Pressure Vessel - Pre-Analysis & Start-Up

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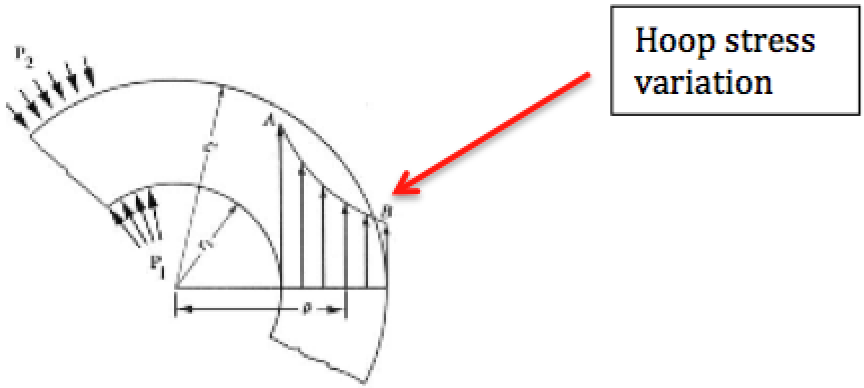
Pre-Analysis & Start-Up

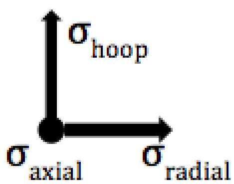
Pre-Analysis

The equations for stresses in thin- and thick-wall cylinders can be found in many mechanics of materials references, and are summarized here, with a = inner radius, b = outer radius, r = radial position where stress is to be found, and t = wall thickness.

	Thin-wall	Thick-wall
Hoop Stress	$\sigma_\theta = \frac{pa}{t}$	$\sigma_\theta = \frac{pa^2\left(r^2+b^2\right)}{r^2\left(b^2-a^2\right)}$
Axial Stress	$\sigma_{ax} = \frac{pa}{2t}$	$\sigma_{ax} = \frac{pa^2}{b^2-a^2}$

Notice that in thick-wall theory, the hoop stress varies with the radial position, while the stress is assumed to be constant in thin-wall theory. Comparing the substitution of a and b for r in the hoop stress thick-wall equation will convince you that stress is greater on the inner surface. The hoop stress variation in thick-walled vessels can be depicted as follows (the view shown corresponds to looking from above the pressure vessel):





By using the parameters given in the problem statement and the above formulae for hoop stress, we find that the maximum hoop stresses using the thin-wall and thick-wall approximations yield **3000 psi** and **3571 psi**, respectively. This corresponds to a 16% difference which tells us that the thin wall theory might not be adequate for this geometry. Thin-wall theory actually gives good results when b/a ratio is less than 1.10, and that is not the case here.

Notice that the axial stresses are constant for both theories since they do not depend on radius. For this example, the thin-wall and thick-wall approximations yield **1500 psi** and **1285 psi**, respectively.

The radial stresses at the inner and outer surfaces can be deduced from the boundary conditions:

- The radial stress at the outer surface is **0 psi** since the traction is zero at a free surface.
- The radial stress at the inner surface is **-1000 psi** since it has to equal the applied normal traction (radial direction is also the normal direction here). The negative sign indicates that the applied traction is compressive.

The following tables display the results of these approximations:

		FEA Axisymmetric	Thin-Wall Equation	Thick-Wall Equation
HOOP STRESS (psi)	Inner Surface	?	3000	3571.4
	Outer Surface	?	3000	2571.4
AXIAL STRESS (psi)	(Constant for both theories)	?	1500	1285.7

		FEA Axisymmetric	Boundary Conditions
RADIAL STRESS (psi)	Inner Surface	?	-1000
	Outer Surface	?	0

We will fill in the missing information by performing an axisymmetric analysis using ANSYS. We will then compare the numerical results from ANSYS to the analytical results.

Start-Up

Launch ANSYS Workbench and start a "Static Structural" analysis in the project page as shown in the video below.

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