Tension and Bending Test (Report #2)

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Group 2, Lab #4, Wednesday, 2-2:50 pm
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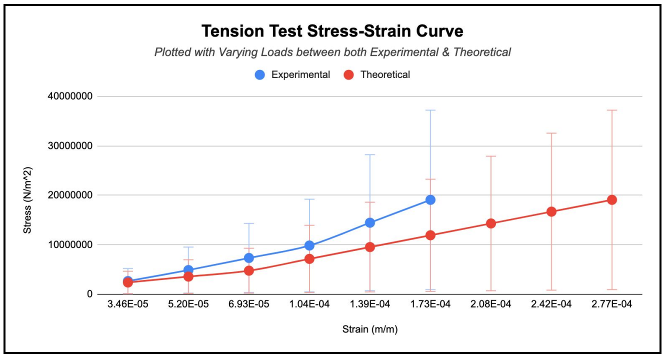
Introduction

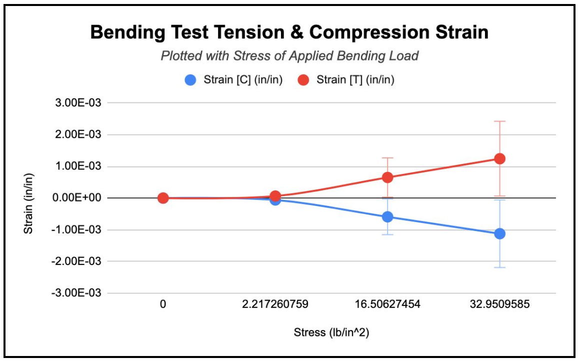
This lab was intended to experiment with Young's modulus, a material property that is different in value but constant in a given material. By carefully preparing a sample with strain gauges to sustain applied loadings via tension and bending tests, strain values were measured and recorded through the data acquisition (DAQ) system and the computer application LabView. The remainder of the report illustrates the experiment steps, graphs and calculations of the data collected, analyzation of the results, and discussions on what the expected results of various possible scenarios would be.

Methodology and Procedures

1. *Prepare the sample on each side:* Clean the sample with solvent for each step, then sand down the sample and use tweezers to etch the surface. A strain gauge is carefully aligned on the markings, and then a drop of glue and tape is used to ensure the gauge is still clean and unbroken. The strain gauge must be glued to the sample to enshure there is a strong bond with each other, so when the sample undergoes tension or compression, the strain gauge can accurately measure this deflection. As a result, the data collection error would be significantly low. After the glue has dried, separate, stripe, and tin the ends of two 12" long lead wires. Lastly, scratch the terminals on the strain gauge, and solder a wire to each terminal.
2. *Bending Test:* Set up the DAQ system by attaching a power supply adaptor, a USB cable, two RJ-50 cables, and two NI-9945 terminal blocks to the NI-9178. The USB is connected to a laptop running the LabView software, and the blocks are attached to the lead wires of the sample with a flat-bit screwdriver. Use a caliper to take measurements of the sample and weigh the caliper, two water bottles and S-hook. With, one end of the sample clamped to the corner of a table, measure the sample in various distances. Have both channels selected on the LabView GUI, and offset null, shunt calibration, and logging mode on before strain recording. A shunt calibration is a procedure that calibrates a Wheatstone bridge strain gauge circuit to reduce errors pertaining to electrical characteristics, specifically the resistance for this experiment. It also electrically simulates a full-scale load output so the data collected is accurately scaled. Null offset accounts for any errors/imbalances before resistance is measured between strain gauges. When there is no load, the output voltage must be zero for the system, and performed before shunt calibration. The value has to be zero since strain gauges are not always accurate and have the possibly faulty strain readings. Add a load to stabilize the signal, starting with the the S-hook (0.072lb), then the first water bottle (0.536lb), and lastly, the second bottle (0.534lb). Stop recording, and remove the loads and clamp. Save the TDMS file as a spreadsheet.
3. *Tension Test:* One end of the sample is freely attached to the hook in the tension device, and the loading is zeroed out. With a new file, begin recording strain at 0 Newtons (N). Waiting each time for the signal to stabilize, turn the crank clockwise to apply loadings at approximately 50 N intervals, from 0 to 400 N. Record each precise loading. Save the TDMS file as a spreadsheet.

