# Tensile Test

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**In this experiment we tested the tensile strength of two different aluminum samples in a tensile force machine. One sample was brittle while the other was ductile. The purpose of this lab was to analyze the properties of brittle versus ductile materials and identify the type of aluminum alloy that each piece represented. For the brittle material, the two possible materials were Aluminum MIC 6 and Aluminum 711.0-T1. For the ductile material, the two possibilities were Aluminum 6061-T6 and Aluminum 3003. From plain observations the brittle material can be categorized, because crack propagation and necking occurs in ductile materials, while in brittle materials snap without showing signs of strain occurs. After testing we chose the brittle material to be Aluminum MIC 6 and the ductile Aluminum 6061-T6 each with an elastic modulus of 2.022e+08 Pa and 8.208e+07 Pa respectively.**

## Nomenclature

E= Elastic Modulus [MPa] , $A_0$ = Initial Area [m^2], $\sigma$ = Normal Stress [MPa]
P= Tensile load [N], $\varepsilon$ = Normal Strain [mm/mm], $L_0$ = Initial Length [m]

## I. Introduction

Deciding what material to use, as well as its strength, is one of the most fundamental problems engineers face during the design process. The most common test used to determine a materials strength is the tensile test. Through this test, data is collected producing a load-versus-elongation curve which can then be translated into a stress-versus-strain curve, which provides basic information about the material. This information includes period of elastic deformation, period of plastic deformation, Young's Modulus, Yield Strength, Tensile Strength, and point of failure. Knowing this information allows engineers to compare various materials and determine which one fits their exact design criteria. During this lab, two types of materials, one brittle and one ductile, were tested through the tensile test. This test was performed using an Instron machine in conjunction with an Extensometer and was run until the test material failed (fractured). From this test, it was possible to determine which sample was ductile and which was brittle because brittle materials have the ability sustain a lot of force, but for a shorter period of time and they show no warning signs of when they are about to fail; on the other hand, ductile materials cannot sustain as much force, but can endure it for a longer period of time and show signs of failure or yielding.

## II. Experimental Apparatus/ Procedure

This experiment was conducted using an Extensometer in addition to an Instron machine. To conduct the experiment, multiple steps had to be executed. First, the material sample, which was dog bone shaped to ensure fracture happened in the narrow area, was gathered and placed in the Instron Machine. Placing it in the machine involved lining up the edges of the sample and the edges of the clamps, and then tightening the top and bottom clamps onto the material. After this, the Extensometer was fitted to the center of the sample in order to provide highly accurate elongation data. The Instron machine was then extended slightly to take out any play in the grips,

[redacted]

ensuring the collected data was accurate, and then the computer data was zeroed. From this point the Instron machine was measured based off of extension data instead of force until the sample experienced failure. For a more detailed procedure, see the Tensile Procedure document on Canvas under the course files[1].

## III. Analytical Procedure

In order to calculate the ultimate tensile strength, as well as yield strength the strain and stress had to be found for each of the metal dog bones. The extensometer measures elongation, thus, this value has to be changed in terms of strain. This can be done by taking the difference between the final length and the initial length of the material over the original unloaded length (Equation 1). We are assuming the material's nominal stress area to be a rectangular shape of 0.0127m by 0.0038 m**,** which helps us find the stress the material experiences until fracture (Equation 2). All of this can be accomplished using Matlab, because the load data as well as the length can be made into an input array and be manipulated to make the various mathematical calculations to find the material properties (equations 1-3). Furthermore, the elastic modulus of the materials can be found by dividing the stress by strain, the ultimate tensile strength is the maximum point on the strain/stress curve (in the brittle material it is also the facture point), the yield strength is where the elastic region of the material (constant linear region) is moved by 0.002 or 0.2% of the strain, therefore, where this new line intersects the experimental data curve is the yield strength point of the material.

$$\varepsilon = \frac{l-l_0}{l_0} \quad (1) \qquad \sigma = \frac{F}{A_0} \quad (2) \qquad E = \frac{\sigma}{\varepsilon} \quad (3)$$

