Tensile Strength

ENGR45 – Materials Science Laboratory

Chad Philip Johnson

Submitted: May 15th 2013

Abstract

Stress versus strain diagrams serve to communicate a great amount of information regarding certain properties of a material, such as hardness, ductility, elasticity, and strength. These diagrams are produced by applying known amounts of stress to a sample and then measuring the resulting strain. From this graph of information important comparisons can be made between the different diagrams representing unique materials. In this experiment the procedure of procuring data through tensile strength tests was practiced to create stress versus strain diagrams for three metal samples: aluminum, stainless steel and cold finish 1040 steel.

Sample	Tensile Strength (Experimental)	Tensile Strength (Accepted)	Percent Difference
Aluminum	N/A	N/A	N/A
Stainless Steel	774 MPa	N/A	N/A
Cold Finish 1040 Steel	850 MPa	590 MPa	44.1%

Procedure

Each metal sample used in the experiment was a bolt having a diameter of 0.505″. These bolts are fashioned so that they can be securely loaded into a testing device where a linear stress is then applied which results in a measurable linear strain in the sample. For this experiment a Tinius Olsen brand tensile test machine was used to apply and measure force, from which the stress was calculated using the relationship:

$$\sigma = \frac{F}{A}$$

where *A* is the area of the cross-section of the bolt.

Before being loaded into the machine each sample was given a 2″ mark along the length of the bolt using an indenter. This was done so that a measurement of final strain could be performed on the sample by reassembling the broken bolt after fracture and measuring the final distance between the two marks. An extensometer capable of taking measurements to 1/10000″ was then carefully outfitted to the bolt so that changes in the length could be recorded along with the associated applied stress.

Measurements were taken until the material's tensile strength was reached: the point at which the applied force began to decrease due to necking in the sample. When this occurred the extensometer was removed to protect it from being damaged by the impending fracture. Both the tensile strength and ultimate tensile strength (force reading at fracture) were recorded for each sample. A picture of the tensile testing machine used in the testing of these samples is shown below in **Picture 1**.

Picture 1. Tinius Olsen brand tensile test machine.

The tensile strength of a material was found by using the aforementioned equation with the maximum force value divided by the original cross-sectional area of the bolt:

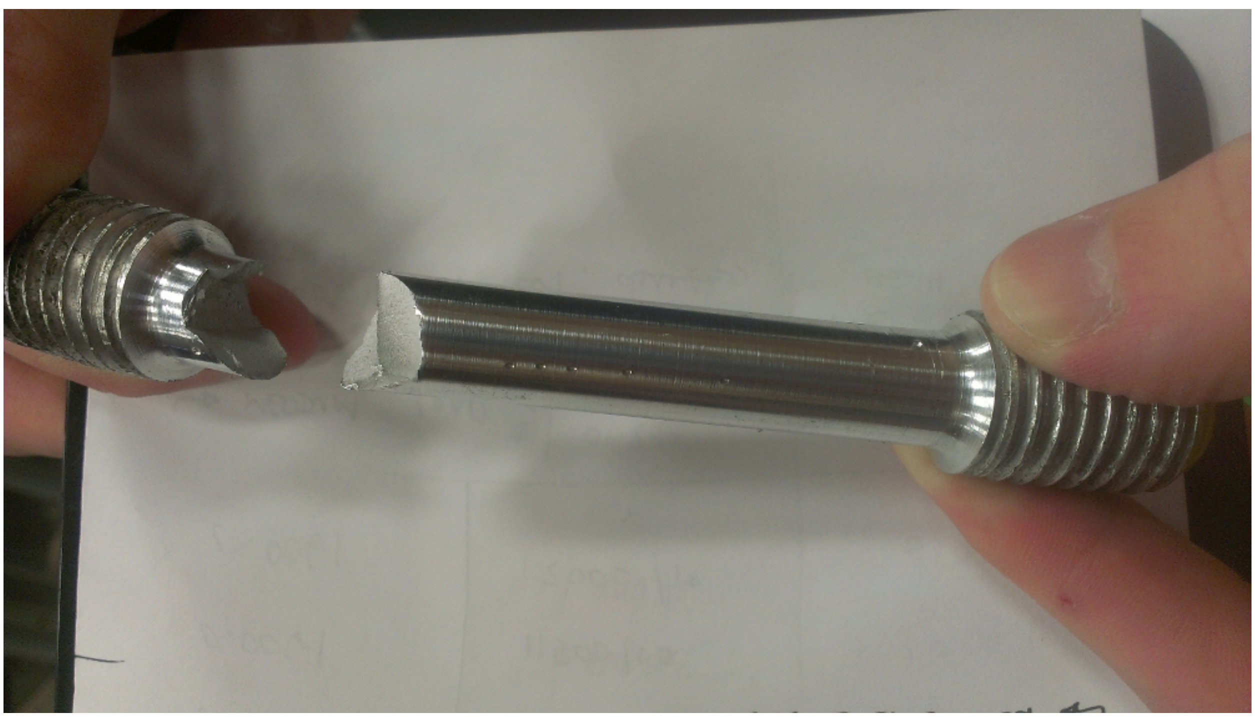
$$\sigma_{TS} = \frac{F_{max}}{A_{original}}$$

