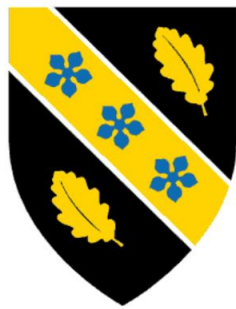


MODULE: MATERIALS AND MANUFACTURING

MODULE CODE: ACHA4025

ASSIGNMENT 1

ENGINEERING MATERIALS



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SUBMISSION DATE: 4th 2026 (23:59)

1839 Words

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1 Introduction

This report is written from the prospective of an engineer within a Dakar Rally team, where a driveshaft has failed on both cars within a stage of each other. With the driveshaft being manufactured from aluminium of an unknown alloy, a sample of this aluminium alloy had been provided for an investigation to be conducted. The maximum expected stress that the driveshaft would experience is known to be 90MPa.

The following report will show the methodology, supported by images of the test procedure carried out during a tensile test of an aluminium specimen carried out within the laboratory at the IQ building at UWTSD. Additionally, this report will analyse and discuss the test and data, calculating various values such as tensile strength, young's modulus and yield strength. The cause of the material failure will also be identified and discussed, also supported by images.

2 Literature review

Driveshafts are responsible for the transfer of power from the engine to the wheels. They experience high levels of torque and must be able to withstand vertical, lateral and rotational forces. Due to this, they must be thoroughly tested for their applications and it is crucial that the correct materials must be selected.

What materials would be suitable for a driveshaft?

The most common material that is used for driveshafts is steel, however it is most commonly found in general automotive applications or heavy-duty vehicles (Gebresilassie, 2012). Two other materials that can be used for driveshafts are Aluminium and Carbon Fiber. Both of which are more suitable and can be found in motorsport applications (Manuel, 2024).

Aluminium and carbon fibre are both used in motorsport due to their strength and lightweight properties however, although it is more expensive, carbon fibre has a much better strength to weight ratio than that of an aluminium driveshaft. (Manuel, 2024). Aluminium is also a good option due to its price. While it lacks some strength when compared to carbon fibre, it is a lot more cost effective to replace if it becomes damaged or fails, which is likely in a demanding motorsport such as the Dakar Rally, with the event spanning over the course of 15 days of tough terrain (Dakar, 2026).

How can each material be tested?

There are multiple ways of material testing however testing can be expensive, so it is essential to perform the correct tests. One method of material testing is through the use of Computer aided design or CAD and FEA. Finite element analysis or better known as FEA allows for simulated testing with the ability to apply different forces and loads to the driveshaft. The FEA then can highlight weak points and also provide data such as tensile strength (Zhao et al., 2019). While the tensile test that was performed in the lab provided an insight to the different properties of the aluminium alloy, it does include testing for the torsional stress and strength of the material.

Which material would be better suited for a driveshaft used in the Dakar Rally?

There is not one ideal material for a driveshaft as there are multiple variables to factor in and consider. Cost of manufacturing, weight and strength to list some of these variables. In motorsport, weight must be kept to a minimum to maximise performance. However, in a motorsport as demanding as the Dakar Rally, strength and cost of replacement are two of the more important variables to consider when deciding a material to use for the driveshaft. For these reasons, an aluminium alloy would be the best option due to it being lightweight, strong and cheaper than carbon fibre.

3 Methodology

This section of the report will demonstrate the methodology of the tensile test that took place in the lab of the UWTSD IQ building.

The Tensile tester:



Figure 1 - Image of the Tensile Tester used

Above is an image of the Tensile Tester. Fitted to the provided work panel, the Tensile Tester has a top and bottom chuck in which the test specimen can be securely fitted. Above where the specimen is fitted, there is a top plate. At the top surface of the tester, there is an adjustable load nut that can be turned to pull the top plate and top chuck upwards, stretching the test specimen. Below the bottom chuck is the Dial Indicator or DTI gauge with the pin on a small adjustable plate. Finally, there are two springs positioned below which are used in order for the Dial Indicator to measure the spring deflection which shows the force applied to the test specimen.

Setup:

Before the test is performed, the test must be set up correctly. First, the Tensile Tester must be secured to the test panel. Once the Tensile Tester is secured in place, the load nut must be adjusted to allow the test specimen to align with the top and bottom chuck. Once the top and bottom chuck are aligned with the test specimen, the test specimen can be securely fitted to the chucks via two screws fastened by an Alan key. At this point, the Dial Indicator

can be pre-loaded by adjusting the small adjustable plate below the pin. When the pin and plate have met, the plate must be adjusted upwards so that there is a slight load on the Dial Indicator. The last step of the setup is to then set the Dial Indicator to zero. This is done by adjusting the outer face until the Dial Indicator needle is aligned with zero.

