UNIVERSITY POLICY UP07/21

This policy promotes ethical scholarship, academic literacy and encourages academic integrity. UWA believes that success in promoting ethical scholarship and developing skills in academic literacy is crucial to fostering an institutional culture of academic integrity.

ETHICAL SCHOLARSHIP

Ethical scholarship entails the pursuit of scholarly enquiry marked by honesty and integrity. It is reflected both in individual and group approaches to study and assessment tasks, and is part of a broader institutional commitment to maintain and extend robust, defensible and transparent educational standards and practices.

ACADEMIC LITERACY

Academic literacy may be defined as the capacity to undertake study and research, and to communicate findings and knowledge, in a manner appropriate to the particular disciplinary conventions and scholarly standards expected at University level.

ACADEMIC INTEGRITY

Academic integrity is a core value of education and involves acting with the principles of honesty, trust, fairness, and responsibility in learning, teaching and research and requires respect for knowledge and its development.

PLAGIARISM

Plagiarism at UWA is defined as “the **unattributed** (not referenced) use of someone else’s words, creations, ideas, arguments, etc. as one’s own”.

It is also referred to as academic misconduct and misuse of evidence. Plagiarism occurs when authors do not reference sufficiently; reference in the wrong place, or in the wrong way or don’t reference at all. It also includes presenting someone else’s work as your own. Buying and selling assignments is one of the most serious forms of plagiarism.

Information about avoiding plagiarism is available from the STUDYSmarter Survival Guide.

REFERENCING

Referencing is acknowledging that you have used information from different sources.

Reason to reference includes:

- To avoid being guilty of plagiarism;
- To lend credibility/evidence to your argument; and
- To show the research that you have done

There are many referencing styles used at UWA. Find out which style is commonly used in your discipline.

Information about referencing is available from the STUDYSmarter Survival Guide.

ACADEMIC MISCONDUCT

UWA defines academic misconduct as “any activity or practice engaged in by a student that breaches explicit guidelines relating to the production of work for assessment, in a manner that compromises or defeats the purpose of that assessment”.

Breach of Academic Conduct is any activity or practice engaged in by a student that compromises academic integrity. Levels of Breaches of Academic Conduct relate to the severity of the breach and are defined as Minor Breach (Level 1); Moderate Breach (Level 2); and Major Breach (Level 3).

Information about academic misconduct is available from the University Policy on: Academic Conduct website.

Tensile Testing of Materials

ENSC1004

Semester 1, 2021

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Table of Contents

Introduction:

The purpose of this report is to determine the Young's modulus, ductility, tensile strength, and yield strength for each of the three materials: aluminium alloy, mild steel, and polyvinyl chloride (PVC).

The Young's modulus is a measure of stiffness, with a higher value being indicative of a stiffer material. Ductility is defined by the amount of plastic deformation a material can undergo without fracturing. Tensile strength is the maximum amount of stress a material can endure without fracturing, and yield strength is the point just before the onset of plastic deformation.

All these properties can be determined easily through a stress-strain graph. The graph was acquired with a typical benchtop tensile tester and thin sample specimens of each material.

Experimental:

The benchtop tensile tester shown in Figure 1 was used for the experiment.

