Material Science – ENGG*2120: Winter 2020

LAB SUBMISSION COVER SHEET

Lab Performed: Tensile Strength

Date Performed: February 11th, Tuesday

Date Submitted (Date **AND** Day of Week): March 3rd, Tuesday.

Group Number: 04

GTA Name: Maninderjit Singh

GROUP PARTICIPATION EVALUATION FORM

*****ALL GROUP MEMBERS MUST SIGN TO RECEIVE THEIR MARKS*****

By signing the cover sheet each member is stating that they made a significant contribution to the writing of this lab report and that the distribution of sections completed is accurate.

Group Members		Sections Completed
Name (Printed)	**Signature**	
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Huda Ameer	[illegible]	Results
Nasiba Alchach	[illegible]	Discussion questions: 1,2,5
Nishat Tamanna	Nishat	Discussion questions: 3,4,7
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University of Guelph

ENGG*2120: Material Science

Lab 2: Tensile strength

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Summary

The Tensile test is one of the most important mechanical tests performed on different materials. Tensile properties are used to select materials suitable for engineering applications. Since the material properties can be concluded by measuring the force needed to prolong the specimen to a breaking point. Hence, test results are used to differentiate between different materials or different manufacturing conditions while developing new manufacturing methods or new materials. Therefore, this experiment was performed to identify the importance of the tensile test machine applications. During the laboratory experiment, six different samples were tested and the Young's Modulus, yield stress, ultimate tensile strength, % elongation and % difference were calculated.

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1.0 Introduction

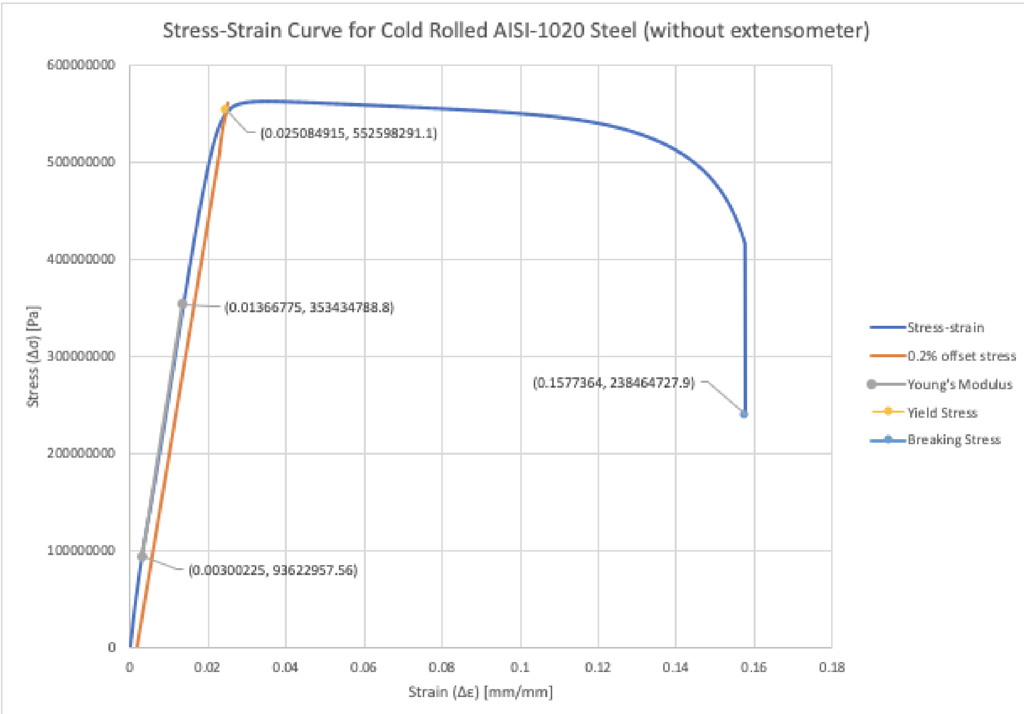
As an engineer, it is very crucial to understand the limitations and strength of the different types of materials. For example, the ultimate tensile strength test (UTS) is significant if the metal to be used without breaking. Also, the Tensile test which considered one of the most common tests in use, especially that it is one of the easiest mechanical tests in terms of procedure and one of the simplest in terms of determining the results. Most of the standard specifications are based on the tensile test as a basis to indicate the properties of metal and considered an important connotation in determining these properties. The metallic materials usually have high tensile strength. Therefore, it requires testing in tensile strength to show the extent of its tolerance during operation. A tensile strength test has been performed during this lab for six different samples with the use of an Instron testing machine with 50 KN load cells. The results were recorded, and a stress-strain curve was plotted and analyzed to conclude the properties and limitation of each of the used samples.

