Lab 5 - Strain Gages

Report
An individual, short report is due at 8:00 AM on the Thursday of the next week of classes after you complete this lab. Answer all of the questions and provide any calculations or plots requested in the handout.

Procedures
Strain Gage Installation and Testing
Each laboratory group will install the same number of gages on a beam as there are members of the laboratory group. Each student must install and wire at least one gage correctly!

For the case of two-person groups, the two gages will be installed in “mirror” locations on opposite sides of the beam and used in a half-bridge circuit. For three-person groups, the first two gages will be installed and implemented as just described. The third gage will be installed in a separate location on the same beam and used in a quarter-bridge circuit.

Refer to the Student Manual for Strain Gage Technology handout for installation instructions. The process for installing the two “mirror” gages and testing the cantilever beam is described below.

1. Measure and record the beam dimensions using the calipers and micrometer provided at each lab bench. Since the beam is not completely uniform, measure width and thickness at a minimum of at least 10 locations. These values will be used in your uncertainty calculations for the expected outputs. You will use this data to calculate the average width and thickness of the beam and to assign an uncertainty to those measurements.

2. Record the resistance and expected gage factor (and its uncertainty!) of the strain gages.

3. Install both gages on the beam so that the long axes of the gages correspond to the long axis of the beam. These gages are to be placed on opposite sides of the beam (at the same longitudinal location) such that one will be under tension and the other in compression during loading of the beam. In effect, the two gages should “mirror” each other if you were to slice the beam through its neutral axis.

4. Solder the stranded lead wires to the gages, and tape the leads to the beam to minimize the chance of pulling the wires from the gages. Measure the resistance of the gages after soldering to verify proper installation.
   - If you measure an open circuit, one of the solder connections is loose or detached.
   - If you measure a very low resistance (fraction of an ohm), then you have a short circuit. Check to see if your solder has bubbled from one tab to the other on the gage.

5. Connect the strain gages to adjacent legs in a half-bridge arrangement, as shown in Figure L5-1. Use 348Ω resistors for the other two legs of the bridge. Use a power
supply \( (V_{in}) \) of +12 volts DC. Do not use +/- 12 V, only 12 V. As shown in the figure, use a 10kΩ to 100kΩ potentiometer across the bridge from top to bottom to "zero" the output of your bridge with no load.

At this point, if you are in a three-person lab group, install your third gage at some other location along the length of the beam. The installation should be as described above, but you will implement this single gage in a quarter-bridge circuit. That circuit is very similar to the circuit shown above in Figure L5-1; see your notes for the differences. From this point on through the lab, any voltage measurements that you make for the half-bridge circuit should also be made for the quarter-bridge circuit.

6. Mount the beam on the stand provided. Measure the cantilevered length of the beam and the longitudinal location of the strain gages using a tape measure.

7. Measure and record the bridge input voltage \( V_{in} \). It is also a good idea to measure \( V_{in} \) periodically throughout the experiment to determine if supply voltage drift has occurred.

8. Load the beam using the weights provided by the lab instructor.

9. Record each weight and the corresponding bridge output voltage \( V_{out} \) for each beam load. Use the millivolt (mV) setting on the DMM to get accurate readings.

10. Repeat steps 8-9 at least one more time, with different students applying loads and recording the data (note that good engineering practice requires at least 10 repeated measurements).

11. Remove the threaded rod from the end of the beam and use the wire/washer combination provided by the lab instructor. Repeat steps 8-9 two more times with the same weights used earlier.

* Note that this figure assumes two things. First, that one strain gage is under compression and the second is under tension. Hence, \( R - \Delta R \) and \( R + \Delta R \). Secondly, it assumes that the two gages are identical in that the shift in resistance of one, \( +\Delta R \), is equal to the shift of the other, \( -\Delta R \). Does physical alignment have anything to do with this?
Outside Lab:
1. For each load, calculate the maximum bending stress and the bending stress at the strain gages and compare those values to the typical yield strength values for aluminum.
2. For each measured value of $V_{out}$, calculate an expected load value using the appropriate stress/strain formulas, the measured dimensions of the beam, and the half-bridge equation.
3. Plot the expected (calculated) load vs. the actual applied load (measured from the digital scales) for the two different loading cases (threaded rod and wire/washer).
4. Compare your plots with an ideal straight line, where the expected/calculated load equals the actual applied load and discuss any discrepancies. Note the assumptions involved in the stress/strain formulas.
5. Determine the uncertainties in your measurements and include uncertainty ("error") bars on all relevant plots.
6. Discuss the meaning of the expected, calculated values (Step 5 above) overlapping the uncertainty error bars.