Experiment #2

Brinell hardness test

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Section PI-X

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1. Objective

The objective of this experiment is to perform the tension test on aluminum and steel and to analyze their respective stress-strain curve.

2. Introduction

The stress strain curve is a very useful tool for engineers since it displays various mechanical properties of the material being analyzed. It gives properties like toughness, resilience, elasticity, yield point and elongation. These are extremely important parameters that must be considered when designing mechanical parts or the individual members of a structure. The tension test is done by applying a slowly increasing uniaxial load until the specimen fails. The test specimen has a dog bone shape.

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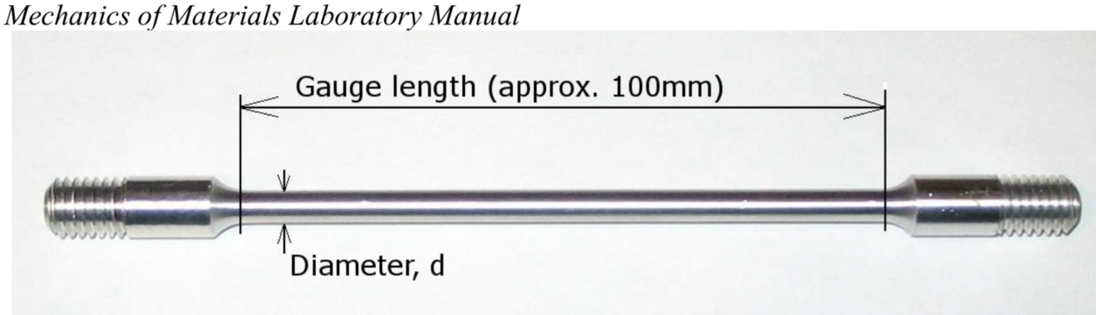


Figure 1: tension test specimen shape

3. Procedure

Start by measuring diameter of specimen using the Vernier calipers. Then securely place the specimen in the deformation measuring device using the 2 set screws to secure the sample. Then zero the display using blue button. All samples have same gage length of 100 mm. Reset load readout by pressing zero button. Then install screw caps by screwing them to the end and loosening them half a turn. Install specimen in the gripping devices of the testing machine. Then apply the load carefully and a slow rate and record the readings of the load by video. Readings are taken at each increment of 500 N. When the force applied is greater than 5000 N, decrease increments down to 200 N. Keep increasing the force until the display stops increasing. At that point start measuring data based on deformation at specific increments. When failure is reached, record the maximum load stored in memory of load read out by pressing LB/KG key. Remove the sample from the testing machine without removing the 2 set screws. Fit the fractured ends together using the v groove instrument to exactly match the failure surfaces. Read the final gauge deformation on the deformation display. Measure fracture diameter of the failed specimen.

The equipment used in this experiment were the tension setting machine used to apply a steady load on the sample , deformation measurement device to measure deformation, Vernier caliper, one steel and one aluminum specimen and a v-groove tray to fit fractured pieces.