Similarly, the ultimate tensile strength of a material was found by dividing the final applied force by the final cross-sectional area of the bolt:

$$\sigma_{UTS} = \frac{F_{final}}{A_{final}}$$

Results

Measurements for the stress and strain of the aluminum bolt proved problematic. Measurements taken from the extensometer eventually stalled at a particular value even as additional stress was applied. The fracture occurred near the top region of the bolt, outside of the area where the extensometer was capable of taking readings (see **Picture 2**). This was unexpected, as the fracture point typically occurs within the center region of the bolt. In addition to this peculiarity, sudden fracture also occurred in the bolt, preventing a tensile strength and ultimate tensile strength to be measured. The data recorded for this portion of the experiment is represented in **Figure 1** and **Figure 2** located at the end of this report. The force applied to the bolt at fracture was 9.56×10^4N with the net change in length being 0.16" and the final diameter measuring 0.465".



Picture 2. Fracture of aluminum sample.

The experimental data for the Stainless Steel and Cold Finish 1040 Steel samples can be found in **Figure 3** and **Figure 4**, respectively. For the Stainless Steel sample the tensile strength was found to be 774 MPa and the approximate ultimate tensile strength value was 1.84 GPa. Unfortunately, the true identity of the Stainless Steel sample was not known and the experimental value for the tensile strength could not be compared to an accepted value. For the Cold Finish 1040 Steel sample the tensile strength was found to be 850 MPa, representing a percent difference of 44.1% from the accepted value of 590 MPa. A reading for the force applied at fracture for this sample was not recorded.

Conclusion

The experimental value for the tensile strength of Cold Finish 1040 Steel was the only successful measurement and this differed greatly from the accepted value. Overall, the results of this experiment should be discarded, as time limitations did not permit a more thorough experimental process. Instead, this experiment served as an appropriate introduction on how to operate the tensile testing machine. It is expected that future procedures will benefit from these initial tests and much more accurate values for the tested materials will be produced.