2.0 Experimental Apparatus and Procedures

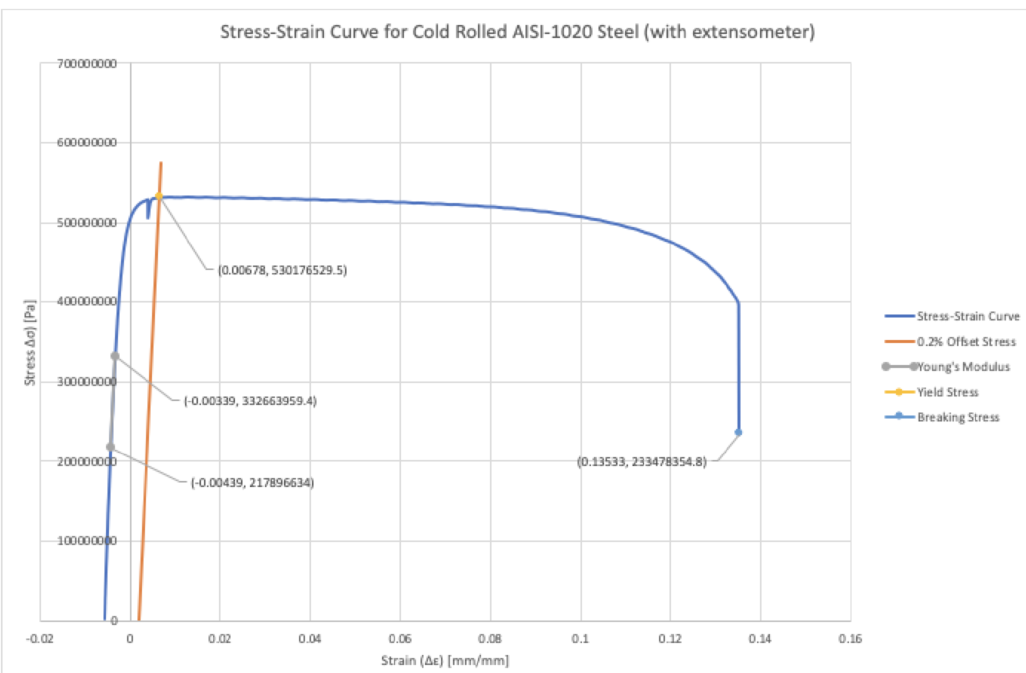
The experiment apparatus and procedures used for this lab are outlined in the ENGG*2120 Lab Manual [1].