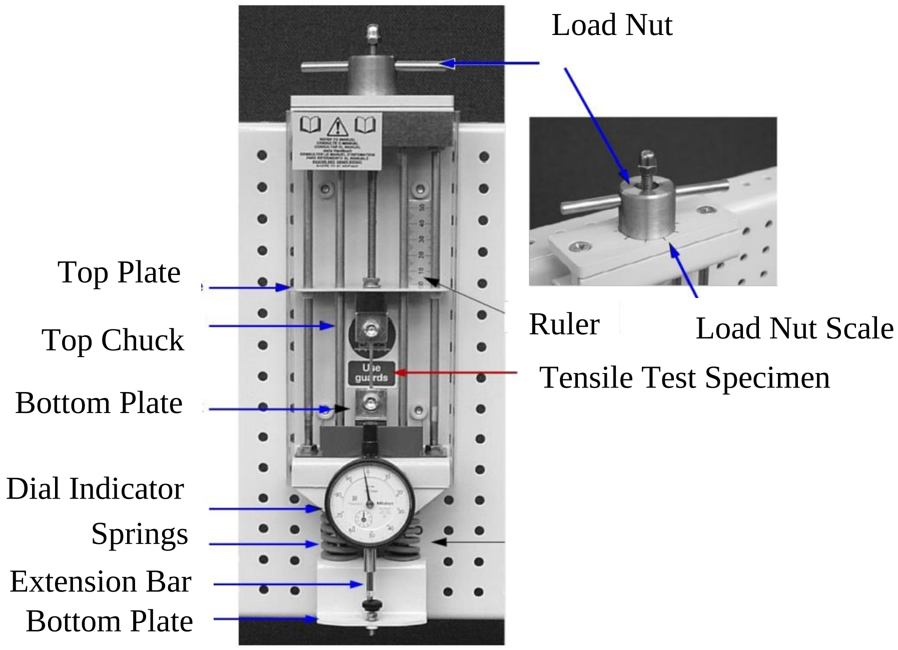

Figure 1. Tensile Tester (Lab 1 Manual: Tensile Testing of Materials, 2021)

Each tensile test specimen had the same unique shape as a two-dimensional dumbbell, with holes in the centre of each wide flat section on either side to facilitate the holding of the specimen on to the tensile tester.

Before bolting the test specimen on to the tensile bench, each had their length, width, and depth measured with dial callipers on the thin section. The specimen was then fixed to the chucks with an Allen key. The load nut was rotated clockwise until there was some movement on the dial indicator, when this happened the indicator was then adjusted to show 0. The Safety Guard was then fitted.

For the metal specimens the locknut was rotated 2 notches clockwise at a consistent rate, with each notch representing 0.1mm. This put the specimen under a tensile load. The number on the dial was then recorded as well as the number of notches that have been rotated so far, before the locknut was rotated again. This process repeated until the specimens fractured.

For the PVC, the process was slightly different. Instead of repeatedly turning the locknut 2 notches each time, it was turned 1 notch 20 times, then 5 notches 10 times, then 1 notch up every time after until 10 notches. By this time, the needle on the dial kept dipping down. In this case, the number the dial read immediately after the turning was recorded for consistency. This was continued until the PVC fractured.

After fracturing the now broken specimens were put together to have their final lengths measured with dial callipers.

Results:

Table 1. Tensile Testing Results for Mild Steel

Original Cross-Sectional Area (mm^2): 1.71 Original Length (mm): 31						
Measured Data		Calculated Data				
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MPa)	Nominal Strain	Adjusted Nominal Strain
0	0	0	0	0	0	0
0.2	0.14	14	0.06	8.19	0.00193	0.00193
0.4	0.31	31	0.09	18.1	0.00290	0.00290
0.6	0.49	49	0.11	28.7	0.00355	0.00355
0.8	0.69	69	0.11	40.4	0.00355	0.00355
1	0.86	86	0.14	50.3	0.00452	0.00452
1.2	1.05	105	0.15	61.4	0.00484	0.00484
1.4	1.22	122	0.18	71.3	0.00581	0.00581
1.6	1.38	138	0.22	80.7	0.00710	0.00710
1.8	1.55	155	0.25	90.6	0.00806	0.00806
2	1.73	173	0.27	101	0.00871	0.00871
2.2	1.9	190	0.3	111	0.00968	0.00968
2.4	1.75	175	0.65	102	0.0210	0.00997
2.6	1.91	191	0.69	112	0.0223	0.0113
2.8	2.12	212	0.68	124	0.0220	0.0109
3	2.28	228	0.72	133	0.0232	0.0122
3.2	2.45	245	0.75	143	0.0242	0.0132
3.4	2.62	262	0.78	153	0.0252	0.0142
3.6	2.77	277	0.83	162	0.0268	0.0158
3.8	2.99	299	0.81	175	0.0261	0.0151
4	3.15	315	0.85	184	0.0274	0.0164
4.2	3.33	333	0.87	195	0.0281	0.0171

Table 1 Cont.

