22.314/1.56/2.084/13.14 Fall 2006

Problem Set II

Due 09/26/06

1. Consider a cylindrical vessel of inner radius R and wall thickness t with flat ends. The pressure inside the vessel is P_i and the surrounding pressure P_o. What is the relative error in estimating the maximum value of the stress intensity in the cylinder based on the thin shell approximation for values of:

$$t/R = 0.03$$
$$t/R = 0.10$$
$$t/R = 0.15$$
$$t/R = 0.30$$

Consider two cases:

$$P_i = 2P_o$$
$$P_i = 20P_o$$

2. A pressure vessel is constructed of a cylinder with a hemispherical head at each end. There is no external restraint to either axial or radial displacement. Inside radius of both cylinder and hemispheres is R. The wall thickness is uniform at a value t. The length of the cylinder is L. No flaws or stress concentrations are present. Dimensions are:

R = 110 cm
t= 11 cm
L = 433 cm

Material properties:

Young's modulus = 200 GPa
Poisson's ratio = 0.3
Coefficient of thermal expansion = 12 $\mu m/mK$

The vessel is pressurized to a design pressure P = 15.5 MPa.

Questions:

(a) What is the total (peak) stress as a function of radial position (z) at a junction between cylinder and hemisphere.

(b) What is the maximum radial displacement of the vessel cylinder and sphere?