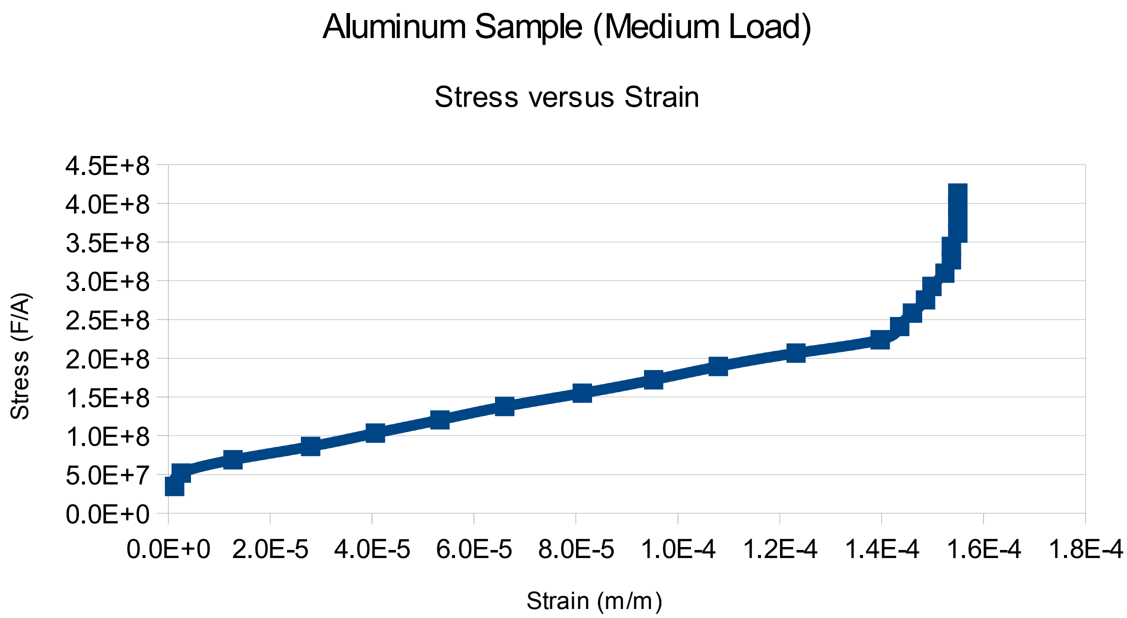


Figure 1. Stress versus strain diagram for aluminum sample with machine set at medium load.

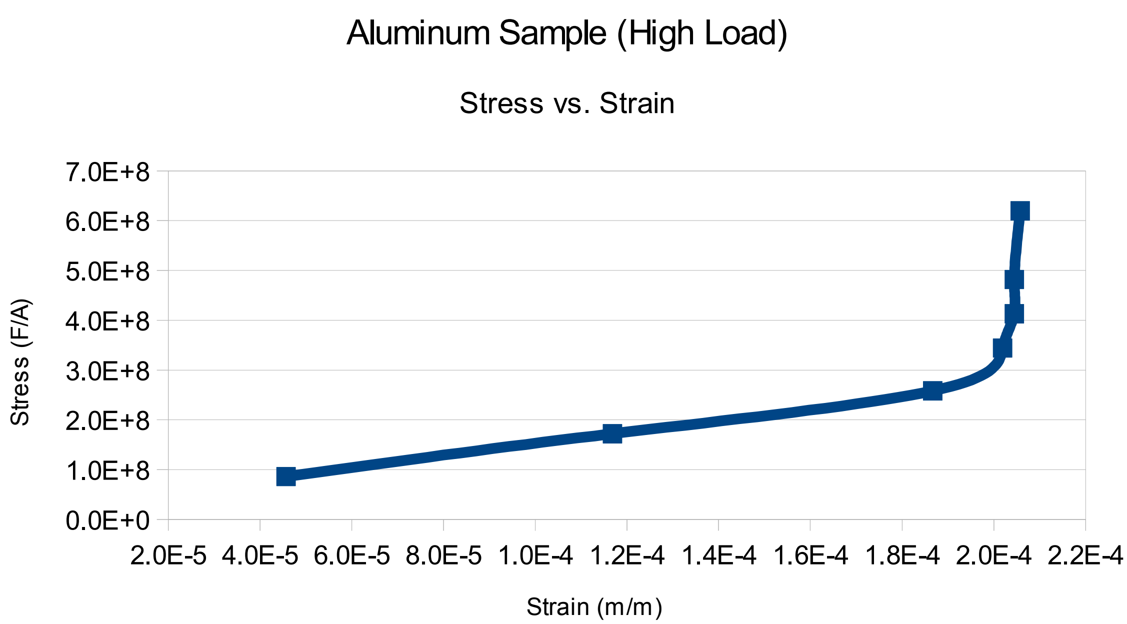


Figure 2. Stress versus strain diagram for aluminum sample with machine set at high load.