Measured Data		Calculated Data				
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MPa)	Nominal Strain	Adjusted Nominal Strain
4.4	3.51	351	0.89	205	0.0287	0.0177
4.6	3.65	365	0.95	214	0.0306	0.0196
4.8	3.86	386	0.94	226	0.0303	0.0193
5	4.01	401	0.99	235	0.0319	0.0209
5.2	4.19	419	1.01	245	0.0326	0.0216
5.4	4.39	439	1.01	257	0.0326	0.0216
5.6	4.55	455	1.05	266	0.034	0.0229
5.8	4.74	474	1.06	277	0.0342	0.0232
6	4.91	491	1.09	287	0.0352	0.024
6.2	5.05	505	1.15	295	0.0371	0.0261
6.4	5.17	517	1.23	302	0.0397	0.0287
6.6	5.27	527	1.33	308	0.0429	0.0319
6.8	5.36	536	1.44	314	0.0465	0.0355
7	5.42	542	1.58	317	0.0510	0.0400
7.2	5.51	551	1.69	322	0.0545	0.0435
7.4	5.56	556	1.84	325	0.0594	0.0484
7.6	5.65	565	1.95	330	0.0629	0.0519
7.8	5.71	571	2.09	334	0.0674	0.0564
8	5.75	575	2.25	336	0.0726	0.0616
8.2	5.78	578	2.42	338	0.0781	0.0671
8.4	5.84	584	2.56	342	0.0826	0.0716
8.6	5.85	585	2.75	342	0.0887	0.0777
8.8	5.87	587	2.93	343	0.0945	0.0835
9	Fracture					

The final length of the mild steel was 33.7mm .

Force can be measured by multiplying the dial indicator value by 100. The reason this can be done is that the springs have a combined spring rate of 100 N/mm. For example, if the dial indicator read 4.55mm, the force applied is 455N.

Extension is calculated by subtracting load nut movement by dial indicator.

Stress is calculated with the equation $\sigma = \frac{F}{\mathrm{Ao}}$, where σ is stress in pascals, F is force applied in newtons, and A_o is the original cross section of the specimen in meters^2. Stress here is engineering stress, which is defined as applied force over original cross-sectional area of a material.

Strain is calculated with the equation $\varepsilon = \frac{\Delta L}{Lo}$, where ε is strain, which is unitless, ΔL is the difference between the current length and the original length, this value is the same as the extension column. L_o is the original length of the specimen. Similar, to before, strain here is engineering strain, which is defined as the amount a material deforms per unit length. That is the reason strain is unitless or in the specific case of this table mm/mm.

Adjusted strain is a column that takes the strain and subtracts 0.11 away from it past the point 0.210 shown in the strain column in Table 1. This column was required because the specimen slipped in its chucks at that point thus requiring the need to rectify it.