3.0 Results

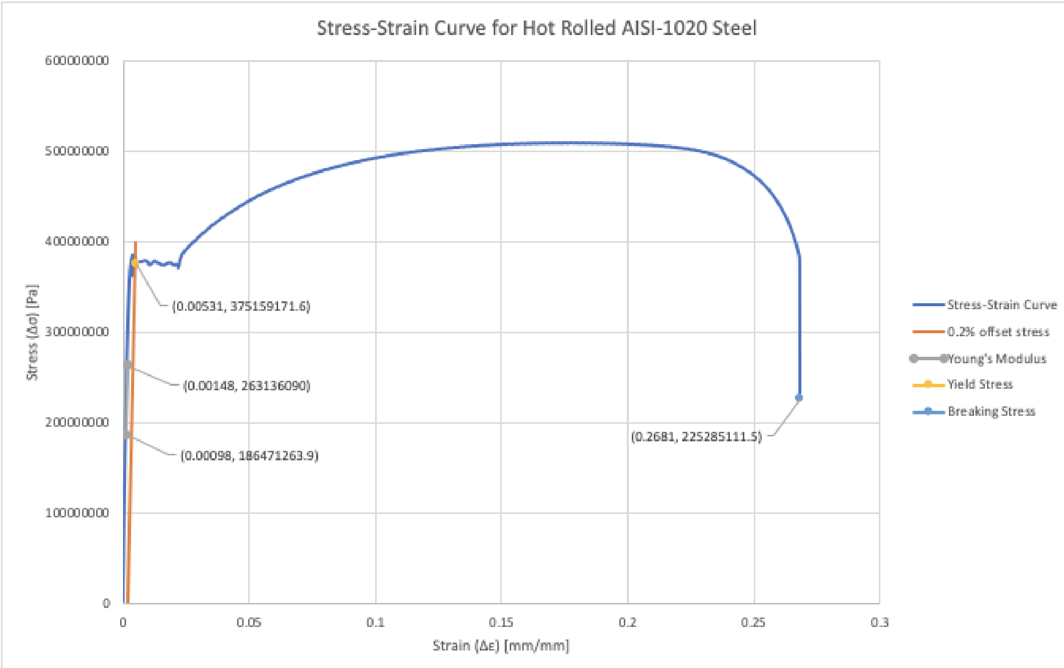
3.1 Calculations, Tables and Graphs



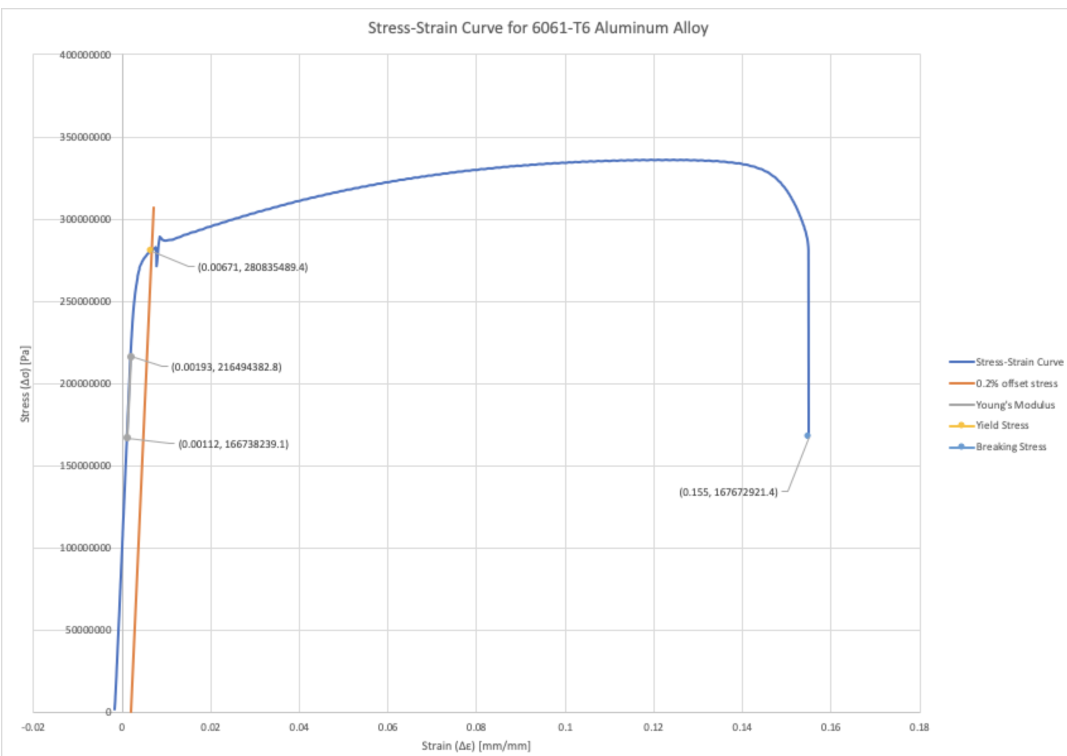
Graph 1: *Cold Rolled 1020 Steel Stress Strain Curve*



