Mechanics of Materials II:

Thin-Walled Pressure Vessels and Torsion

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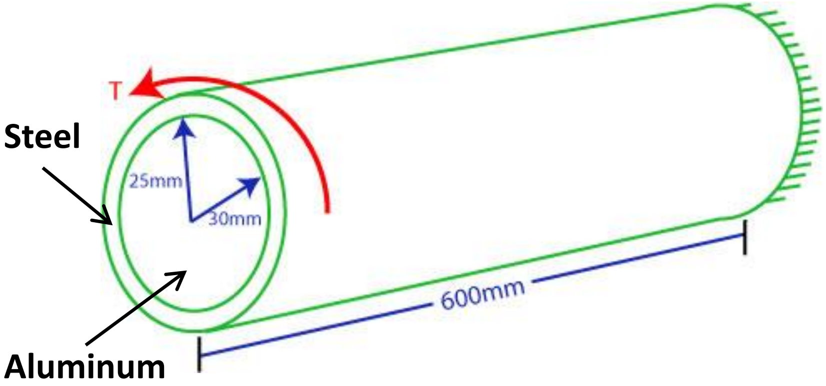
Module 22 Learning Outcome

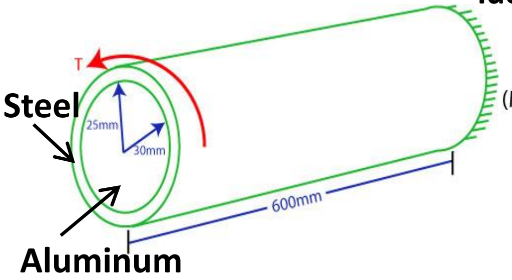
- Solve a problem for the inelastic torsion of straight cylindrical shafts

Inelastic Torsion of Straight Cylindrical Shafts

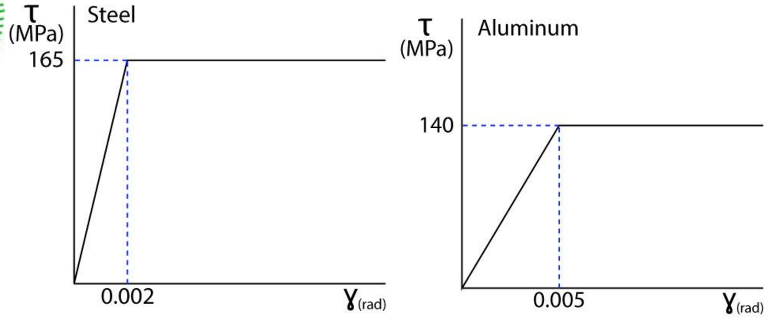
You decide to do some tests regarding a new torsion bar design.
To start this initiative you decide to do an analysis.



Inelastic Torsion of Straight Cylindrical Shafts



Idealized Shear Stress-Strain Diagrams

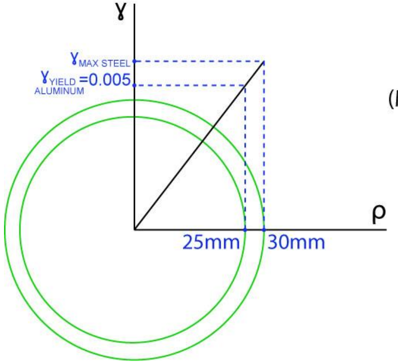


Worksheet:

A composite torsion bar is made of an aluminum core surrounding by steel. The aluminum and steel are perfectly bonded together. A torque, T, is applied at a magnitude where the aluminum just begins to yield.

a) Determine the torque, T, required for the aluminum to just begin yielding.