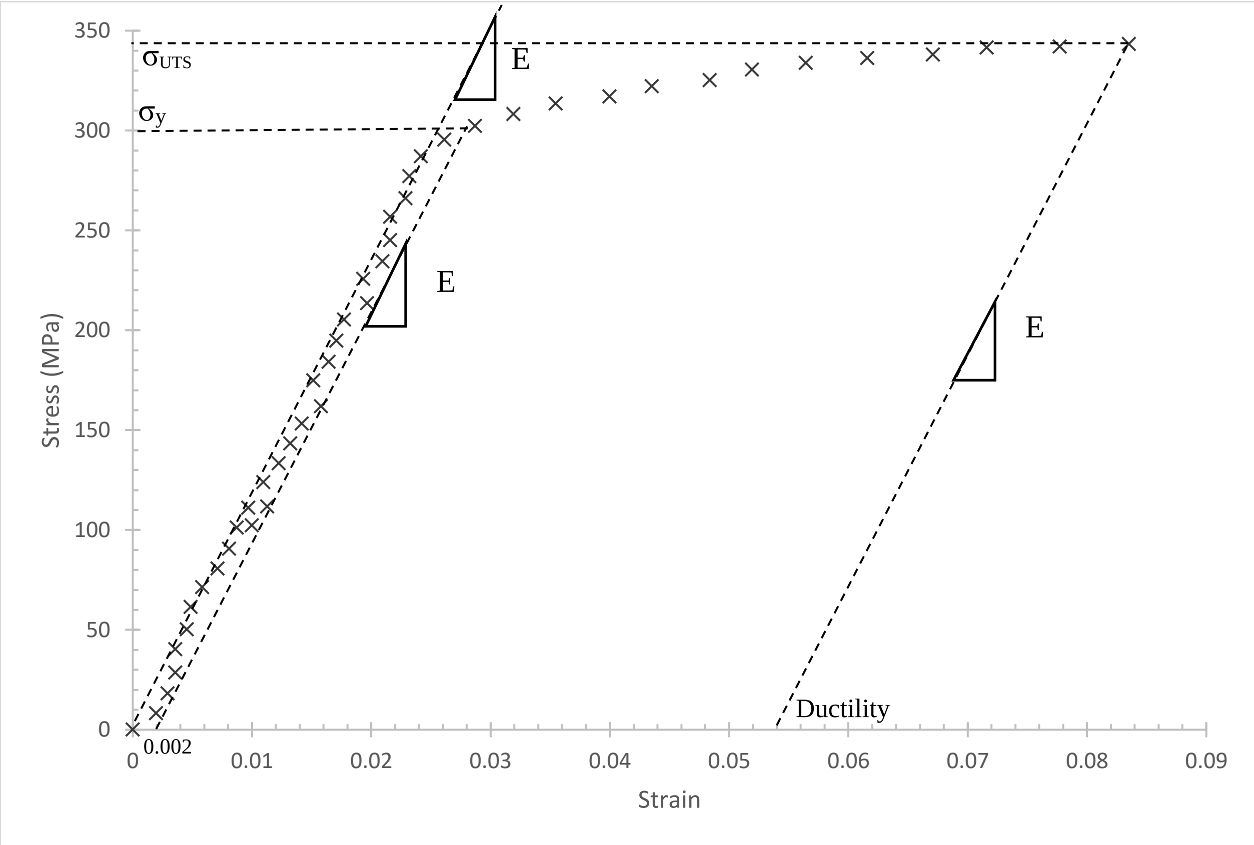

Figure 1. The Tensile Stress-Strain Curve for Mild Steel

To find the Young's Modulus (E) from a stress-strain curve the gradient must be taken from the linear portion of the graph. The point (0.02, 240) and (0, 0) are gathered from the line from Figure 1. $E = \frac{240\ X\ 10^6}{0.02}$ =12.0 GPa.

The yield strength (σ_y) can be found by offsetting the strain by 0.002 and finding where the offset gradient interacts with the rest of the curve. σ_y = 300 MPa.

The ultimate tensile strength (σ_{UTS}) can be found by finding the local maximum before the onset of necking on the graph, unfortunately, as shown in Figure 1, we cannot see this local maximum before necking. The reason for this is that the fracture occurred halfway through and thus data could not be gathered. Thus, to approximate the ultimate tensile strength the global maximum of the graph was used. σ_{UTS} = 345 MPa.

The ductility of the material can be described in two ways. The percent of elongation (%EL), or the percent of cross-sectional reduction (%RA). It can also be found graphically, drawing a line with the same gradient as before, using the fracture point as the end point of the line, would give us a strain value. Multiplying this strain value by 100 would give us the ductility. Which would give a value of 5.40%. As we have only measured the final length and it is more accurate, we will calculate ductility for the summary table using the percent of elongation. $\%EL = \left(\frac{33.7-31}{31}\right)X100 = 8.71\%$

Table 2. Summary Results

	Young's Modulus (Pa)	Yield Strength (Pa)	Ultimate Tensile Strength (Pa)	Ductility (%EL)
Aluminium Alloy	$13.8\text{x}10^9$	$156\text{x}10^6$	$198\text{x}10^6$	8.04
Mild Steel	$12.0\text{x}10^9$	$300\text{x}10^6$	$345\text{x}10^6$	8.71
PVC	$0.580\text{x}10^9$	$25\text{x}10^6$	$25\text{x}10^6$	121

Discussion:

The aluminium alloy and mild steel have the most comparable results. With the aluminium alloy having the highest Young' Modulus of 13.8 GPa, but having a lower yield strength, tensile strength and ductility compared to the steel. Which were 300 MPa, 345 MPa and 8.71% respectively, as seen in Table 2. This means that while aluminium was (experimentally) stiffer, it was less strong and ductile than steel.