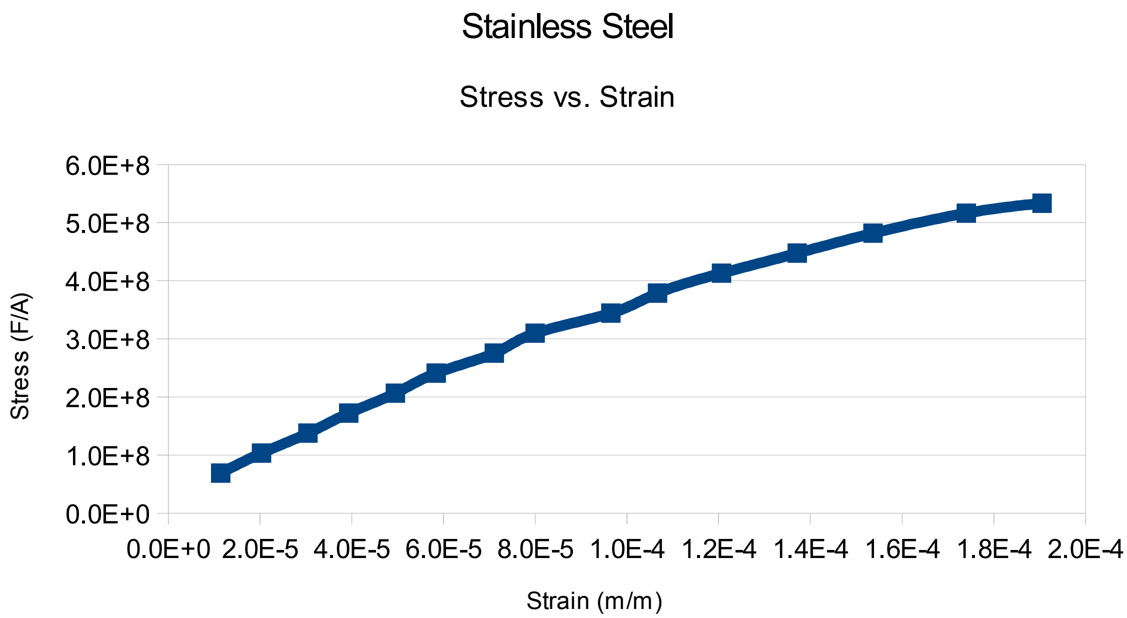


Figure 3. Stress versus strain diagram for Stainless Steel sample.

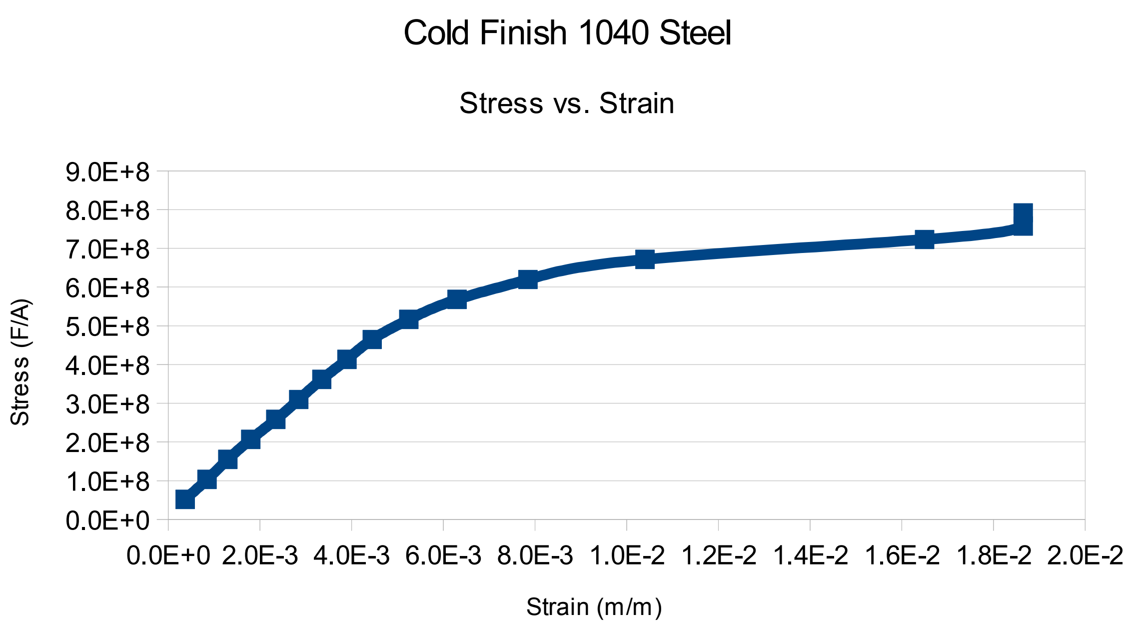


Figure 4. Stress versus strain diagram for Cold Finish 1040 Steel sample.