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***Lab #6: Measurement of Strain***

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| **Course Number and Name:**  **ASE 269K Measurements and Instrumentation** | |
| **Semester and Year:**  **Fall 2013** | |
| **Name of Reporter:**  Zachary Tschirhart | **EID of Reporter:**  zst75 |
| **Unique Number and Meeting Time:**  13580 Monday 1-3pm | **Name of Lab Instructor**  **Shixuan Yang** |
| **Title of Experiment:**  Measurement of Strain | |
| **Date of Experiment Performed:**  October 14, 2013 | **Instructor Comments:** |
| **Date of Report Submitted:**  October 21, 2013 |
| **Names of Group Members:**  Dayle Chang |
| **Grade:** |

**ABSTRACT**

This lab was intended to introduce several concepts about Wheatstone bridges and strain measurements. By connecting the Wheatstone bridge in both a ½ and ¼ bridge configuration, it showed students the advantages and disadvantages of either method. The measurements recorded throughout the lab revealed that the ½ configuration was more accurate, whereas the ¼ configuration showed slightly less accurate measurements and drift. The strain measured was consistent and was the same magnitude as the theoretical value. When measuring the strain at different load distances from the end, the strain also decreased, which is expected and can show students the measurement results.

**OBJECTIVE AND INTRODUCTION**

The objective of this lab is to introduce students to Wheatstone bridges and strain gauge measurements. Students should learn the advantages and disadvantages of ¼ and ½ bridge configurations. Equipment used in the experiment was a Multimeter and DC power supply, Strain Gauge Bridge Circuit, Strain Indicator (Vishay Micro-Measurements Model 2100), Dell Computer w/NI DAQ and Virtual Bench, and a Instron Model 3367 load frame and load cell.

**THEORY AND EXPERIMENTAL METHODS**

Strain from gauge factor:

(1)

Where ∆R is the change in strain gauge resistance, R is the unstrained resistance, and G is the gauge factor.

Theoretical strain of cantilever beam with load at the end:

(2)

Where M is the resisting moment of the section, y is the normal bending stress at a distance from the neutral surface, I is the moment of inertia of the cantilever beam, and E is the Young’s modulus of the beam.

**RESULTS AND DISCUSSION**

**Section 1: Fundamentals o fthe Wheatstone Bridge Circuit and its Application in Strain Measurement**

**1.2**

Question 1 – “Make physical measurements of the beam and loading weight

Beam Length: 10.563 in. from the tip to the sensor, 12.75 in. from the tip to the clamp.

Beam Width: 1 in.

Beam Thickness: 0.125 in.

Material: Aluminum

Load weight: 1.86 lb.

**1.3**

Question 1 – “Sketch a bridge circuit in which the two gauges can be used to measure the strain in the beam when it is loaded as a cantilever beam.”

**1.4**

Question – “Measure and record the resistance of each of the gauges.”

Initial Gauge #1 (top) – 120.52 Ω

Initial Gauge #2 (bottom) – 120.88 Ω

Loaded Gauge #1 (top) – 120.64 Ω

Loaded Gauge #2 (bottom) – 120.65 Ω

Using equation 1 and the fact that a typical thick film resistor has a gauge factor of 100, the following microstrain values were calculated:

Gauge #1 (top) – 9.956 με

Gauge #2 (bottom) – 0.190 με

**1.5**

Question 1 – “What is the input and output resistances of the ½ bridge?”

Input resistance – 120.28 Ω

Output resistance – 120.29 Ω

**1.7**

Question 1 – “Does it drift to zero?”

No, this should not drift since the resistance or capacitance in the circuit isn’t changing.

Question 2 – “With your hand, deflect the end of the beam about one inch. What change in the bridge output does this cause?”

The output was about 12 V when deflecting the beam in the downward direction.

Question 3 – “Deflect the beam approximately the same amount in the opposite direction. How does this change?”

The output was about -12 V when deflecting in the beam in the upward direction.

Question 4 – “When you allow the beam to return to its original position, does the output of the bridge return to zero? Why or why not?

The output does not return to zero, which can be from several reasons. The major cause of not returning to zero is the fact the beam could be slightly deformed or the sensors are slightly stretched from the glue not returning to the original formation.

