ME 423
Instructor: Ramesh Singh

Assigned: August 17, 2024
Due: August 25, 2024

1. The notched torsion tube under combined loading for power transmission is shown in Fig. 1. Find the state of stress in the thin shaded section. Assume the stresses do not vary in that section. Compute the stresses and draw the stress element. Compute the expression for principal stresses. If the yield stress is Y; write down the permissible design stresses for a given material in terms Fz and Mt via Tresca and VonMises criteria for the given loading. (Hint: assume r>>t)

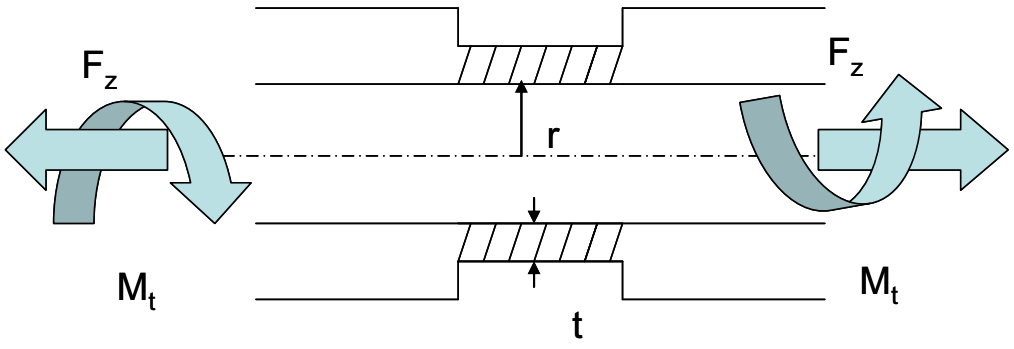


Fig. 1. Torsion tube

The notched torsion tube is supposed to carry an axial load of 500 N and a torsion of 500 Nm. For a factor of safety of 2 (to avoid yielding) and a radius of 100 mm, plot the design stresses versus the thickness of the torsion tube and identify some engineering material and thickness combinations from that plot.

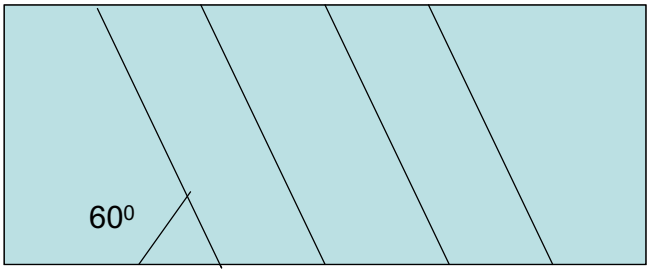
2. A pressurized welded tank is constructed with helical weld that makes α =60 deg. Use thin pressure vessel assumption.

Radius, r = 0.5 m
Wall thickness, t = 15 mm
Pressure, p = 2.4 MPa
E = 200 GPa
Poisson's ratio, v = 0.5

Determine (a) circumferential and longitudinal stresses; (b) Maximum in plane and out of plane shear stresses; (c) the circumferential and longitudinal strains; (d) Normal and shear stress acting on plane parallel and perpendicular to weld orientation. Show it on properly oriented element. Plot the Mohr's circle and show the components at weld plane. (Do not plot to scale, use transformation equations). Using appropriate safely factor what is the recommended weld strength required. Clearly mention what is the likely mode of failure for weld and why?

Select appropriate factor of safety in welds (See the following link)

https://edu.truboprovod.ru/kbase/doc/start/WebHelp_en/Welds.htm#Weld_Safety_Factor_for_Pressure__longitudinal___Wl



3. A thin spherical stainless-steel tank having a diameter of 16 in is used to store propane at a pressure of 3000 psi (lb/in^2).
   The properties of steel are as follows:
   - Yield stress in tension = 140,000 psi
   - Yield stress in shear = 65,000 psi
   - Maximum allowable normal strain = 1000x 10^{-6}
   - Modulus of elasticity = 30x10^6 psi
   - Poisson's ratio = 0.28

   a. The desired factor of safety for design with respect to yielding is 2.75.

      i. Determine the mode in which the material fails/yield.
      ii. Determine the minimum permissible thickness, t_{min} of the tank.

   b. How will your analysis change if the sphere is thick say 2 inch in diameter? Look up the formulation of thick cylinders in text book and find the magnitude and location of maximum von Mises stresses.

4. Show that for plastic deformation, $\varepsilon_x + \varepsilon_y + \varepsilon_z = 0$ and find the value of Poisson's ratio, v.
5. The stress state is as follows: $\sigma_x = 50; \sigma_y = 10; \sigma_z = -20; \tau_{xy} = -15; \tau_{xz} = \tau_{yz} = 0$. Find the principal stresses and maximum shear stresses.
6. Consider a thin-walled tube with close ends and internal pressure p. The wall thickness is t, the inner radius is r, and the ductile material has a yield strength of Y.

   i. Derive the expressions for required thickness corresponding to the specified values of r and the safety factor X against yielding for von Mises and Tresca criteria. Calculate the percentage difference in the thickness obtained from the two criteria.

ii. Explain with some analysis how will the result change if the tube is not considered as a thin tube but a thick-walled tube.

7. A thick plate of steel is dipped in a cryogenic tank kept at -120°C for a very short period. Given: E =200 GPa; coefficient of thermal expansion, $\alpha = 12 \times 10^{-6}/°C$;

    a. What are the strains and stresses acting on the surface of the plate right after immersion? Provide the complete stress and strain tensor with signs (+ for tensile and – for compressive). If the yield stress is 1 GPa, will yielding occur (use Tresca criteria)?
    b. Physically explain the reason for that stress state. How will the nature of stress change if the fluid is very hot instead of cryogenic?

8. A 0.6 m long propeller shaft needs to be designed to transmit 50 hp (1hp = 746 W) at 600 rpm. The shaft is simply supported by bearings at both ends. The shaft experiences bending due to its own weight.
    i. Identify the critical location and show the stress element at the critical location.

    ii. Find the equation of minimum acceptable shaft diameter for a factor of safety of 2. Use the appropriate theory of failure. Will a 40 mm shaft work?

    The tensile yield stress is 240 MPa, and the density of the material is $7.8 \times 10^3 \ \frac{kg}{m^3}$