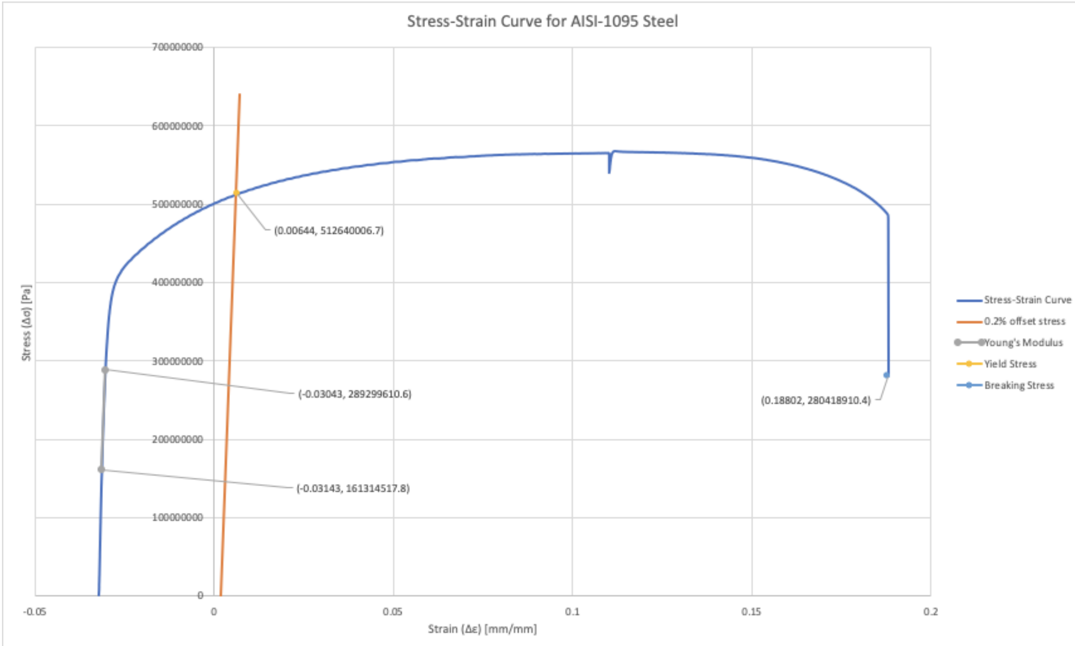
Graph 2: *Cold Rolled 1020 Steel with extensometer Stress Strain Curve*



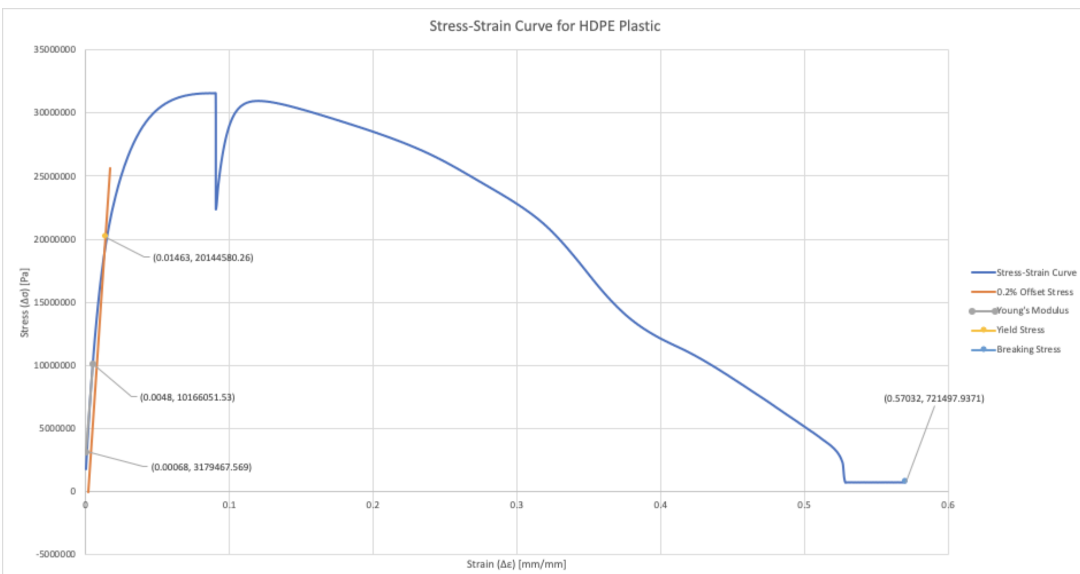
Graph 3: *Hot Rolled Steel Stress Strain Curve*



