Mech 306

Lab #5 Part A
Thin-Wall Pressure Vessels

Group 35

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Brief procedure:

1. Install the axial and circumferential strain gauges following the provided directions from http://www.vishaypg.com/docs/11127/11127B127.pdf. The specifics are omitted here due to this being a standard procedure.
2. Use a digital multimeter to test the connection and ensure that a short circuit has not been created by installing the strain gauges.
3. Balance the strain gauge channels after plugging them into the measurement device to eliminate the effect of internal pressure.
4. Stand the can upright on the table, and place weights on the top surface. Record strain measurements for varying weights up to approximately 20 kg and plot the results.

Measurements and Discussion:

Our results are summarized in the below table. The results were as expected with the axial strain being negative, signifying a compressive stress, and the circumferential strain being positive, signifying a tensile stress.

Table 1: Compressive Mass and Measured Strains

Mass Added (kg)	Weight (N)	Axial strain (ul)	Circumferential strain (ul)
0	0	0	0
3.158	30.97998	-26	10
3.156	61.94034	-56	21
3.149	92.83203	-86	31
3.155	123.78258	-118	41
3.142	154.6056	-149	51
3.155	185.55615	-181	60

Plotting the results from Table 1 resulted in Figures 1 and 2 below. The resulting graphs display a linear relationship as expected by the thin-walled pressure vessel relationships given in the lab document:

$$\varepsilon_\theta = \frac{\sigma_\theta}{E} - \frac{\nu\sigma_a}{E}$$

$$\varepsilon_a = \frac{\sigma_a}{E} - \frac{\nu\sigma_\theta}{E}$$

Here σ_θ is proportional to σ_a, and the axial load comes from the added weight. σ_θ changes because of the pressure change within the can, as described by the known relationship in thin-walled pressure vessels:

$$\sigma_a = \frac{pr}{2t}$$

$$\sigma_\theta = \frac{pr}{t}$$

This yields two linear relationships between applied stress and strain. The comparison to force would also be linear because stress is proportional to force divided by the constant area of the surface being observed.

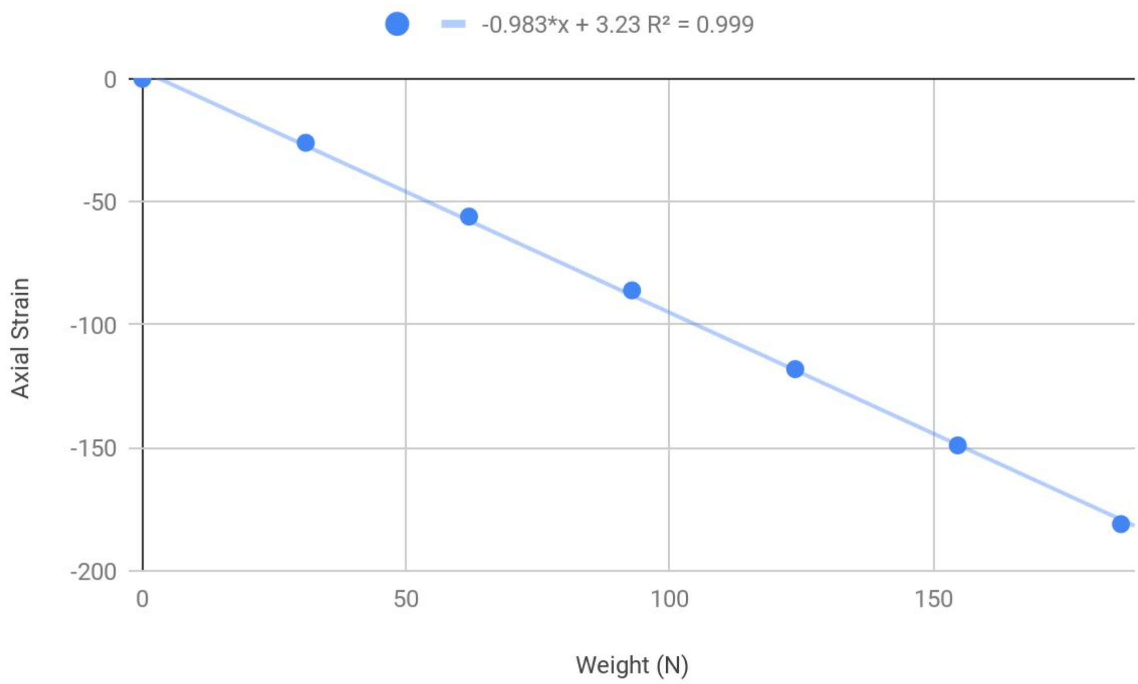

Figure 1: Compressive Mass vs Axial Strain

From the above figure, we see that the axial strain became a larger negative number as more axial load was applied to the can as expected.

