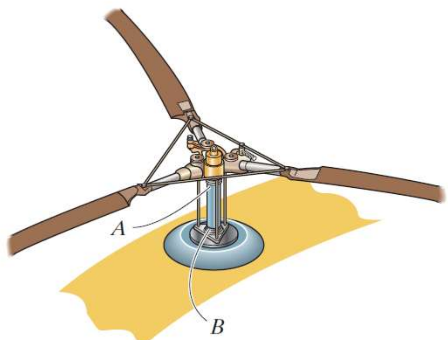
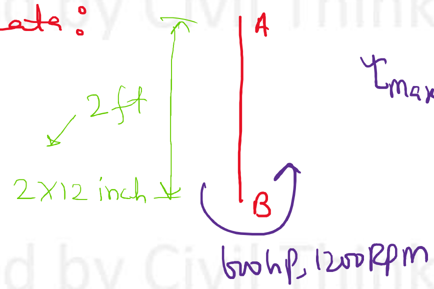


Given Data:



$\tau_{max} = \tau_{allow} = 10.5$ ksi; $\theta = 0.05$ radians

L2 steel, $G = 11 \times 10^6$ ksi

To find: diameter, d of the shaft (means shaft design)

Shaft is designed based on τ_{max} & θ i.e. $d_{min} = \max\{d_{\tau_{max}}, d_\theta\}$

Based on τ_{max}:

$$\frac{\tau_{max}}{R} = \frac{T}{J} \quad \text{[Torsion Equation]}$$

$$T = \frac{Power}{\omega} = \frac{600\,hp \times 550\,lb\cdot ft}{2\pi \times 1200 ...}$$

Based on θ:

$$\frac{G\theta}{L} = \frac{T}{J}$$

$$\frac{11\times10^6 \times 0.05}{} = \frac{2626.06 \times 12}{}$$

$$T = \frac{\text{Power}}{\omega} = \frac{600\,hp \times 550\, lb\cdot ft}{2\pi \times 1200/60\ rad/s}$$

$$\Rightarrow T = 2626.06\ lb\cdot ft$$

$$\frac{10.5\times10^3}{d/2} = \frac{2626.06 \times 12\ lb\cdot inch}{\frac{\pi}{2}\left(\frac{d}{2}\right)^4}$$

$$\Rightarrow \boxed{d = 2.48\ inch} \text{ — } (1)$$

$$\frac{11\times10^6 \times 0.05}{2\times12} = \frac{2626.06\times12}{\frac{\pi}{2}\left(\frac{d}{2}\right)^4}$$

$$\Rightarrow \boxed{d = 1.93\ inch} \text{ — } (2)$$

Minimum Required dia $= d_{min} = Max[2.48, 1.93] = 2.48$ inch

$\Rightarrow d = 2.48$ inch ANS.