Question 5 – “Hand the weight and record the output voltage.”

The output voltage was 8.27 mV at 1.86 lb.

**1.8**

Question 1 – “Create a 1/4-bridge circuit… re-balance the bridge. Hang the weight on the beam again and read the output voltage”

The output voltage was 4.37 mV at 1.86 lb.

**1.9**

Question 1 – “Hold your hand on the active gauge to warm it up. What happens? Why?”

The resistance increases and voltage decreases. This happens because heat increases the resistance in the sensor/resistor. The other explanation is that the material could have increased in length because of the heat.

**Section 2: Use of the Vishay Micro-Measurements 2100 Strain Gauge Conditioner and Amplifier System**

**2.5**

Calibration:

1/2-bridge:

Position A – 0.76 V

Position B – -0.69 V

1/4-bridge:

Position A – 0.42 V

Position B – -0.40 V

**2.6**

Question 1 – “Apply a known load at the tip of the cantilever and measure the output of the strain.”

These calculations were taken in the next section

**Section 3: Measurement of Strain in a Cantilever Beam**

**3.1**

Question 1 – “Record the strain before, during, and after attaching a load to the beam”

Using the calibration values, the following strain values were found:

1/2 - bridge arrangement:

Initial reading – 0.000 με

1.86 lb. load – 8.316 με

Unloaded – -.263 με

1/4 - bridge arrangement:

Initial reading – 0.000 με

1.86 lb. load – 7.691 με

Unloaded – -0.048 με

Question 2 – “Is your measured value of strain consistent with the direct resistance measurement made in Section 1.4?”

Yes, these measurements are similar, but not quite the same as the values in section 1.4.

**3.2**

Question – “With the gauges on the beam still connected in a ½-bridge arrangement, apply the load at the ¼ and ½ the length from the tip of the cantilever beam, and record the strain.

1/2 of the length:

Initial reading – 0.000 με

1.86 lb. load – 5.894 με

Unloaded – 0.000 με

1/4 of the length:

Initial reading – 0.000 με

1.86 lb. load – 3.394 με

Unloaded – -0.026 με

Homework Question 1 – “Sketch the half-bridge Wheatstone bridge circuit”

This was done in Section 1.3

Homework Question 2 – “Calculate the expected strain from the beam bending tests and compare it to the strain measured in 3.1. Briefly explain any discrepancies.”

Using equation 2, the expected strain using the values E = 10x106 psi, I = 0.002 in4, y = 1.87 in., and M = 0.061 slugs-in2 was found to be 5.732 με. The discrepancy could have come from several places including calibration error, beam material non-uniformity, sensor non-linearity, and more than likely human measurement error.

Homework Question 3 – “Explain the differences from the ¼ and ½ bridge. What can you infer from your findings?”

The advantages to using a 1/4-bridge is that only one strain gauge is needed, but the disadvantage is that accuracy is affected. There is also drift that occurs when trying to take the measurement because of the large resistance changes in the system. The 1/2-bridge needs 2 strain gauges, but the output values are more stable and do not drift nearly as much as the 1/4-bridge. Inferring from these findings, if possible use two gauges and set the system up in a ½ bridge configuration to get rid of drift and some inaccuracies.

Homework Question 4 – “Compare the direct gauge reading, the box constructions and the Vishay 21000.”

The direct gauge reading had a strain calculated to be 9.956 με; the box construction and the Vishay 2100 had a strain value of 8.316 με. If the theoretical value is lower than all of these, it would seem that the Vishay 2100 had the best closest to theoretical results.

**CONCLUSIONS**

In conclusion, this lab showed several concepts about Wheatstone bridges and strain measurements using different techniques to get measurements. Hooking the Wheatstone bridge in both a ½ and ¼ bridge configuration showed students the advantages and disadvantages of either method, mainly dealing with inaccurate measurements and drift from the ¼ configuration. The strain measured was consistent and was the same magnitude as the theoretical value.

**BIBLIOGRAPHY**

RAVI-CHANDAR, Krishnaswamy. *Lab #6: Measurements of strain*. Rep. no. 1. N.p.: n.p., n.d. Print.