## IV. Results

### A. Sample 1 Data Sam and Abdulla

| **Measurement** | **Casted/Brittle Data** | **Reference Data (Al MIC 6)** | **Error** | **Extruded Data** | **Reference Data (Al 6061-T6)[4]** | **Error** |
|---|---|---|---|---|---|---|
| Elastic Modulus | 2.022e+08Pa | 71,000 MPa | 99.71% | 8.208e+07 Pa | 6894.75729 MPa | 98.81% |
| Ultimate Tensile Strength (MPa) | 155.34 | 166 | 6.42% | 299.31 | 310.26408 | 3.53% |
| Yield Strength (MPa) | 96.169 | 105 | 8.41% | 267.72 | 275.79029 | 2.92% |
| Fracture Stress (MPa) | 155.34 | | | 204.9 | | |

**Table 3** - Sam and Abdulla Data

### B. Sample 2 Data Gera and Raymie

| **Measurement** | **Casted Data** | **Reference (Al MIC 6)** | **Error** | **Extruded Data** | **Reference Data (Al 6061-T6)[4]** | **Error** |
|---|---|---|---|---|---|---|
| Elastic Modulus | 2.072e+08 PA | 71,000 MPa | 99.71% | 8.324e+07 Pa | 6894.75729 MPa | 98.79% |
| Ultimate Tensile Strength (MPa) | 156.14 | 166 | 5.93% | 300.02 | 310.26408 | 3.30% |
| Yield Strength (MPa) | 94.056 | 105 | 10.42% | 267.72 | 275.79029 | 2.92% |
| Fracture Stress (MPa) | 156.14 | | | 293.59 | | |