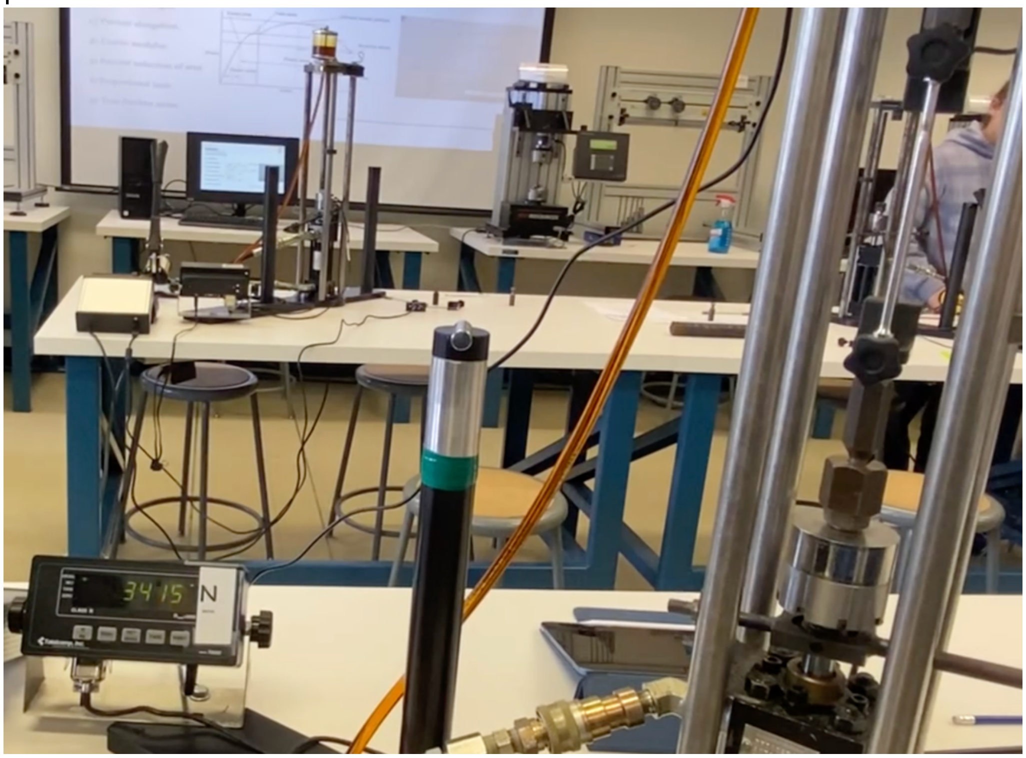


Figure 2: demonstration of proper set up

4. Analysis of the results

$$(1)\sigma = \frac{P}{A}$$

$$(2)\varepsilon = \frac{\delta}{L}$$

σ = tensile stresses on specimen
ε = strain (mm/mm)
P= load applied to the specimen(N)
A= cross section area of the specimen (mm^2)
L= gauge length (mm)
δ = elongation (mm)