The obvious outlier is the PVC, being an order of magnitude smaller from the metals Young's Modulus, yield strength, and tensile strength. As well as being a order of magnitude larger in ductility. This means while it is not stiff nor strong, it has the largest capabilities for plastic deformation. PVC being an outlier here makes sense as it is the only non-metallic material of the group, instead belonging to the polymer classification.

The experimentally calculated moduli are widely different from accepted known values. A method to see exactly how far apart the two values are a percent difference formula can be utilised. $\frac{|A-B|}{\left(\frac{A+B}{2}\right)}X100 = \%$ Where A and B are the two values being compared. Calculating these values for the aluminium, steel, and PVC give the percentages: 133%, 178%, and 135% respectively. None of the experimental values seem close to the known values at all, with steel having a percentage difference of 178%. Reasons for these discrepancies could account due to the thinness of the specimens. Any defects in the material would affect the material a great deal more than in thicker specimens. Other possible reasons could include the apparatus used to perform the test, which were not the most accurate or precise.

Conclusion:

The values for the Young's Modulus, yield strength, tensile strength, and ductility was all found for an aluminium alloy, mild steel and PVC using a tensile test. By plotting the data on to a stress-strain curve, the properties could all be found be using the graph. The report shows how this can be done as annotated on Figure 1. While the values experimentally worked out are nowhere near accepted textbook numbers, the report was useful to demonstrate the method of acquiring these properties.

References:

Lab 1Manual: Tensile Testing of Materials. (2021). In H. Yang (Ed.), *ENSC 1004: Engineering Materials* (pp. 3-6). University of Western Australia

Week 4-L8 (C3.Strengths & Ductility-2). (2021). In H. Yang (Ed.), *ENSC 1004: Engineering Materials* (pp. 5-7). University of Western Australia

Appendix:

Table A1. Tensile Testing Results for Aluminium Alloy

Original Cross-Sectional Area (mm^2): 1.62 Original Length (mm): 31.1					
Measured Data		Calculated Data			
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MPa)	Nominal Strain
0	0	0	0	0	0
0.2	0.15	15	0.05	9.26	0.00161
0.4	0.32	32	0.08	19.8	0.00257
0.6	0.5	50	0.1	30.8	0.00322
0.8	0.68	68	0.12	41.9	0.00386
1	0.86	86	0.14	53.1	0.00450
1.2	1.04	104	0.16	64.2	0.00515
1.4	1.22	122	0.18	75.3	0.00579
1.6	1.4	140	0.2	86.4	0.00643
1.8	1.58	158	0.22	97.5	0.00707
2	1.77	177	0.23	109	0.00740
2.2	1.94	194	0.26	120	0.00836
2.4	2.13	213	0.27	131	0.00868
2.6	2.31	231	0.29	143	0.00933
2.8	2.45	245	0.35	151	0.0113
3	2.54	254	0.46	157	0.0148
3.2	2.66	266	0.54	164	0.0174
3.4	2.61	261	0.79	161	0.0254
3.6	2.79	279	0.81	172	0.0260
3.8	2.87	287	0.93	177	0.0299
4	2.95	295	1.05	182	0.0338
4.2	3.01	301	1.19	186	0.0382
4.4	3.07	307	1.33	190	0.0428
4.6	3.14	314	1.46	194	0.0469
4.8	3.17	317	1.63	196	0.0524
5	3.18	318	1.82	196	0.0585
5.2	3.21	321	1.99	198	0.0640
5.38	Fracture				