**Table 4 -** Gera and Raymie Data

### C. Sample Data Graphs

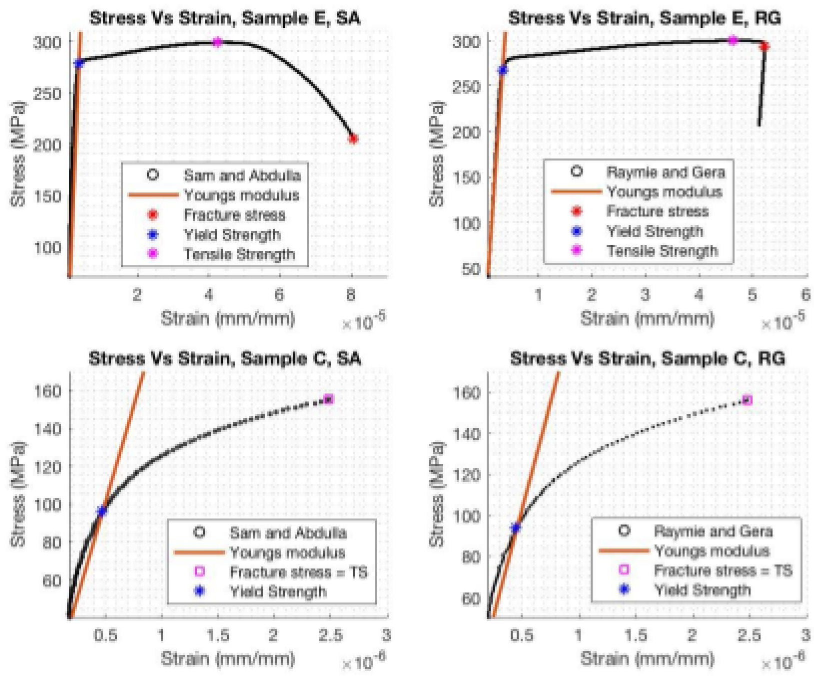



Figure 1. Stress v Strain Curve 2 Samples

### V. Discussion

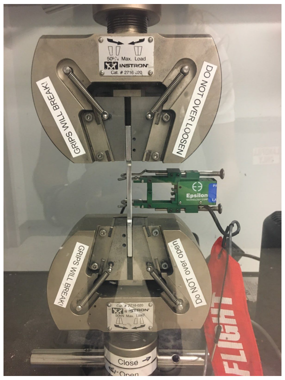
Both data sets had erroneous data at the beginning of the set this is due to the clamps still adjusting (slipping). Since the erroneous data is at the start of the data set, the tests for the material don't start perfectly at zero elongation and zero load, therefore, the total change in this error data has to be subtracted from the correct data values
this way it is truncated and properly zeroed (note the nominal stress and strain for the two tests are on table 1 and 2 above). From the calculations above, as well as, the graphs created from the sample data, the material we are using can be determined by finding which one closely matches the material properties from the reference values. The elastic modulus is a property, therefore, there are no two specimens with the same elastic modulus but they can be close since it is the same ductile or brittle material property- this is due to defects on the structure of the material. The elastic modulus between the sample data and the reference has a large difference (98.79% difference) however the primary qualities of the material such as tensile strength and yield strength are very similar (5.93% error). The large difference in the Young's modulus may be due to error in manufacturing as well as human errors in data collection. The system had been used multiple times before we got out data, thus, this may have a large influence in the young's modulus discrepancy but not really on the fundamental value of the material (tensile strength and yield strength). Not only were there errors in the machine/ data collection but each material is exposed to change in temperature, humidity, slipping, and not consistent manufacturing which creates defects on the material; these extraneous circumstances make the data not perfectly match the theoretical values. Nonetheless the casted material is going to have a higher fracture stress value compared to the extruded since little yielding occurs; indicating which sample/dog bone is the brittle and which one is the ductile. In the appendix section you will be able to see the necking that happened to the extruded material as well as the snap of the casted where you can put the two halves together with minimal surface deformation.

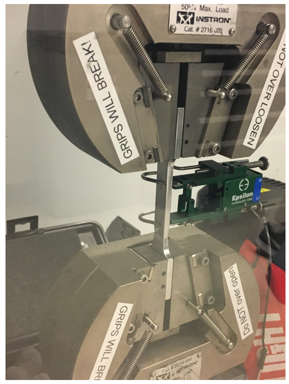
### VI. Conclusion

Overall this was great lab to really be exposed to the scientific process as well as put to test the theory we have been learning in the classroom. The ductile material matched the Aluminum 6061-T6 reference data and the brittle material matched Aluminum Mic 6 in regards to the ultimate tensile strength as well as yield strength of each material. Although both are aluminums their material properties or characteristics are different because it is stronger with more yielding strength than the other. In the future it would be helpful to have only two tests at a time since we were the last group using the lab equipment and out data originally was not completely inaccurate, furthermore, it would be helpful to have the experimental procedure in a more condense manner in order for groups to go through the process faster and easier.

## VIII. Appendix

**Sample Pictures:**




Brittle material snaps without of necking like the extruded sample.

Necking can be seen on the left (ductile/extruded) sample) and fast fracture can be seen on the right (brittle/casted sample)

## VII. References

[1] "Lab Procedure." *ASEN1022_LabDescription_Summer18* . Jellife Jackson, . Web. 22 June. 2018.

[3] Shackelford, James F. *Introduction to Materials Science for Engineers*. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2009. Print.

[4] "ASM Material Data Sheet." *ASM Material Data Sheet*. ASM Aerospace Specification Metals Inc., 2018. Web. http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=ma6061t621 June. 2018.

[5] "Aluminum 711.0-T1, Permanent Mold Cast." *Aluminum 711.0-T1, Permanent Mold Cast*. MatWeb, 2018. Web.https://www.makeitfrom.com/material-properties/711.0-711.0-T1-ZC60A-A07110-formerly-C712.0-Cast-Aluminum 21 June. 2018.

[6] "Comparison Chart." *Microprocessors* 1.7 (1977): 434-39. *Clintonaluminum*. Clintonaluminum, 2018. Web. https://www.upmet.com/sites/default/files/datasheets/mic-6.pdf 21 June. 2018.