Sample calculations

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

$$\sigma = \frac{500N}{\pi(0.002.51)^2}$$

$$\sigma = 25.26622\ MPa$$

$$\varepsilon = \frac{\delta}{L}$$

$$\varepsilon = \frac{(1.1065\ m - 1.00\ m)}{0.1\ m}$$

$$\varepsilon = 0.1065\ m$$

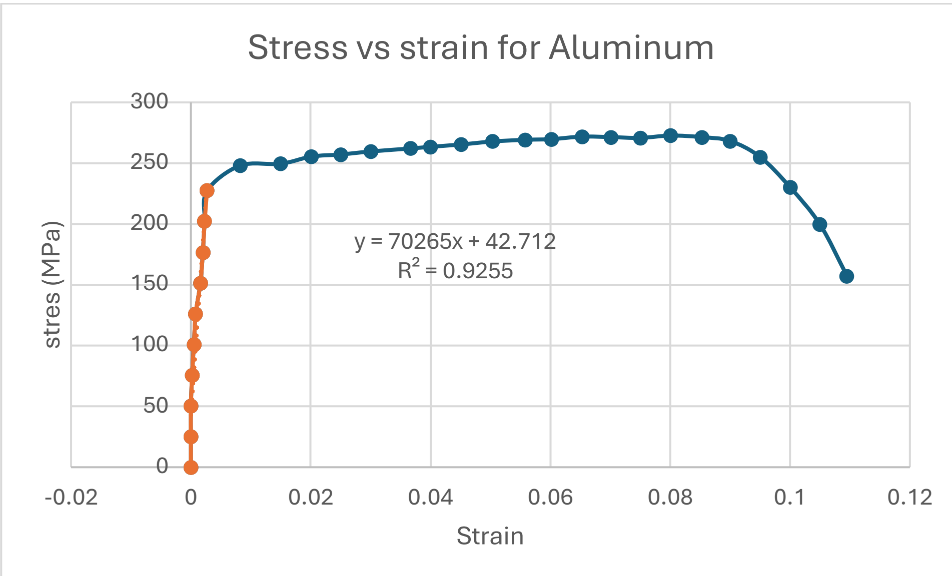
Data for Aluminum

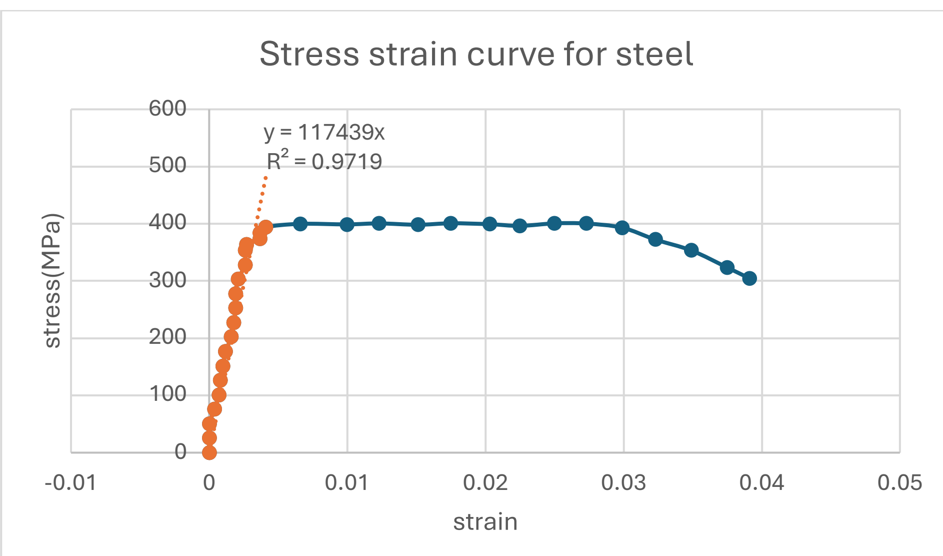
P(N)	deformation(mm)		stress(Mpa)	strain
0	0		0	0
500	0		25.2622884	0
1000	0		50.5245768	0
1500	0.02		75.7868652	0.0002
2000	0.05		101.049154	0.0005
2500	0.08		126.311442	0.0008
3000	0.16		151.57373	0.0016
3500	0.2		176.836019	0.002
4000	0.23		202.098307	0.0023
4500	0.27		227.360596	0.0027
4909	0.82		248.025147	0.0082
4939	1.5		249.540885	0.015
5056	2.01		255.45226	0.0201
5090	2.5		257.170096	0.025
5140	3.01		259.696325	0.0301
5188	3.67		262.121504	0.0367
5215	4		263.485668	0.04
5253	4.51		265.405602	0.0451
5302	5.04		267.881306	0.0504
5329	5.58		269.24547	0.0558
5340	6.02		269.80124	0.0602
5381	6.53		271.872748	0.0653
5373	7.01		271.468551	0.0701
5360	7.5		270.811732	0.075
5398	8.01		272.731665	0.0801
5372	8.53		271.418026	0.0853
5310	9		268.285503	0.09
5050	9.5		255.149113	0.095
4558	10		230.291021	0.1
3951	10.5		199.622603	0.105
3115	10.95		157.384057	0.1095