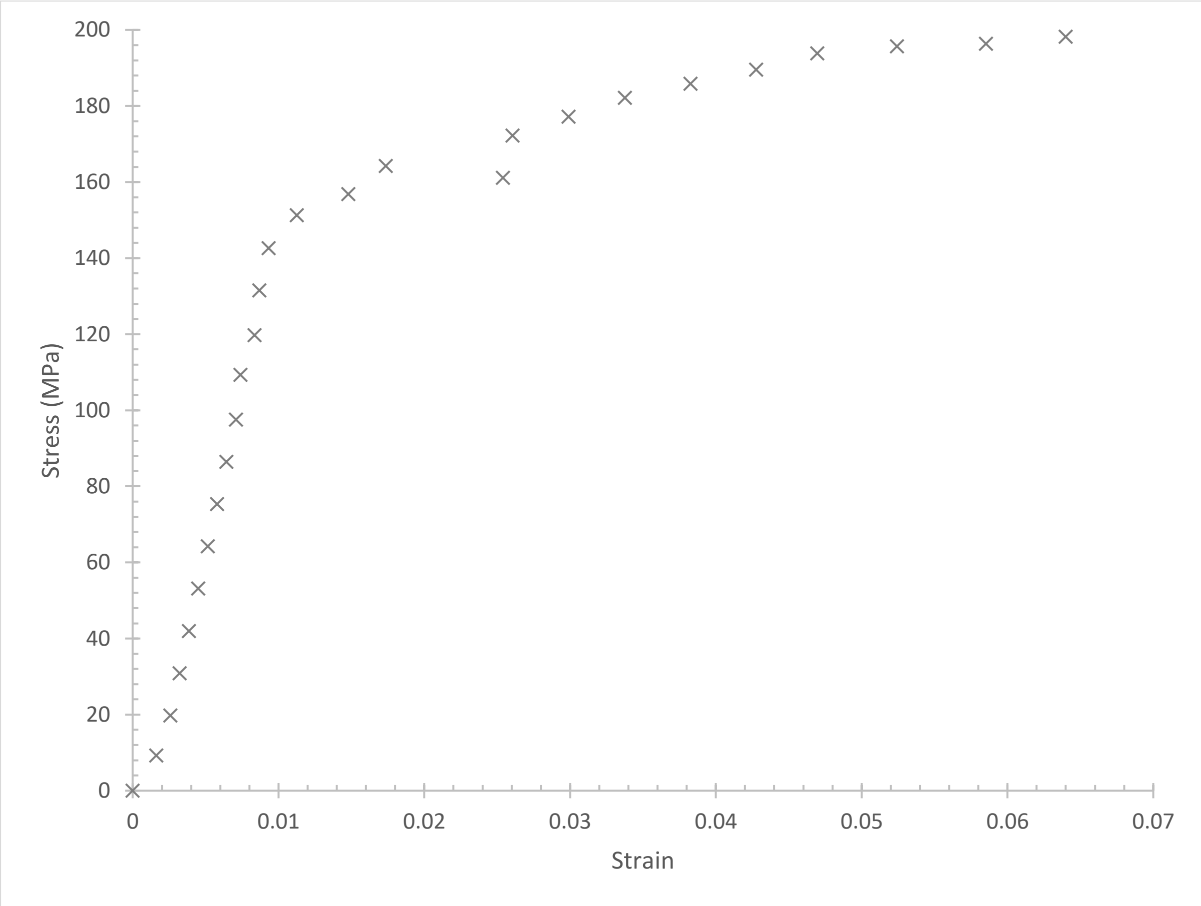

Figure A1. The Tensile Stress-Strain Curve for Aluminium Alloy

Table A2. Tensile Testing Results for PVC

Original Cross-Sectional Area (mm^2): 2.2 Original Length (mm): 31.3					
Measured Data		Calculated Data			
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MPa)	Nominal Strain
0	0	0	0	0	0
0.1	0.04	4	0.06	1.82	0.00193
0.2	0.08	8	0.12	3.64	0.00386
0.3	0.11	11	0.19	5.00	0.00611
0.4	0.14	14	0.26	6.36	0.00836
0.5	0.19	19	0.31	8.64	0.00997
0.6	0.22	22	0.38	10.0	0.0122
0.7	0.26	26	0.44	11.8	0.0141
0.8	0.3	30	0.5	13.6	0.0161
0.9	0.28	28	0.62	12.7	0.0199
1	0.3	30	0.7	13.6	0.0225

Table A2 Cont.

