CASE STUDY

Product Group: Vishay Foil Resistors

Thermal Pressure Measurement of Fluids

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Accurate and sensitive thermal pressure measurement of fluids

Industry/Application Area Thermal dynamics of fluids

Product Used: 1285G trimmer, S102C resistor (Vishay Foil Resistors)
SR-4 strain gage (Micro-Measurements)

The Challenge

Highly sensitive and accurate strain measurements are required for the stainless steel tube used in thermal pressure measurement of fluids. The strain measurement accuracy must be sufficient to detect differences between 0.002% to 0.02 %. But the initial strain or resistance of the strain gage is difficult to control due to the possible tension induced when bonding to the tube.

The Solution

The SR-4 strain gage was bonded to the steel tube and incorporated into a Wheatstone bridge consisting of S102C resistors and a 1285G trimmer. For the measurement process, initially the circuit is balanced by the trimmer, compensating for the initial strain or resistance of strain gage. During the test, the strain of the tube surface is monitored by the strain gage, through the output voltage from Wheatstone bridge.

The User Explains

The principles of thermal dynamics of fluids are very useful in industry, especially in processing and manufacturing. The thermal pressure coefficient, which is the temperature dependence of pressure, is an important parameter for fluids. In our project, a steel tube is filled with fluid and sealed, then placed in an oven for heating (Figure 1).

During heating, the pressure of the fluid inside the tube is increased. The strain gage that is bonded to the tube measures the strain on the tube. The strain on the tube has two components: expansion due to temperature, and expansion due to inside pressure. The latter will be extracted from the whole signal to monitor the pressure change inside. This part of the strain represents 0.002% to 0.02 % of the total, so highly sensitive and accurate strain measurements are necessary.

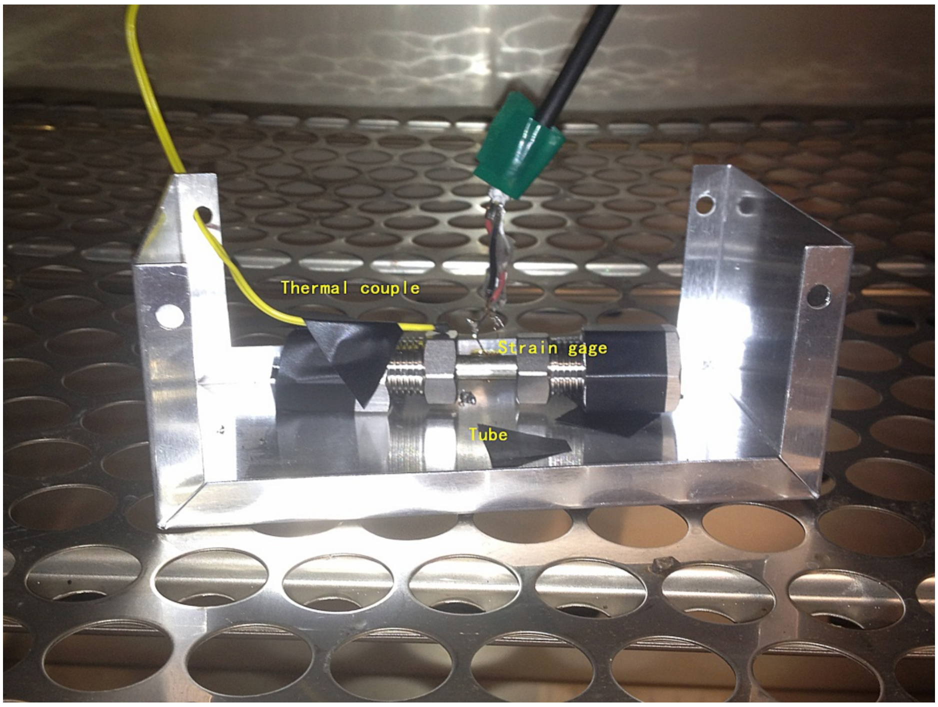

Figure 1 - Tube filled with fluids

The strain gage is connected with one arm of a Wheatstone bridge, and then connected to a lock-in amplifier to obtain the output voltage signal. In the beginning, the Wheatstone bridge is balanced to give a zero Uout. During the test, the strain is proportional to the resistance change of the strain gage, which can be obtained from Uout (see Equation 1). Comparing the strain change of an empty steel tube versus a tube with fluid under the same temperature, the pressure change of fluid inside can be obtained.

$$\varepsilon = \frac{\Delta R}{2R_0} = \frac{2U_{out}}{U_{ex}}$$

Our current problem is that bonding to the tube by adhesive is very likely to create a little tension on the strain gage, which means the initial strain of the gage is not zero. Due to the initial ΔR (around 0.6%), the Wheatstone bridge is not balanced. During the test, the strain-induced resistance change (below 0.02%) is much smaller than the initial ΔR, which lowers the accuracy of our method greatly.

Therefore, we choose to incorporate the 1285G trimmer and S102C resistors from VPG into our Wheatstone bridge. No matter what the strain or resistance of the strain gage is initially, the Wheatstone bridge can be always balanced by the 1285G trimmer. Then the resistance change during the test, and therefore the strain change of the empty steel tube versus the tube with fluid under the same temperature, can be obtained accurately (Figure 2). Finally, the pressure change of fluid inside the tube can be obtained, to give us the thermal pressure coefficient.

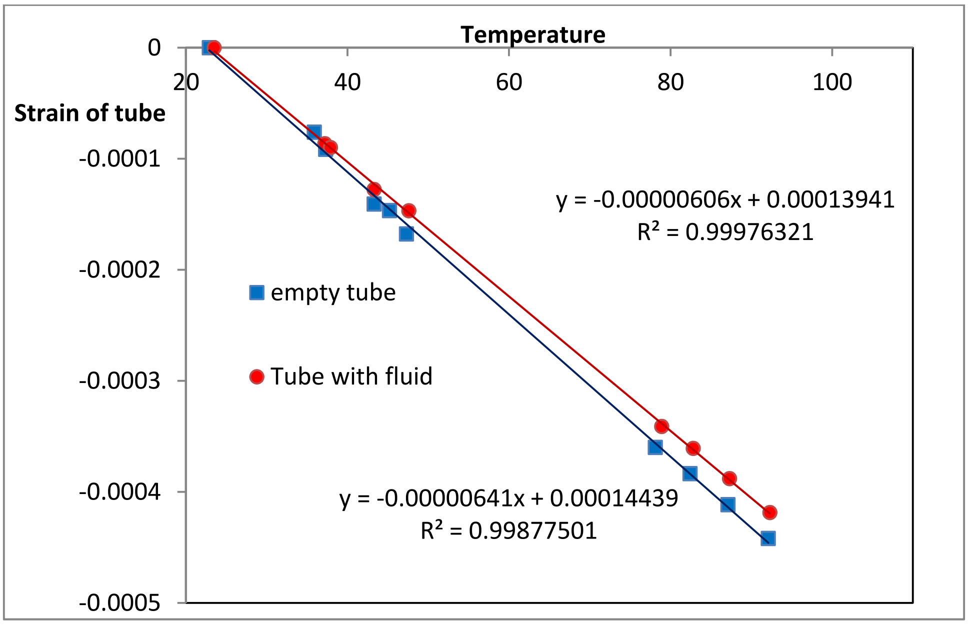

Figure 2 - Strain of tube vs. Temperature

In summary, the S102C resistors provide us good accuracy and stability, and the 1285G trimmer enables us to balance the Wheatstone bridge very accurately before each test, which in turn allows us to accurately measure the thermal pressure of fluids inside the steel tube.

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