Pressure Testing on an Integrated Thermal Structural Cryogenic Tank Fabricated by Friction Stir Welding

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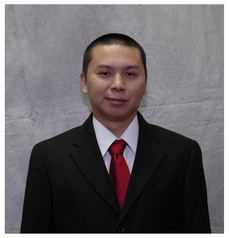


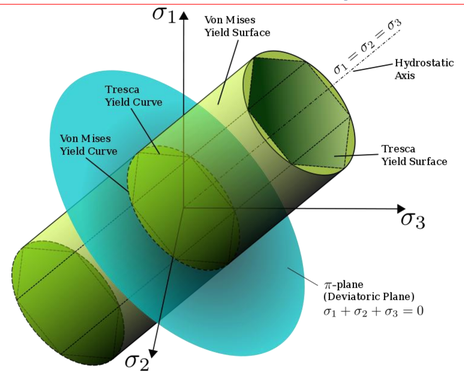
Objectives

Establish a working cryogenic test facility for running a series of temperature and pressure tests on a friction stir welded cryogenic tank. Mount a series of strain gauges and thermal couples on the cryogenic tank for collecting strain, pressure and temperature data. Conduct tests that can calculate the cryogenic tank walls heat flux and burst pressure.

Approach

The von Mises failure theory calculates that the burst pressure should be about 900 PSI. By using the thermal resistance model for a cylinder the heat flux is predicted to be 50 W/m2*K. These data modeling tools are only approximations.

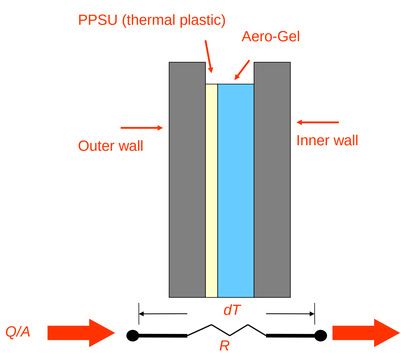
Von Mises Failure Theory



The von Mises yield surfaces in principal stress coordinates circumscribes a cylinder with radius $\sqrt{\frac{2}{3}}\sigma_y$ around the hydrostatic axis. Also shown is Tresca's hexagonal yield surface.

Picture from http://en.wikipedia.org/wiki/Von_Mises_yield_criterion

Thermal Resistance Model



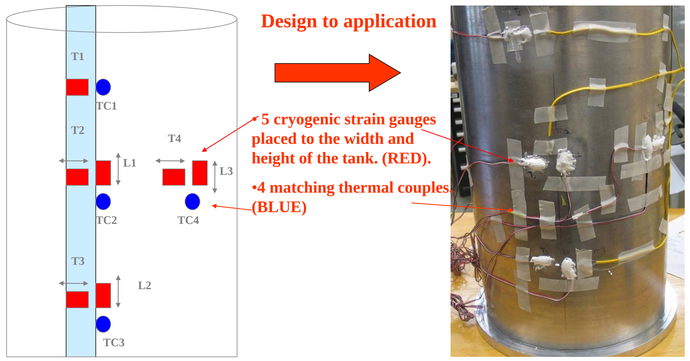
The thermal resistance is defined as the ratio of the temperature difference, dT, to the heat transfer Q. Ohm's law states that the electrical resistance is defined as the ratio of the voltage drop across a resistor to the current flow across the resistor. The insulation from the PPSU and the aero-gel acts as a resistor.

DV = I R or *R = DV/ I* (Ohm's Law)

DT = (Q/A) R or *R = DT / (Q/A)* (on a per unit area basis)

Where *(Q/A) is* the heat transfer.

Thermal Couple and Strain Gauge Layout



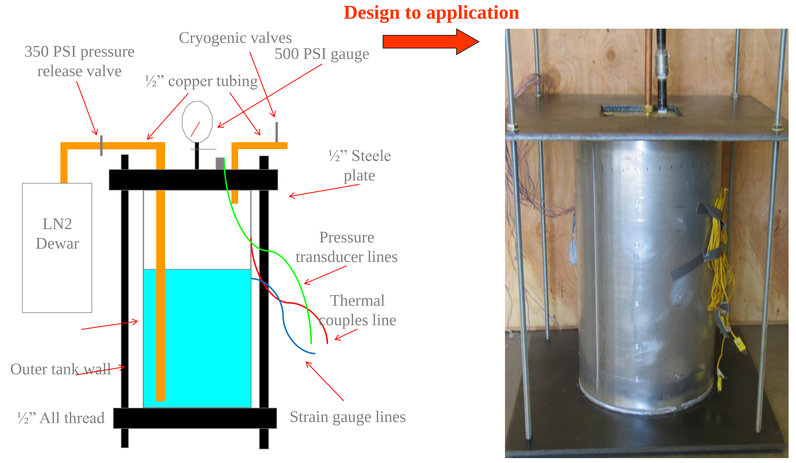
Hydrostatic burst Test

The hydrostatic burst test uses a pressure washer to pump water into the cryogenic tank until failure. While collecting the pressure and strain data to get the exact burst pressure of the cryogenic tank. A pressure transducer will be measuring the exact pressure inside the tank while testing.

Thermal Cycle Test

The thermal cycle test fills the cryogenic tank with liquid nitrogen and caps the structure off. This will cause pressure to build up over time from the boil off of the liquid nitrogen. Using the rate of pressure build up over time calculation can be obtained for predicting the heat flux. A pressure transducer will be monitoring the pressure inside the tank. Thermal couples and strain gauges mounted on the inner tank wall will collect thermal and strain data while testing.

Final Design for the Thermal Cycle and Hydrostatic Burst Tests



Progress

The project is in its final stages and testing should begin early next week. Starting with the thermal cycle test and ending with the hydrostatic burst test. All the cryogenic parts have arrived and have been successfully installed on the cryogenic tank. The thermal couples, strain gauges and pressure transducer have been linked up to the data acquisition system. All results will be reported the appropriated channels. An updated poster, report and presentation will be given in the upcoming school semester at a to be determined conference.

Future Work

- Hydrostatic Burst Test
- Thermal Cycle Test

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