Strain Gauges

1. **OBJECTIVES:**

This experiment includes techniques for installing and using foil strain gages. Gages will be used to measure the strains on a soda can to calculate its internal pressure, and measure the strains on a cantilever beam to calculating Poisson's ratio and Young’s modulus for the material.

2. **EQUIPMENT:**

![Strain Gauge Application Kit](image1)

![Strain Indicator Box](image2)

![Strain Gauge](image3)

![3 Conductor Lead Wire](image4)

![Beam specimen](image5)

![Micrometer Head](image6)

![Soda can](image7)

![Cantilever beam](image8)
EMCH 361 Lab 3 Measurements and Instrumentation

- Strain gage application kit
- Practice strain gage (week 1)
- 2 strain gages (week 2)
- Soda can or sample beam (week 2)
- Lead wire (3 conductor)
- 2 Strain indicator boxes (P-3500)
- 3 Conductor Lead Wire
- Weight set
- Soldering iron

3. INTRODUCTION:

Strain gages are used for measuring strain ($\varepsilon$) on a flat surface. Stress ($\sigma$) can be calculated knowing the constitutive equations, which relate stress and strain. For this lab, materials will assumed to fall into the linear elastic region, using Young's Modulus to relate stress and strain

$$\sigma = E \cdot \varepsilon$$  

(1)

This lab uses pairs of strain gages, applied perpendicular to each other. Strain has an effect on both directions, so this relationship is defined in Hooke's Law. Strain gages are limited to planar use, so the 2D version of Hooke’s Law [2] is used.

$$\varepsilon_x = \frac{\sigma_x}{E} - \nu \frac{\sigma_y}{E}$$  

(2)

Where $\nu$ is the Poisson's ratio, a material constant.

Strain is reflected as a change in the resistance of the gage. Using a Wheatstone Bridge circuit, the strains can be measured. From the strains and material properties, the stresses can then be determined.

4. PROCEDURE:

4.1 Practice gage installation

1. Watch the demonstration of strain gage mounting and soldering techniques.
2. Mount the practice gage to an aluminum base and solder the lead wires. Use the volt-ohmmeter to verify the continuity of the solder joints and look for any short circuits. Lead wires only need to be a couple of inches long since no measurements can be made from the gages.
3. Decide as a group which experiment will be performed; the cantilever beam or soda can.

4.2 Soda can experiment:

1. Mount 2 strain gages on the soda can. They need to be as close as possible to the center of the can. One will take the longitudinal strain and the other measures hoop or circumferential strain.
2. Solder leads to each gage about 2 feet long. Use the VOM to check for continuity and short circuits.
3. Connect the leads to two of the strain indicators and set the controls for the measurement. Zero the indicator box. Open the can. There should now be strain readings on both boxes to use in calculating the internal pressure of the can.
4. Take the dimensional measurements that will be required for the pressure calculations.
4.3 Cantilever beam experiment:

1. Mount 2 strain gages on the beam. They must be centered about the longitudinal position on the beam, one in the longitudinal direction and the other one in the transverse direction. This can be done mounting them side-by-side or using the top and bottom of the beam.

2. Solder leads to each gage about 2½ feet long. Use the VOM to check for continuity and short circuits.

3. Connect the leads to 2 of the strain gage indicator boxes and set the controls for the measurement. Zero the indicator box. Measure the strain from each gage as weight is added to the beam. Take at least three readings in increasing weight, then at least three as the weight is removed.

4. Take the dimensional measurements necessary to complete the beam calculation.

5. REPORT REQUIREMENTS:

5.1 Theory

1. Explain how the equations for your experiment were determined. This can be based on the derivations done in class. Include explanations of all equations and variables (bending stress, moment of inertia, Young’s modulus). What assumptions must be made to use the equations from class for this experiment?

2. Explain the operation of a Wheatstone Bridge. Include the equation for output as a function of excitation voltage and strain for the type of bridge used in this experiment.

5.2 Miscellaneous

1. In the apparatus section, the installation equipment can be listed as an installation kit. A list of the contents (without unnecessary detail) can be put in a table.

2. The procedure only needs to cover the second part of the lab.

3. When giving the procedure for strain gage installation, give a brief summary and a reference to the strain gage application book. In the summary, just mention the steps; e.g. surface abrasion instead of the details of sanding.

5.3 Results and Analysis

1. For the soda can experiment, calculate the internal pressure of the can using the result of each strain gage (use the equations for thin-walled pressure vessels). Compare the results and explain any difference. Was the strain on the indicator positive or negative? Why? State if the internal pressure you calculated make sens.

2. For the soda can experiment, list the values used for aluminum properties and give a reference to the source.

3. For the beam experiment, give calculated values of the modulus of elasticity and Poisson’s ratio. Find a reference to a similar material and compare the results.

4. Discuss the validity of the assumptions used in deriving the equations, using results and measurements to support any arguments.

5. For the beam experiment, there should be a linear relationship between load and output (strain). Quantify how well your data followed this pattern. Include linearity, precision, and hysteresis in the discussion. Plot the hysteresis curves for loading and unloading for both strain gauges.