Note: Due to the nature of the test and to avoid sharp fragments becoming projectile towards the users face or eyes, a safety guard is included and should be fitted into place each time.

Test Procedure:

During this test, each measurement taken from the Dial Indicator will need to be recorded onto the provided table. To begin, the load nut must be turned 0.2 of a millimetre. This will pull the top chuck upward, applying load to the aluminium test specimen, extending it with each turn. At this point, the measurement must be taken from the Dial Indicator and recorded. Between 0mm and 5mm the load nut movement was adjusted in increments of 0.2mm before then increasing to 1mm per load nut movement. This procedure is performed until the aluminium test specimen stretches beyond its elastic limits.

Additional Images:



Figure 2 - Image of aluminium specimen after failure



Figure 3 - Close-up image of the fracture

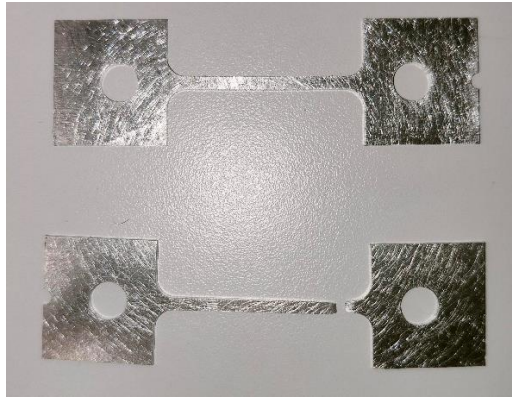


Figure 4 - Image comparing before and after testing

4 Test results

Table 1 - Aluminium specimen measurements

Specimen Material:	Aluminium
Original cross-sectional area (m²):	0.000002
Original Length (mm):	31

Table 2 - Table of results and calculated values

Load Nut Movment (mm)	Dail Indicator (mm)	Force (N)	Extension (mm)	Stress MPa	Strain ϵ	Extension Incremental (mm)
0	0	0	0	0	0	0
0.2	0.09	9	0.11	4.5	0.003548387	0.11
0.4	0.17	17	0.23	8.5	0.007419355	0.12
0.6	0.26	26	0.34	13	0.010967742	0.11
0.8	0.34	34	0.46	17	0.01483871	0.12
1	0.42	42	0.58	21	0.018709677	0.12
1.2	0.51	51	0.69	25.5	0.022258065	0.11
1.4	0.6	60	0.8	30	0.025806452	0.11
1.6	0.69	69	0.91	34.5	0.029354839	0.11
1.8	0.79	79	1.01	39.5	0.032580645	0.1
2	0.9	90	1.1	45	0.035483871	0.09
2.2	0.99	99	1.21	49.5	0.039032258	0.11
2.4	1.08	108	1.32	54	0.042580645	0.11
2.6	1.18	118	1.42	59	0.045806452	0.1
2.8	1.27	127	1.53	63.5	0.049354839	0.11
3	1.36	136	1.64	68	0.052903226	0.11
3.2	1.45	145	1.75	72.5	0.056451613	0.11
3.4	1.55	155	1.85	77.5	0.059677419	0.1
3.6	1.65	165	1.95	82.5	0.062903226	0.1
3.8	1.74	174	2.06	87	0.066451613	0.11
4	1.83	183	2.17	91.5	0.07	0.11
4.2	1.93	193	2.27	96.5	0.073225806	0.1
4.4	2.02	202	2.38	101	0.076774194	0.11
4.6	2.11	211	2.49	105.5	0.080322581	0.11
4.8	2.2	220	2.6	110	0.083870968	0.11
5	2.27	227	2.73	113.5	0.088064516	0.13
6	2.34	234	3.66	117	0.118064516	0.93
7	2.86	286	4.14	143	0.133548387	0.48