Graph 4: *Aluminum Alloy Stress Strain Curve*



Graph 5: *1095 Steel Stress Strain Curve*



Graph 6: *Plastic Stress Strain Curve*

Table 1: *Properties of Sample*

Sample	0.2% Offset Yield Strength	Ultimate Tensile Strength	Modulus of Elasticity	Breaking Stress	Percent Elongation (%)
Cold Rolled AISI-1020 Steel	552.60	562.21	24,360.01	238.46	21.59
Cold Rolled AISI-1020 Steel (with extensometer)	530.18	531.24	114,767.33	233.48	14.88
Hot Rolled Steel	375.16	508.38	153,329.65	255.29	24.78
Aluminum Alloy	280.84	266.23	61,427.34	167.67	14.91
AISI-1095 Steel	512.64	567.12	127,985.09	280.42	22.28
HDPE Plastic	20.14	31.53	1,695.77	0.7215	48.02

3.2 Property Material Ranking

Table 2: *Ranking of Materials*

Ranking of Materials	0.2% Offset Yield Strength	Ultimate Tensile Strength	Modulus of Elasticity	Breaking Stress	% Elongation
Lowest	HDPE Plastic	HDPE Plastic	HDPE Plastic	HDPE Plastic	Cold Rolled (with)
	Aluminum	Aluminum	Cold Rolled (without)	Aluminum	Aluminum
	Hot Rolled Steel	Hot Rolled Steel	Aluminum	Cold Rolled (with)	Cold Rolled (without)
Highest	AISI-1095	Cold Rolled (with)	Cold Rolled (with)	Cold Rolled (without)	AISI-1095
	Cold Rolled (with)	Cold Rolled (without)	AISI-1095	Hot Rolled Steel	Hot Rolled Steel
	Cold Rolled (without)	AISI-1095	Hot Rolled Steel	AISI-1095	HDPE Plastic

Table 3: *Theoretical Values of Samples*

Sample	0.2% Offset Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Modulus of Elasticity (MPa)	Percent Elongation (%)
Cold Rolled AISI-1020 Steel	350	420	186000	15
Hot Rolled Steel	205	380	186000	15
Aluminum Alloy	276	310	68900	17
AISI-1095 Steel	570	657	200000	38
HDPE Plastic	26	26	1000	150

**Note: The values used in this table are from [13], [14], [15], [16], [17], [18]

Table 4: *Percent Difference between theoretical and calculated values (%)*

Sample	0.2% Offset Yield Strength	Ultimate Tensile Strength (MPa)	Modulus of Elasticity	Percent Elongation (%)
Cold Rolled AISI-1020 Steel (without extensometer)	57.71	33.86	86.90	43.93
Cold Rolled AISI-1020 Steel (with extensometer)	51.48	27.20	38.29	0.80
Hot Rolled Steel	83.00	33.78	17.56	65.20
Aluminum Alloy	1.75	14.12	10.85	12.29
AISI-1095 Steel	10.06	13.68	36.01	41.37
HDPE Plastic	22.54	21.27	69.58	67.99

4.0 Discussion

Hard materials are generally high in ultimate tensile strength, and may or may not be rough [2]. If specific strength is considered then plastic fibres such as kevlar and spectra are stronger than steel but when squished, they are absolutely not hard [3]. Strength represents how much pressure the material can withstand while toughness, on the other hand, represents how much stress a material can handle before it breaks down [4]. According to our observations and results of this lab, the strongest material tested in this lab was determined to be steel, followed by cold rolled steel. For applications needing heavy load bearing such as structural support grinders, a solid or durable material would be most practical as they need to endure high stress levels without deforming or fracturing.