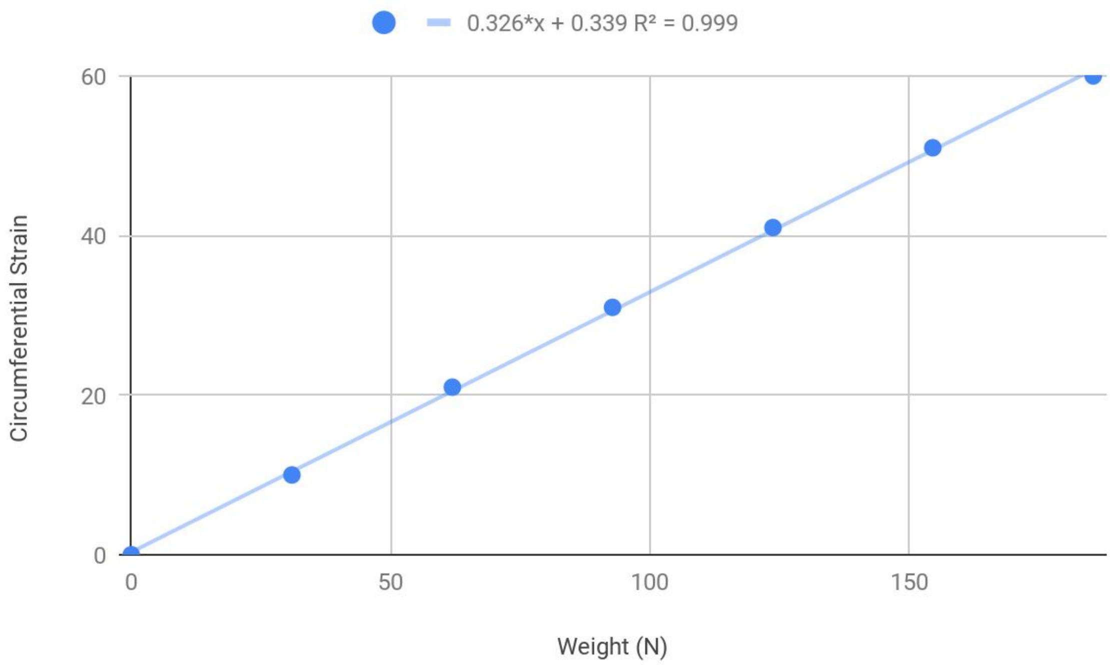

Figure 2: Compressive Mass vs Circumferential Strain

From the previously discussed equations, we expected that the circumferential strain would increase positively (representing a tensile load) due to the compressive axial component.

Although both graphs display minimal deviation from the linear trendlines, there is an aspect of error in the measurements that could be accounted for by the temperature fluctuations within the lab or electrical systems. This temperature difference could be eliminated in future testing by implementing one of the prelab techniques such as the quarter-bridge circuit with a dummy strain gauge, the half-bridge circuit, or the full bridge circuit.

Part B Procedure

For part B, we will first measure the effect of temperature on the can pressure. Then we will complete the initial objective, determining the air pressure in the can.

Temperature Variance

1. Place a strain gauge (calling this gauge the “control gauge” from now on) on an empty can (or even just a piece of aluminum). The strain on the control gauge can then be subtracted from the ones on the pressurized can for each of the trials; this removes the effect of temperature on the strain gauges.
2. Create an ice bath of sufficient size to submerge the can and the control gauge in.

3. Attach all strain gauge wires to the switch and balance unit, and seal the can and control gauge inside a plastic bag so they can be submerged in the water without damaging the electronics.
4. Place the can and control gauge in the water and wait until the system reaches a steady state (strain readings stabilize). Record the temperature and the strain gauge readings.
5. Apply some heat to the water system to change the temperature of the water. Repeat steps 2-3 for gradually increasing temperatures up to around 40C. Repeat for around ~10 trials (depending on how long each trial takes on how much time we have).

Can Pressure

1. With the can at room temperature, record the strain gauge readings.
2. Depressurize the can and record the strain gauge readings (do not empty the can).
3. Re-pressurize the can to the strain values in step 1.