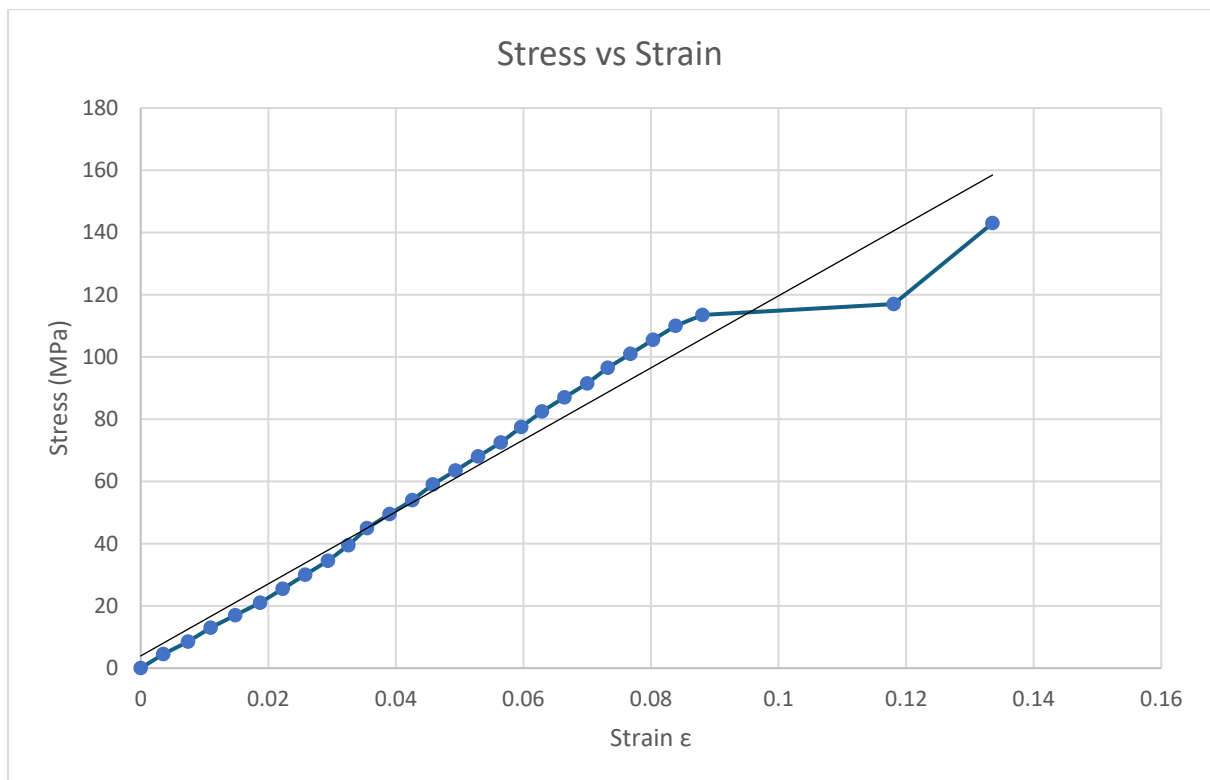


Figure 5 - Graph from recorded and calculated test results

5 Analysis

Table 3 - Table of calculated values

Tensile Strength (MPa):	143
Yield Strength (MPa):	110
% Elongation:	13.35483871
Youngs Modulus (GPa):	1.335

Yield strength (MPa): 110

This is the value of the last data point before the Aluminium specimen started to go past its elastic limits and start to permanently deform.

Tensile strength (MPa): 143

This is the final measurement recorded before the aluminium specimen failed.

Young's modulus (GPa): 1.335

Youngs modulus was calculated with the use of the gradient of a section of the graph. This section as seen in the graph below from the beginning of the tensile test to the point where the aluminium specimen began to permanently deform. This is called the elastic region, (TecQuiptment Ltd, 2012a). As this gradient would show the Young's modulus in MPa, it needed to be converted into GPa. This was done by dividing the original value of 1335 by 1000.