Ductility is a solid material's ability to move under tensile stress. A ductile material is essentially a fibre that can be conveniently extended to a wire when pulled [6]. The most ductile material was HDPE Plastic, which a designer would choose in several applications that require the material to bend or fold without breaking such as packaging applications and wire insulation [6].

The properties of a material can be determined by their chemical composition and internal structure [7]. Since all materials are made up of atoms, therefore atomic bonding has a significant impact on the properties of materials. The type of bonding between atoms (ionic, covalent, metallic or Van der Waals) that a material composes of can result in different properties [8]. The electrostatic attraction between the positively charged metal ions and the negatively charged delocalized electrons shape metal bonds. Since local bonds can slide across each other (i.e. easily broken and reformed) [9], positively charged metal ions create normal structures and make metals more ductile and malleable [10].

The deformation behaviour for both the materials is not the same. Metals, when stretched, start to deform and eventually break down. Thermoplastics, on the other hand, extend much longer until they break down in the end. This concurs that the deformation in metals is very small in comparison with thermoplastics. Deformation at a microstructural level seems to primarily rely on the stress curves of the metal itself, in that, the rise in recrystallization temperatures induced a rise in the production tension, leading to a greater deformation. While thermoplastic polymer blocks the development of the crystalline stage, producing less tension, and lower deformation, in the case of metals, however, the deformation occurs at a steady state forming necking and suddenly a fracture occurs and finally breaks nearly instantaneously.

In the experiment, the cold rolled steel improved its ultimate tensile strength, as shown by the highest tensile level of 420 MPa for cold rolled steel, while hot rolled steel had only 380 MPa. Higher carbon content also implies that a material is harder, but not as rigid, less ductile. Cold-rolled steel has an improvement in strength of almost 20% by use of strain hardening relative to hot-rolled steel. Cold rolled steel allows highly accurate forms to be made. Since the experiment is carried out at room temperature, as during hot rolling, the steel will not shrink as it cools. Hot rolled steel is suitable where dimensional tolerances are not as critical as material strength, and when surface finishing is not the main criterion. Cold-rolling method is most suitable for smaller parts that need more accuracy and longevity [11].

An extensometer is a device that clasps both above and below the predicted point of fracturing when conducting a tensile measure. It is used to sense the material interactions of smaller strains and deformations. Extensometer parameters are defined by the sample properties to be measured including form and length, design specifications and the performance criteria to be observed [12]. Using an extensometer helps determine more accurate results for strain and elastic modulus.

Based on the data taken from the tensile experiment, outlined in Table 1, an observation can be made about the impact of the use of an extensometer on the 1020 cold rolled steel. The two samples showed similar results, in terms of the ultimate tensile strength, breaking stress and percent elongation. This lack of significant difference in these measurements is due to the removal of the extensometer as plastic deformation began to occur. As an extensometer should determine more accurate results for strain and elastic modulus, it is fitting that a significant increase in the Modulus of Elasticity is recorded. The 1020 cold rolled steel sample with the extronsometer had a Young's Modulus of 114.767MPa, while the cold rolled steel sample without the extensometer measured a young's modulus of 24.360MPa. This difference observed can be explained by the gauge accuracy given with the use of an extensometer. The design of the tensile tester may have altered the results if there was difference in size between the samples, thinner samples would be more susceptible to result-affecting breakage.

Each of the tested materials has its own uses, for which it is best suited. For shafts, mildly strained wheels, heavy working surfaces and frames, the AISI 1020 stainless steel can be used. In welding and construction, hot-rolled steel is used to create tracks for railways. In engineering systems and parts, aluminium alloys are commonly used where light weight or corrosive resistance is needed. For starters, aerospace after metal-skinned aircraft were introduced. For springs or cutting tools that need sharp edges like lawn or grain cutting tools, AISI 1095 Carbon Steel can be used. HDPE is used in plastic bottles, corrosion-resistant pipe production and timber processing.

