In Figure 3 we show a mechanism whereby a torque $T$ acts on bevel gear $A$ having a mean diameter of 3 in, which in turn acts on bevel gear $B$ having a mean diameter of 15 in. A torque is thus transmitted to the vertical tube $C$. This tube also supports a force $P$, as can be seen in the diagram. What are the shear stress and normal stress over cross sections of the tube for the following data: $P = 500$ lb, $T = 300$ in-lb, $t = 0.125$ in and $D = 3$ in.

\[ T = Fr_A \quad \text{and} \quad M_B = Fr_B \quad (1) \]

\[ M_B = T \frac{r_B}{r_A} = 300 \left( \frac{15}{3} \right) = 1500 \text{ lb-in} \]

\[ M_B = \int_A \int_A \tau_t r dA \Rightarrow \int_A \int_A \tau_t r (r dr d\theta) \]

\[ M_B = \int_{r_i}^{r_o} \int_0^{2\pi} \tau_t r^2 dr d\theta = \tau_t \left( 2\pi \right) \left( \frac{r_o^3}{3} - \frac{r_i^3}{3} \right) \]

\[ \tau_t = \frac{3 M_B}{2\pi} \left( \frac{1}{r_o^3 - r_i^3} \right) \quad (2) \]

\[ r_o = 3 \times \frac{1}{2} = 1.5 \text{ in} \]

\[ r_i = 1.5 - \frac{1}{8} = 1.375 \text{ in} \]

\[ \tau_t = \frac{3 \times 1500}{2\pi} \left( \frac{1}{(1.5^3 - 1.375^3)} \right) \Rightarrow \tau_t = 923.66 \text{ psi} \]

\[ \sigma_n = \frac{P}{A} = \frac{500}{\frac{\pi}{4} \left[ 3^2 - (3 - \frac{2}{8})^2 \right]} \]

\[ \sigma_n = 442.87 \text{ psi} \]

Normal stress