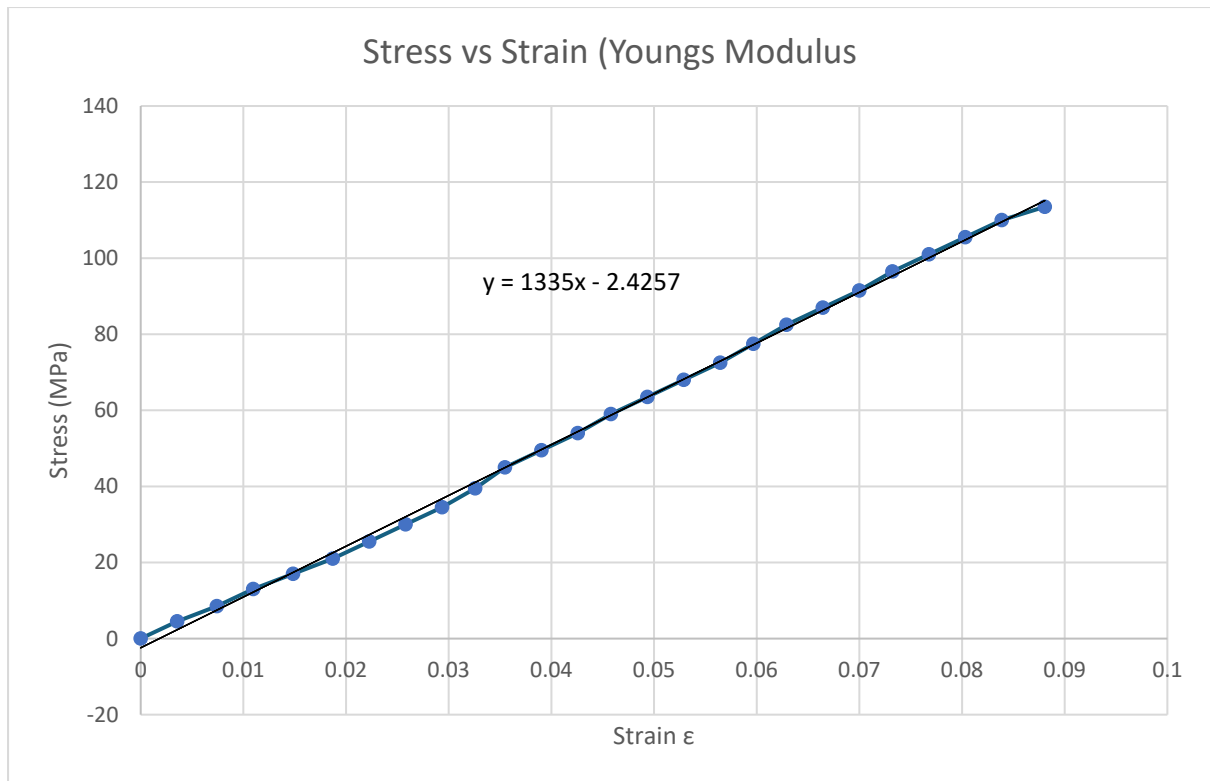


Figure 6 - A section of graph used to calculate Young's modulus

Expected graph shape vs Actual graph shape:

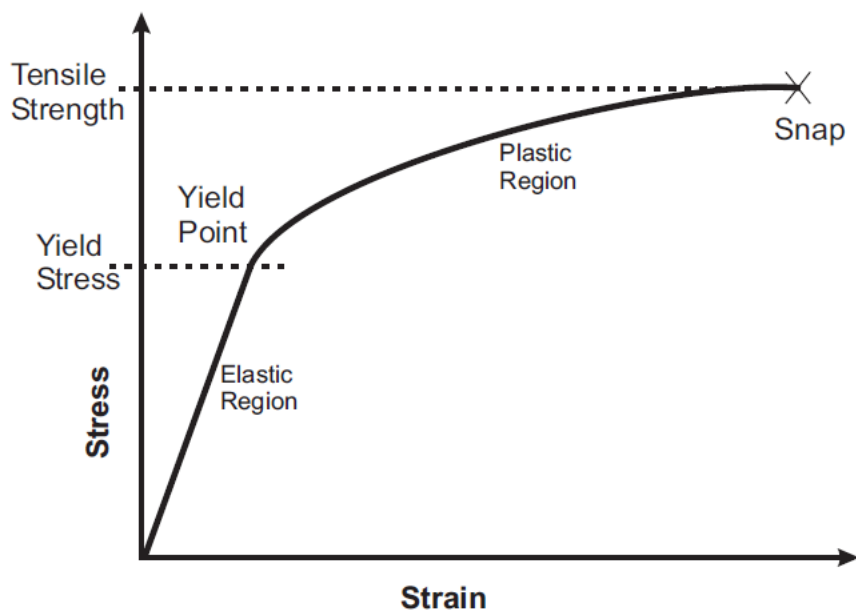


Figure 7 - Expected graph shape (TecQuiptment Ltd, 2012a)

Above is the expected shape of the graph. When comparing this with the graph from the measured and calculated results as seen in Figure 5 - Graph from recorded and calculated

test results the shape is similar towards the start, however it then abruptly jumps forward and then has an aggressive spike at the end. This is due to a mistake while measuring. While the provided table prompts the individual who is performing the test to record measurements in increments of 0.2mm, it then prompts the individual who is performing the test to do this up until and then take all further measurements in increments of 1mm on the load adjustment nut. Due to this, a lower resolution of data was recorded with only two data points on the graph being shown after the aluminium test specimen started to permanently deform. If all data was recorded in the original load adjustment nut increments of 0.2mm, the graph would have been smooth and more closely resemble the expected graph shape shown that is presented in *Figure 7 - Expected graph shape* (TecQuipment Ltd, 2012a)

How can the accuracy of this test be improved?

One way the accuracy of this tensile test could be improved is by the use of more expensive testing equipment that would perform the test and record the results digitally, providing the most accurate results possible. If this test was to be done by a tensile testing machine, the moment the test specimen fails would also be able to be recorded more accurately as human reaction speeds and movements are not as accurate as a calibrated machine (Zwickroell, n.d.).

Another way the accuracy of this test could be improved is by adjusting the increment of load nut adjustment from 0.2mm to 0.1mm. This will create more data points and create a more detailed table of results and a smoother graph.

To further improve the accuracy of this tensile test, the test can be performed a further two times, therefore performing the test a total of three times. This would then allow for errors in recorded measurements to be easily identified and any false results or if a test specimen is weaker than the others.

6 Conclusion

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