Torsion in Shafts. Question 5-50 Solution

Friday, 14 March, 2025 05:32 PM

5-50. The hydrofoil boat has an A-36 steel propeller shaft that is 100 ft long. It is connected to an in-line diesel engine that delivers a maximum power of 2500 hp and causes the shaft to rotate at 1700 rpm. If the outer diameter of the shaft is 8 in. and the wall thickness is -g in., determine the maximum shear stress developed in the shaft. Also, what is the "wind up," or angle of twist in the shaft at full power?

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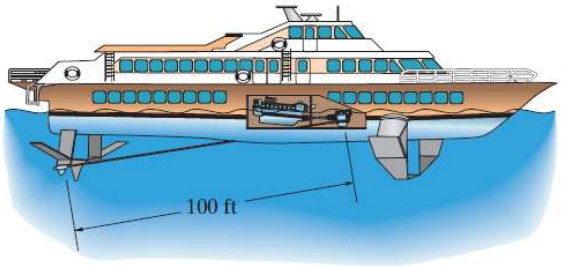
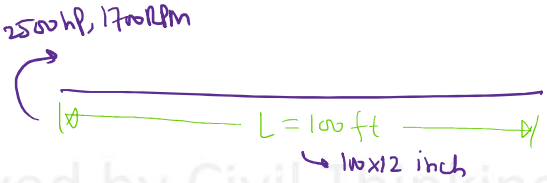
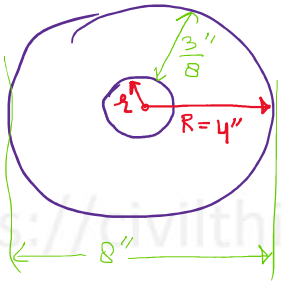


Given Data:





$r = 4 - \frac{3}{8} = 3.5''$

$= \frac{3.5}{12} = \frac{7}{24}$ feet

$R = \frac{4}{12} = \frac{1}{3}$ feet

To find: τ_{max}, Angle of twist, θ at full power.

We know:

$$\frac{\tau_{max}}{R} = \frac{T_{max}}{J}$$ [Torsion Equation]

[To convert hp to lb·ft/s: 1 hp = 550 lb ft/s]

$$T_{max} = \frac{\text{Power}}{\omega} = \frac{2500\,hp \times (550\ lb\,ft/s)}{2\pi \times \frac{1700}{60}\ rad/s} = \frac{412500}{17\pi}\ lb\cdot ft$$

$R = \frac{1}{3}$ feet

$$J = \frac{\pi}{2}\left[R^4 - r^4\right] = \frac{\pi}{2}\left[\left(\frac{1}{3}\right)^4 - \left(\frac{7}{24}\right)^4\right] = \frac{565\pi}{22104}$$

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$$\Rightarrow \frac{\tau_{max}}{1/3} = \frac{412500/17\pi}{565\pi/22118} \Rightarrow \tau_{max} = 320818.92\ lb/ft^2 = 2.83\ ksi$$

Lets find angle of twist, θ :

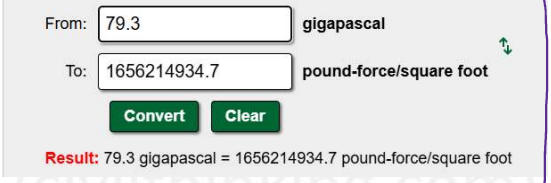
We Know:

$$\frac{G\theta}{L} = \frac{T}{J} \qquad \text{[Torsion Equation - Part 2]}$$

$$\frac{1656214934.7 \times \theta}{100\,ft \times 144} = \frac{\frac{412500}{17\pi}\ lb.ft}{\frac{565\pi}{22118}\ ft^4}$$

$\Rightarrow \theta = 0.058\ rad = 3.32°$

G of A36 steel = 79.3 GPa
↓ conversion to lbf/ft^2



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