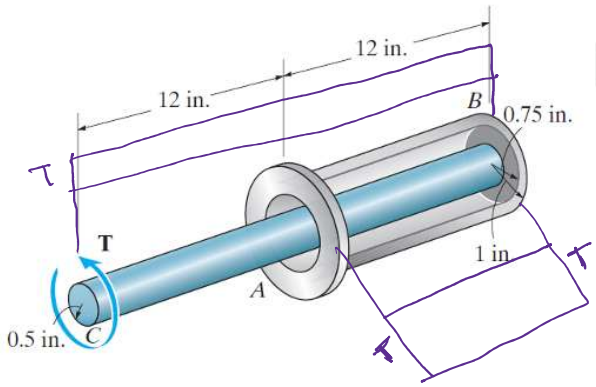
Torsion in Shafts. Question 5-64 Solution

Sunday, 16 March, 2025 06:17 PM

*5-64. The device serves as a compact torsion spring. It is made of A-36 steel and consists of a solid inner shaft CB which is surrounded by and attached to a tube AB using a rigid ring at B. The ring at A can also be assumed rigid and is fixed from rotating. If the allowable shear stress for the material is T_{allow} =12 ksi and the angle of twist at C is limited to 3^0, determine the maximum torque T that can be applied at the end C.

***5–64.** The device serves as a compact torsion spring. It is made of A-36 steel and consists of a solid inner shaft *CB* which is surrounded by and attached to a tube *AB* using a rigid ring at *B*. The ring at *A* can also be assumed rigid and is fixed from rotating. If the allowable shear stress for the material is $\tau_{allow} = 12$ ksi and the angle of twist at *C* is limited to $\phi_{allow} = 3°$, determine the maximum torque *T* that can be applied at the end *C*.



Shear stress check:

$$\frac{T_{AB}}{J_{AB}} = \frac{\tau_{AB}}{R_{AB}} \quad (\tau_{AB} \to 12\ \text{ksi})$$

$$\Rightarrow \frac{T_{AB}}{\frac{\pi}{2}\left[1^4 - 0.75^4\right]} = \frac{12\ \text{ksi}}{1^4} \Rightarrow T_{AB} = 12 \times \frac{\pi}{2}\left[1 - 0.75^4\right]$$

$$\Rightarrow T_{AB} = 12.885 = T$$

$$\frac{T_{CB}}{J_{CB}} = \frac{\tau_{CB}}{R_{CB}}; \quad (\tau_{CB} \to 12\ \text{ksi},\ J_{CB} \to \tfrac{\pi}{2}0.5^4,\ R_{CB} \to 0.5)$$

$$\Rightarrow T_{CB} = 2.3562 = T$$

Twist check!

$$\phi_C = 3^\circ \times \frac{\pi}{180} = \phi_{CB} + \phi_{BA} = \frac{T \times 24}{11 \times 10^3 \times \frac{\pi}{2} 0.5^4} + \frac{T \times 12}{11 \times 10^3 \times \frac{\pi}{2}(1 - 0.75^4)}$$

$$\Rightarrow T = 2.253\ \text{kip.in}$$

$$\text{Max Torque, } T = \text{Min}\left\{2.253\ \text{kip.in}, 2.3562, 12.885\right\} = 2.253\ \text{kip.in}\ \text{ANS.}$$

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