Inelastic Torsion of Straight Cylindrical Shafts



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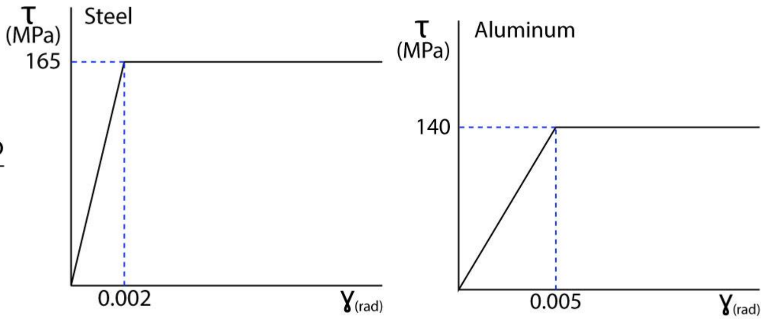

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$$\frac{\gamma_{MAX\ STEEL}}{r_{OUTER}} = \frac{\gamma}{\rho} = \frac{\gamma_{YIELD\ ALUM}}{r_{ELASTIC\ ALUM}}$$

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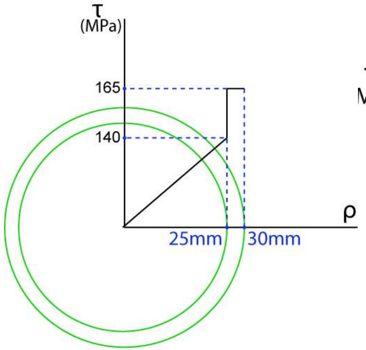

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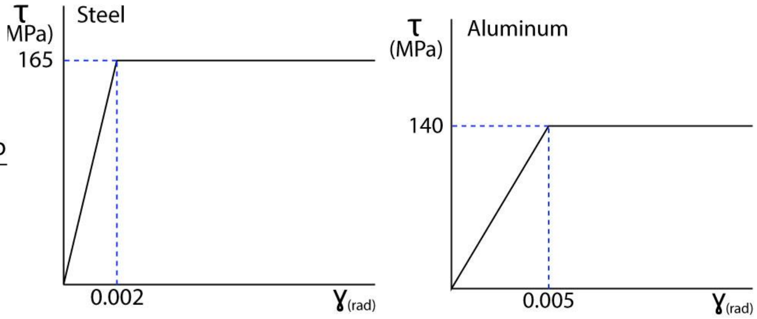

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$$T_{TOTAL} = T_{\substack{ELASTIC\\ALUMINUM}} + T_{\substack{PLASTIC\\STEEL}}$$

$$T_{\substack{ELASTIC\\ALUMINUM}} = \frac{\tau_{\substack{YIELD\\ALUMINUM}} \; J_{\substack{ELASTIC\\REGION}}}{r_{ELASTIC}}$$

$$T_{\substack{ELASTIC\\ALUMINUM}} = \frac{(140\,MPa)\dfrac{\pi}{2}(25\,mm)^4}{25\,mm} = \underline{3{,}436{,}000\ N \cdot mm}$$

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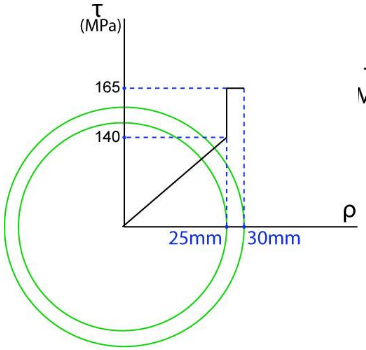

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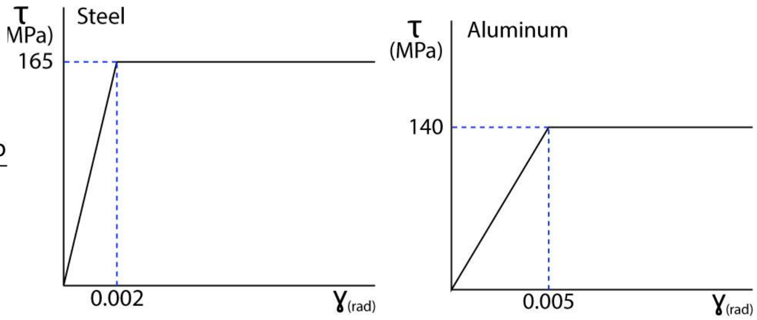

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$$T_{\substack{ELASTIC \\ ALUMINUM}} = \underline{3{,}436{,}000\ N \cdot mm}$$

$$T_{\substack{PLASTIC \\ STEEL}} = \frac{2}{3}\pi\ \tau_{\substack{YIELD \\ STEEL}}\left(r_{OUTER}^3 - r_{ELASTIC}^3\right)$$