The tensile test used an Instron testing machine, as the machine system completed the readings for the results, it can be assumed that the values yielded high accuracy. Meaning that the errors produced in the calculation are most likely human error. During the use of the testing machine, error could be accounted for by misaligned samples. If the sample was not placed exactly along the direction of the tensile force acting on the sample, then the cross-sectional area used in the calculations would not directly relate to the data collected from the Instron. Prior to conducting the experiment, dimensions of the samples were taken using a caliper, with an allowable tolerance of +/- 0.02mm, inaccuracy due to the way in which the instrument was used in also probable. As several different students may have measured the samples. There is also the possibility of discrepancies within the results. The measurements taken after the sample was stretched and separated, allowed for further inaccuracy as the location of the necessary measurements was not evident. This human error would influence the calculations for tensile strength as it uses the cross-sectional area of the samples. Other outside factors, such as temperature, material condition and possible internal flaws, could also be the source of calculation and measurement errors. In order to obtain results with less error, a method of obtaining average results based on several samples for each material could be implemented.

5.0 Conclusion

The results of the tensile test conducted for all the samples revealed that ultimate tensile strength was greater for the metals samples and lower elongation value compared to polymers. The experiment outcomes showed the following:

A. AISI-1095 steel is the strongest material among all samples, with the highest ultimate tensile and breaking stress while the HDPE plastic is the weakest material with the highest elongation percentage
B. The hot rolled steel has the greatest modulus of elasticity while the HDPE plastic has the smallest modulus of elasticity.

To end with, the data above should be a good tool for engineers to be able to decide on the right material that fits the specifications of different applications.

6.0 References

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7.0 Appendix

7.1 Appendix A

Table: *Initial and Post Compression Dimensions*

Sample	Initial Dimensions			Post-Tension Dimensions	
	Length (mm)	Width (mm)	Thickness (mm)	Length (mm)	Neck width (mm)
Cold Rolled AISI-1020 Steel (without extensometer)	89.03	18.26	3.17	108.25	14.04
Cold Rolled AISI-1020 Steel (with extensometer)	88.87	18.28	3.19	102.09	12.90
Hot Rolled Steel	88.96	18.26	3.21	111.00	13.74
Aluminum Alloy	88.80	18.35	3.17	102.04	16.59
AISI-1095 Steel	88.81	18.37	3.25	108.60	13.94
HDPE Plastic	89.05	18.04	3.16	131.81	1.70

Calculation Sample 1: Cross-sectional Area of Aluminum

$$A = lw$$

$$A = \left(\frac{18.35mm}{1000\ mm/m}\right)\left(\frac{3.17mm}{1000\ mm/m}\right)$$

$$A = 0.0000581695\ m^2$$

Calculation Sample 2: Modulus of Elasticity for Aluminum

$$E = \frac{216494382.8 - 166738239.1}{0.00193 - 0.00112}$$

$$E = 61427337881\ Pa$$

Calculation Sample 3: Stress of Aluminum

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

$$\sigma = \frac{3.69791 * 10^3\ N}{0.0000581695\ m^2}$$

$$\sigma = 63571287.36\ Pa$$

Calculation Sample 4: Percent Elongation of Aluminum

$$\%\ Elongation = \frac{final\ length - initial\ length}{initial\ length} * 100\%$$

$$\%\ Elongation = \frac{108.25\ mm - 89.03\ mm}{89.03\ mm} * 100\%$$

$$\%\ Elongation = 21.58822869\ \%$$

Calculation Sample 5: Strain of Cold Rolled AISI-1020 Steel (without extensometer):

$$\varepsilon = \frac{\Delta l}{l_0}$$

$$\varepsilon = \frac{1.38345\ mm}{88.80\ mm}$$

$$\varepsilon = 0.01553914\ mm/mm$$