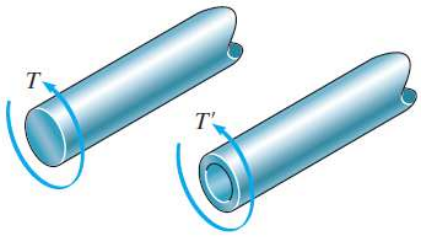
Torsion in Shafts problem 5-1 Solution:

Saturday, 8 March, 2025 07:48 PM

•5-1. A shaft is made of a steel alloy having an allowable shear stress of T_{allow} 12 ksi. If the diameter of the shaft is 1.5 in., determine the maximum torque T that can be transmitted. What would be the maximum torque T' if a 1-in.-diameter hole is bored through the shaft? Sketch the shear-stress distribution along a radial line in each case.

•5–1. A shaft is made of a steel alloy having an allowable shear stress of $\tau_{allow} = 12$ ksi. If the diameter of the shaft is 1.5 in., determine the maximum torque **T** that can be transmitted. What would be the maximum torque **T'** if a 1-in.-diameter hole is bored through the shaft? Sketch the shear-stress distribution along a radial line in each case.



We know:

$$\frac{\tau}{R} = \frac{T}{J} \quad \text{[Torsion equation]}$$

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

$$R = \frac{dia}{2} = \frac{1.5}{2} =$$

$$J = \frac{\pi}{2} R^4 = \frac{\pi}{2}\left(\frac{1.5}{2}\right)^4$$

$$\Rightarrow \frac{J}{R} = \frac{\pi}{2}\left(\frac{1.5}{2}\right)^3$$

$$\Rightarrow T = 12\,Ksi \times \frac{\pi}{2}\left(\frac{1.5}{2}\right)^2 = 7.95\ kip.in$$

$$T' = \tau \times \frac{J}{R}$$

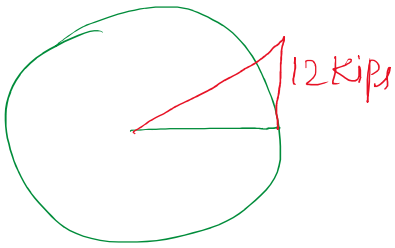
$$\tau = 12\,Ksi$$

$$J = \frac{\pi}{2}\left(\left(\frac{1.5}{2}\right)^4 - \left(\frac{1}{2}\right)^4\right)$$

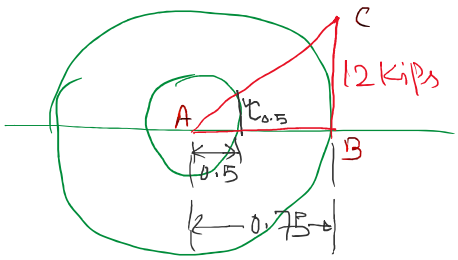
$$R = \frac{1.5}{2}$$

$$T' = 12\,Ksi \times \frac{\frac{\pi}{2}\left(\left(\frac{1.5}{2}\right)^4 - \left(\frac{1}{2}\right)^4\right)}{\frac{1.5}{2}} = 6.38\ kip.in$$

Radial Distribution of Shear Stress in both cases:



[Solid]



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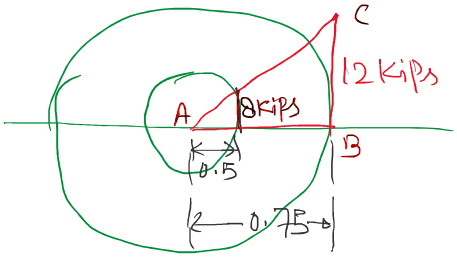
$\frac{1}{2}'' = 0.5''$

$\frac{1.5}{2}'' = 0.75''$

From triangle ABC:

$$\frac{\tau_{0.5}}{0.5} = \frac{12 \text{ kips}}{0.75}$$

$$\Rightarrow \tau_{0.5} = \frac{0.5}{0.75} \times 12 \text{ kips} = 8 \text{ kips}$$



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