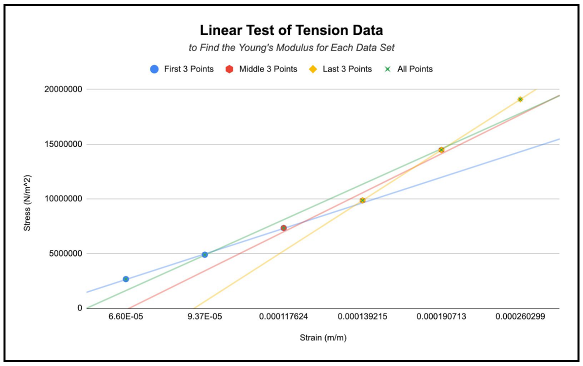
Results





Graph 1 (Left) The graph compares both the experimental and theoretical data of tensile stress on the Al-6061 bar. Theoretical loads increase by 50 N from 0-400 N, but experimental loads differed by small amounts. The experimental data follows closely to the theoretical but because of the varied loads, the trend increases at a faster rate.

Graph 2 (Right) The graph depicts that when the sample is modeled as a cantilever beam - one end is clamped down to the table while the other is hanging off the edge. When the weights are added, both tensile [T] and compressive [C] strain increase.



Graph 3 The data gathered from the tension test only accounted for 6 different loads instead of 9; therefore, the middle data overlaps with the first & last points. The Young's Modulus is calculated by taking the slope from each data set.

Equations:

Poisson's ratio (1) is the material property that results from the longitudinal strain from the tension and bending tests if it were fully bonded in a high strain region. Stress (2) applied to the aluminium sample denotes the force (either [T] or [C]) applied. Hooke's Law (3) defines the linear relationship between σ & ε within the elastic region in Al-6061. $E = 68.9$ GPa which is the theoretical value. Percent Error Formula (4)

$$(1)\quad v = -\frac{\varepsilon_{Lateral}}{\varepsilon_{Axial}} \qquad\qquad (2)\quad \sigma = \frac{F\ (Applied\ Load)}{A\ (Area\ of\ Cross\ Section)}$$

$$(3)\quad \sigma = E\varepsilon\ \ \&\ \ E_{Experimental} = \frac{\Delta\sigma}{\Delta\varepsilon} \qquad\qquad (4)\quad \%_{Error} = \frac{\left|\#_{Experimental} - \#_{Theoretical}\right|}{\#_{Theoretical}} \times 100\%$$

Calculations:

Cross-Sectional Area of Al sample where width (w): 1.66 mm & thickness (t): 12.62 mm

$$A = w(t) = (1.66 \times 10^{-3} m)(.01262 m) = 2.095 \times 10^{-5} m^2 \quad \textit{(Converted mm to m)}$$

Finding experimental stress from data of Tension & Bending tests using (2) w/ the area above & strain for each test was averaged over a 500 sample rate from the DAQ system at each loading.

Load (N)	**σ_T (N/m^2)**	**ε_T (m/m)**	**Load (lb)**	**σ_B (lb/in^2)**	**ε_T (in/in)**	**ε_C (in/in)**
56	2673031.026	.0000660213	0	0	.0000011918	-.00000158597
102.6	4897374.702	.0000937471	.072	2.217260759	.0000640251	-.000059577
153.8	7341288.783	.000117624	.536	16.50627454	.000650507	-.000591261
206.6	9861575.179	.000139215	1.07	32.9509585	.00124188	-.001122741
303.2	14472553.7	.000190713				
400	19093078.76	.000260299				

The Theoretical Values can be found using (2) to find σ and (3) to find ε with exact loads from the Tension test with the approximate forces specified in caption of Graph 1 . Finding the Young's Modulus of the sample using (3) & the experimental tension test data. Finding the % Error using (4) between the theoretical & experimental Young's modulus it can be seen that the last 3 points from the tension test have the smallest percent error.

Discussion

Additional changes to the resistance in the strain gauge will arise due to changes in temperature. However, using the setup described above, any of these changes will be negligible due to relatively steady temperature. With two strain gauges attached on each side and rotating the sample 90 degrees along the longitudinal axis and applying a point load, a smaller strain is expected. Since the sample is rotated such that its thinnest dimension is oriented vertically, the applied force will generate less stress. A horizontal orientation, the default orientation for this lab , produces a larger stress because the distance between the side of the material and the neutral axis is small. Conversely, the vertical orientation results in a larger distance and, therefore, a reduced normal stress. Because stress and strain are proportional, the expected strain is smaller as well.

Conclusion

In order to most accurately measure the strain of the specimen, it is essential that each strain gauge be glued to its surface: ensuring that the gauge deformation matches the sample deformation. For a force applied normal to the gauge, the stress generated will result in a strain, as can be predicted by Young's modulus. By utilizing a 2 active gauge setup, a half bridge, this deformation will generate tension and compression in the top and bottom strain gauges (respectively). Thus, the net change in resistance, across both resistors, will be zero. Using only the last 3 data points produces the smallest percent error, because the data points occur in the steady state region of the graph. Deformation is inherently continuous; it takes time to settle.