Data for steel

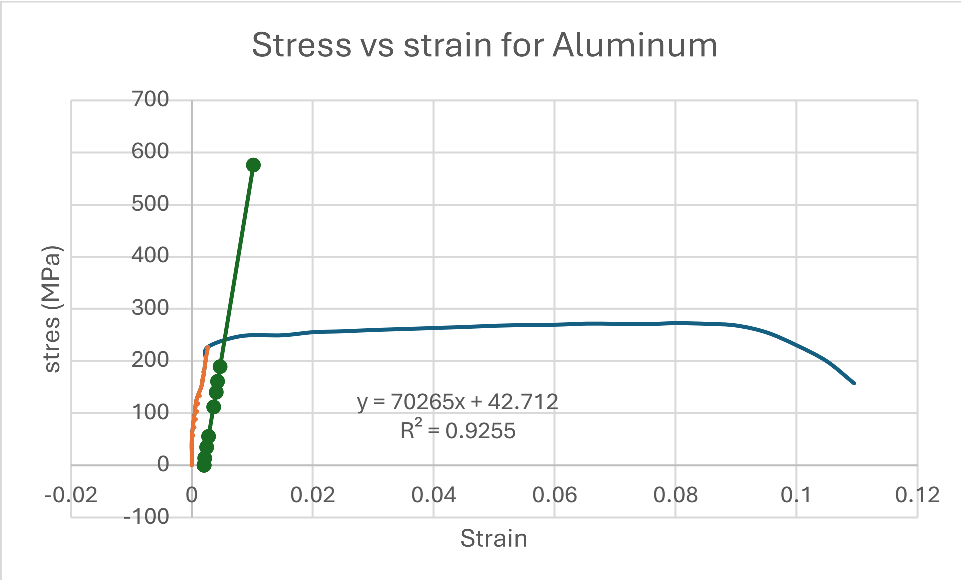
P(N)	deformation(mm)		stress(Mpa)	strain
0	0		0	0
500	0		25.2622884	0
1000	0		50.5245768	0
1500	0.04		75.7868652	0.0004
2000	0.07		101.049154	0.0007
2500	0.08		126.311442	0.0008
3000	0.1		151.57373	0.001
3500	0.12		176.836019	0.0012
4000	0.16		202.098307	0.0016
4500	0.18		227.360596	0.0018
5000	0.19		252.622884	0.0019
5500	0.19		277.885172	0.0019
6000	0.21		303.147461	0.0021
6500	0.26		328.409749	0.0026
7000	0.26		353.672037	0.0026
7200	0.27		363.776953	0.0027
7400	0.37		373.881868	0.0037
7600	0.37		383.986784	0.0037
7800	0.41		394.091699	0.0041
7915	0.66		399.902025	0.0066
7896	1		398.942058	0.01
7930	1.23		400.659894	0.0123
7883	1.51		398.285239	0.0151
7934	1.75		400.861992	0.0175
7902	2.03		399.245206	0.0203
7845	2.25		396.365305	0.0225
7931	2.5		400.710418	0.025
7924	2.73		400.356746	0.0273
7781	2.99		393.131732	0.0299
7369	3.23		372.315606	0.0323
6994	3.49		353.36889	0.0349
6404	3.75		323.55939	0.0375
6032	3.91		304.764247	0.0391