Original Cross-Sectional Area (mm^2): 2.2 Original Length (mm): 31.3					
Measured Data		Calculated Data			
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MPa)	Nominal Strain
1.1	0.32	32	0.78	14.5	0.0251
1.2	0.36	36	0.84	16.4	0.0270
1.3	0.39	39	0.91	17.7	0.0292
1.4	0.42	42	0.98	19.1	0.0316
1.5	0.46	46	1.04	20.9	0.0334
1.6	0.48	48	1.12	21.8	0.0360
1.7	0.51	51	1.19	23.2	0.0383
1.8	0.54	54	1.26	24.5	0.0405
1.9	0.52	52	1.38	23.6	0.0444
2	0.55	55	1.45	25.0	0.0466
2.5	0.45	45	2.05	20.5	0.0659
3	0.45	45	2.55	20.5	0.0820
3.5	0.45	45	3.05	20.5	0.0981
4	0.42	42	3.58	19.1	0.115
4.5	0.43	43	4.07	19.5	0.131
5	0.45	45	4.55	20.5	0.146
6	0.45	45	5.55	20.5	0.178
7	0.45	45	6.55	20.5	0.211
8	0.5	50	7.5	22.7	0.241
9	0.44	44	8.56	20.0	0.275
10	0.48	48	9.52	21.8	0.306
20	0.5	50	19.5	22.7	0.627
30	0.5	50	29.5	22.7	0.949
40	0.52	52	39.48	23.6	1.27
46.5	Fracture				

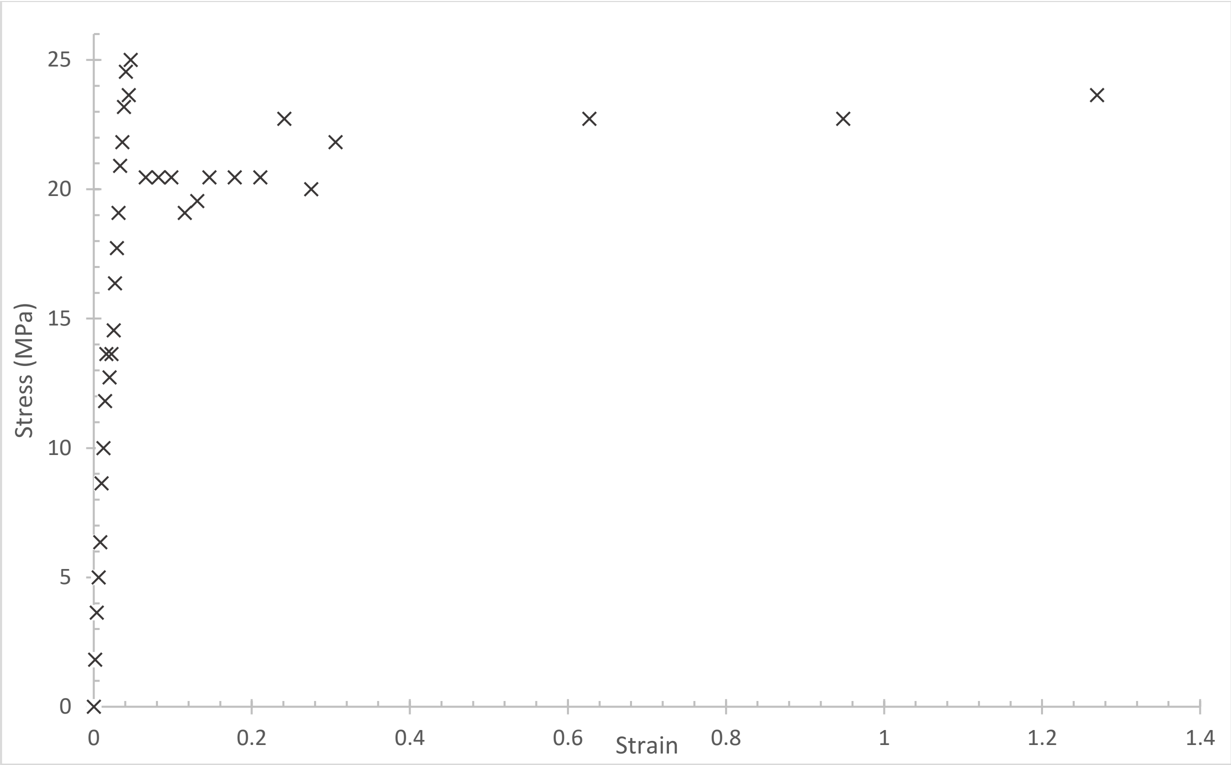

Figure A2. The Tensile Stress-Strain Curve for Aluminium Alloy