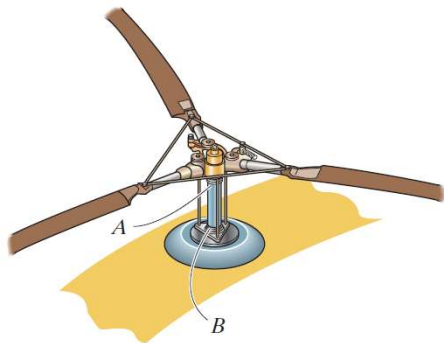


*5-52. The engine of the helicopter is delivering 600 hp to the rotor shaft AB when the blade is rotating at 1200 rev/min. Determine to the nearest $\frac{1}{8}$ in. the diameter of the shaft AB if the allowable shear stress is $\tau_{\text{allow}} = 10.5$ ksi and the vibrations limit the angle of twist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

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Given Data :



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

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

600 hp, 1200 RPM

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

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

Based on τ_{max} :

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

$$T = \frac{\text{Power}}{\omega} = \frac{600 \text{ hp} \times 550 \text{ lb}\cdot\text{ft}}{2\pi \times 1200 \text{ rev/min} \times \frac{1}{60} \text{ min/s}}$$

Based on θ :

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

$$\frac{11 \times 10^6 \times 0.05}{2 \times 12} = \frac{2626.06 \times 12}{J}$$

$$T = \frac{\text{Power}}{\omega} = \frac{600 \text{ hp} \times 550 \text{ lb.ft}}{2\pi \times 1200 \frac{\text{rad}}{\text{min}} \times \frac{1}{60} \times \frac{2\pi \text{ rad}}{180}} \\ \Rightarrow T = 2626.06 \text{ lb.ft}$$

$$\frac{10.5 \times 10^3}{\frac{d}{2}} = \frac{2626.06 \times 12 \text{ lb.inch}}{\frac{\pi}{2} \left(\frac{d}{2}\right)^4}$$

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

$$\frac{11 \times 10^6 \times 0.05}{2 \times 12} = \frac{2626.06 \times 12}{\frac{\pi}{2} \left(\frac{d}{2}\right)^4}$$

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

$$\text{Minimum Required dia} = d_{\min} = \max [2.48, 1.93] = 2.48 \text{ inch}$$

$$\Rightarrow d = 2.48 \text{ inch ANS.}$$

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