

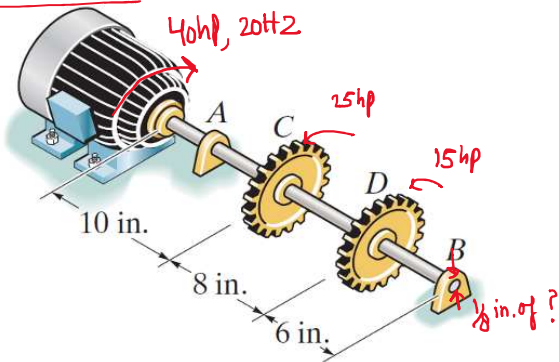
## Torsion in Shafts. Question 5-57 Solution

Saturday, 15 March, 2025 11:25 AM

•5-57. The motor delivers 40 hp to the 304 stainless steel shaft while it rotates at 20 Hz. The shaft is supported on smooth bearings at A and B, which allow free rotation of the shaft. The gears C and D fixed to the shaft remove 25 hp and 15 hp, respectively. Determine the diameter of the shaft to the nearest 1/8 in. if the allowable shear stress is  $\tau_{\text{allow}} = 8$  ksi and the allowable angle of twist of C with respect to D is  $0.2^\circ$

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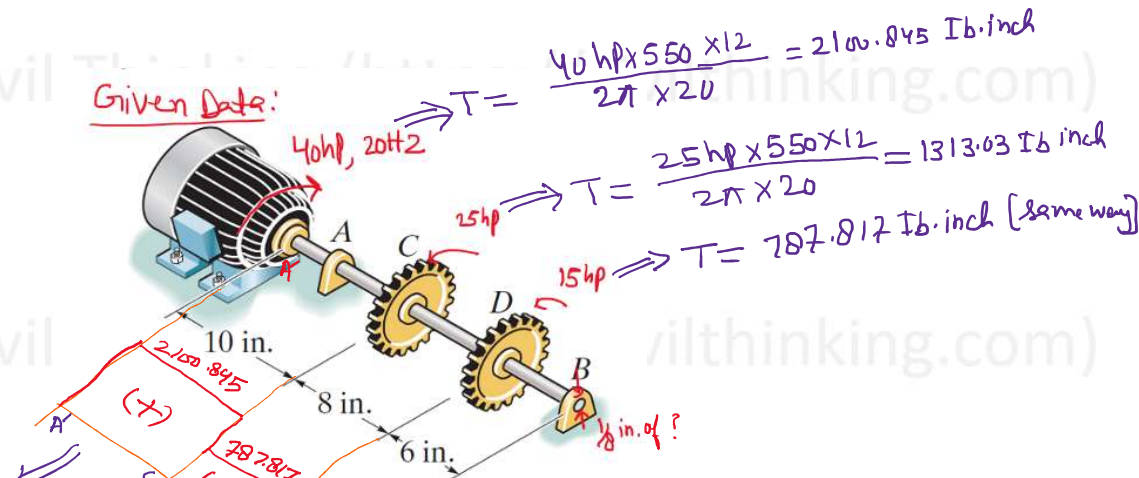
Given Data:



$$\tau_{\text{allow}} = 8 \text{ ksi} ; \theta_{C/D, \text{allow}} = 0.2^\circ$$

To find: Diameter,  $d$  of shaft

Given Data:



$$T_{\text{max}, C} = 2100.845 \text{ Ib}\cdot\text{inch}$$

$$T_{\text{max}, D} = 787.817 \text{ Ib}\cdot\text{inch}$$

$$T_{\text{max}, \text{abs}} = 2100.845 \text{ Ib}\cdot\text{inch}$$

$$\frac{\tau_{allow}}{R} = \frac{T}{J} \Rightarrow \frac{8 \times 10^3}{d/2} = \frac{2100 \cdot 845 \text{ Ib} \cdot \text{inch}}{\frac{\pi}{2} (d/2)^4}$$

$$\Rightarrow d = 1.1018 \text{ inch} \quad \text{--- ①}$$

$$\frac{G\theta}{L} = \frac{T}{J} \Rightarrow \theta = \frac{TL}{GJ}$$

$$\Rightarrow \theta_{c/D} = \frac{787.817 \times 8}{11 \times 10^6 \times \frac{\pi}{2} (d/2)^4} = 0.20 \times \frac{\pi}{180}$$

$$\Rightarrow d = 1.137 \text{ inch} \quad \text{--- ②}$$

$$\begin{aligned} \text{Required dia, } d_{min} &= \max[①, ②] \\ &= 1.137 \text{ inch} \\ &\approx \frac{16}{8} \text{ inch} \quad \text{ANS.} \end{aligned}$$

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