Stress strain curves of Aluminum and steel



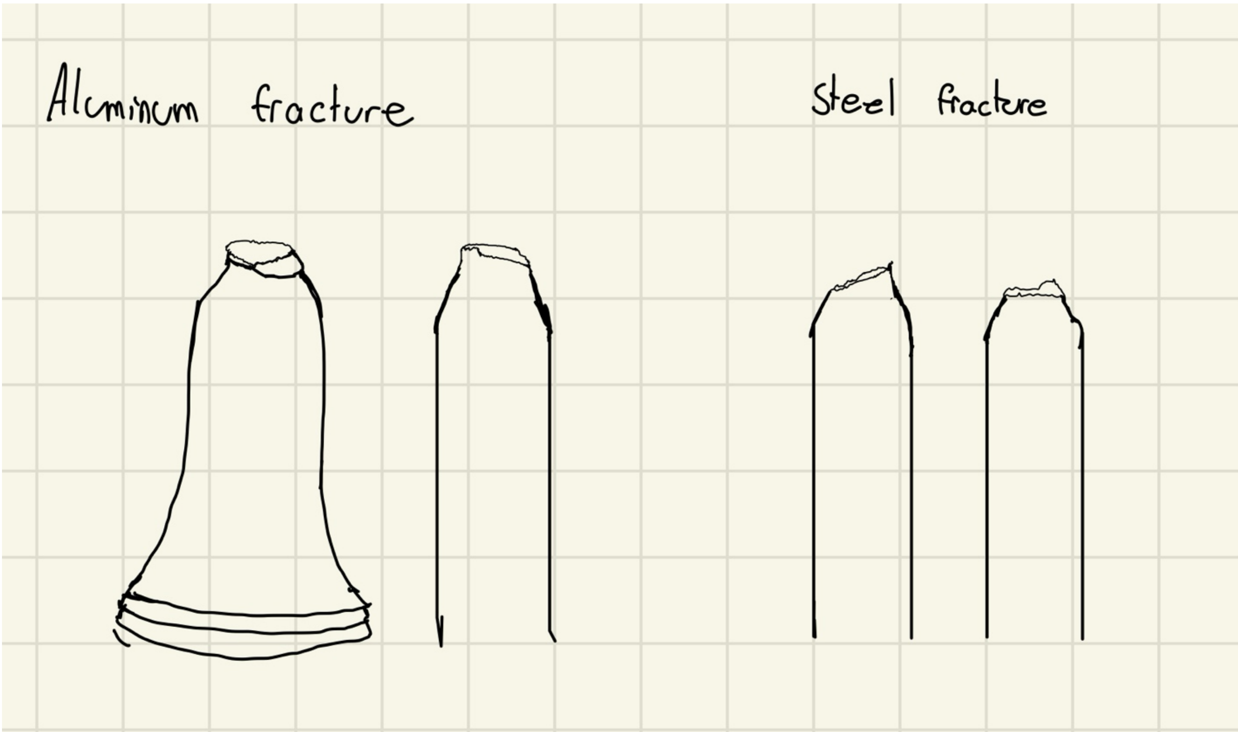


<u>2% offset method</u>



a) The yield strength for aluminum is 249.59 MPa using the offset method. The yield strength of steel using the extension under load method is 395.708 MPa.
b) The ultimate strength of aluminum was 274.146 MPa. The ultimate strength of steel was 357.334 MPa.
c) The percent elongation for aluminum was 10.95%. The percent elongation for steel was 3.91%.
d) The elastic modulus for aluminum was 70.625 GPA and for steel it was 117.439 GPa.
e) The percent reduction in area for aluminum is 72.9%. The reduction of area for steel was 66.39%.
f) The proportional limit of aluminum is 202.09 MPa. The proportional limit of steel is 383.987 MPa.

Sketches of fracture sites of both specimens



5. Discussion

1.The advantages of the stress strain diagram over the load elongation diagram in presenting these results is that the results obtained from the stress strain curve are general and can be applied to all specimens of the same material and the results of the load elongation diagram are specific to the specimen used and it's diameter.

2.The modulus of elasticity measures the resistance to elastic deformation of a material. In other words, it's stiffness. The higher experimental value for the modulus of elasticity obtained for steel indicates that it is greatly resistant to elastic deformation compared to aluminum.

3. No the properties would not appear to be the same since in most materials, the compressive strength differs from the tensile strength. For most materials, Young's modulus is the same but there are some exceptions like concrete and stone. Steel is usually stronger in tension than in compression. Aluminum like most ductile metals is also typically stronger in tension.

4. Ductility is defined by the amount a material plastically deforms before reaching failure. This is usually demonstrated by percent elongation and reduction in area. The toughness can also be considered as an indicator of ductility since it measures the ability of a material to absorb energy when a load is applied.

5. The yield strength for aluminum obtained was 249.59 MPa and the expected value was 275 MPa. The experimental data is a significant amount off the expected value but does resemble it. For steel the expected value was 415 MPa and the obtained value was 395.708 MPa. Similarly to aluminum the obtained value is off by 20 to 25 MPa but still resembles the expected value. The ultimate strength of aluminum is 274.146 MPa and the expected value was 310 MPa. For steel the expected value was 540 MPa and the obtained value was much lower 357.344 MPa. The percent elongation for aluminum was 10.95% which is close to 12%. For steel it was 3.91% and the expected value was 10% which again is significantly inaccurate. The modulus of elasticity obtained for aluminum was 70.265 GPa which is accurate since the expected value is 69 GPa. For steel the obtained value was 117 GPa and the expected value was almost double at 200 GPa.

These inaccuracies could be cause by possible sources of errors due to the equipment in this experiment like air bubbles in the compressor or the seals of the valves weren't tight enough leading to a loss of pressure. These defects could have affected the applied load on the samples. The machines are also not ASTM approved so the values obtained would not be approved values.

References

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