University of Kent

Astronomy, Space Science and Astrophysics

Stress & Strain

Stage 1 - PH370 Physics Labs

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Contents

1 Introduction

The purpose of this experiment is to test and measure multiple quantities listed in in 4 materials listed in . Each material will be tested to destruction first then tested to their individual yield points, which will allow for the Young's modulus to be found and each materials tensile stress, strain and yield stress. The purpose is to understand why certain materials are better suited for different purposes.

2 Aims & Equipment

2.1 Apparatus

- x4 Strips of mild steel
- x4 Strips of duralumin
- x4 Strips of aluminium
- x4 Strips of PVC
- x1 Mini tensile tester
- x1 Vernier caliper

2.2 Data Collected

- Tensile stress of each material
- Tensile strain of each material
- Percentage elongation of each material
- Young's modulus of each material

2.3 Risk Assessment

As this experiment involves testing samples of materials to destruction, the materials may splinter and become shrapnel which has the potential to cause physical damage to the operators hands/eyes and or any exposed upper body part. A guard will be used to keep the tested samples contained to stop shrapnel from causing harm to the operators, the guard is locked onto the test rig itself as an extra precaution. The materials & equipment can fall off the edges of the desk and inflict bruising or injury to the operators feet or any lower body part, this will be controlled by keeping all the equipment in the centre of the desk and away from the edges of the desk.

3 Experimental Procedure

3.1 Experiment Theory

Hooke's Law specifies that the strain in a material is directly proportional to the applied stress within the materials elastic limit. When a majority of solid materials are subject to tensile stresses, within the materials specific elastic limit will obey Hooke's law;

$$F = kx \tag{1}$$

Where;
F = Force
k = Spring constant
x = Length of extension/compression

Young's Modulus is a quantitative measure of the materials elasticity and or stiffness.

$$E = \frac{Stress}{Strain} \tag{2}$$

Where;
E = Young's Modulus
Stress = Force per unit area
Strain = extension/length

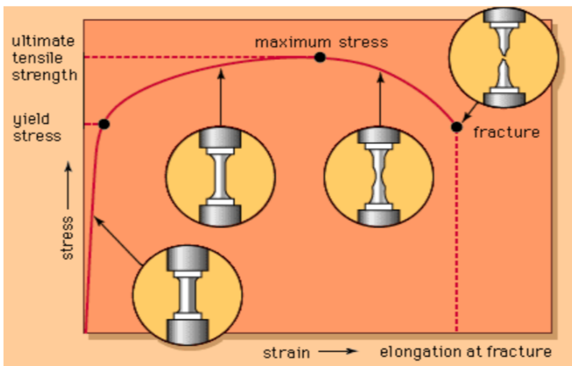

Figure 1: Behaviour of Extension.

The diagram above found in [1] is a graph showing a material being stretched or compressed and what happens to the material during the its test duration, the resulting graph from this experiment should be similar to this.

3.2 Experimental Method

In the first stage of this experiment was to test each four materials to destruction by stretching them past their yield points unto their fracture point as figure 1 shows. After the fracture point has been reached then another new piece of the same four materials will be tested individually and pushed only to their yield point. Using the data, the graph will be plotted found in section 4.1.

Using the graphs, the yield point, tensile stress/ strain can be found and calculate the percentage of elongation, this allows for further analysis of the data and to prove the hypothesis of why certain materials are better than other in certain job requirements.

4 Results & Discussion

4.1 Main Results

Aircraft fuselage are made of duralumin rather than aluminium due to the superior mechanical properties that duralumin has over aluminium. Duralumin is stronger and the same physical weight as aluminum which is imperative for an aircrafts fuselage which is exposed to harsh environmental effects. Even though it is an alloy of aluminium consisting of 94% aluminium, its surface is a thin layer of aluminium which gives duralumin its extensive corrosion resistance. This will be proved throughout the experiment.

The materials used in this experiment were in bag labeled as the following;

(Bag A) = (x4) PVC

(Bag B) = (x4) Mild Steel

(Bag C) = (x4) Aluminium

(Bag D) = (x4) Duralumin

4.2 PVC Sample

Using the mini tensile tester, two pieces of PVC strips were fitted and secured into the rig,

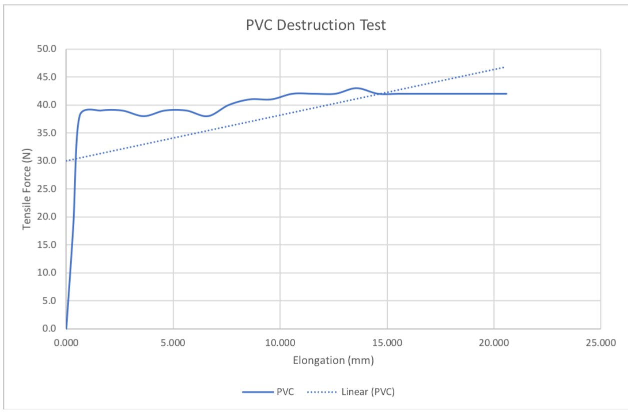

Figure 2: Data collected from PVC destruction.

The young's modulus is represented graphical using the trend line function.

Hooke's Law;

$$F = \frac{13.570}{14} = 0.969mm \tag{3}$$

Tensile Stress;

$$UTS = \frac{0.969}{2.05} = 0.473N/mm^2 \tag{4}$$

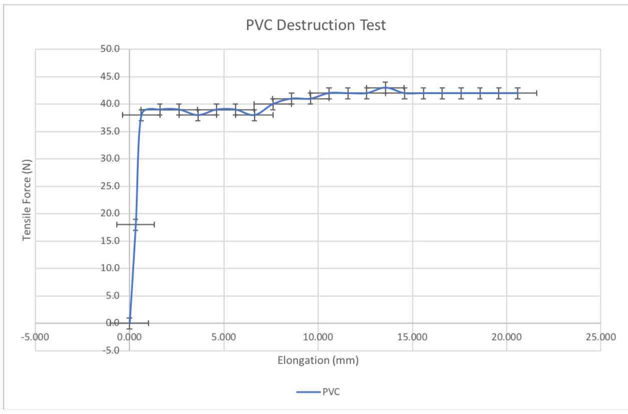

Figure 3: Data collected from PVC destruction with error.

[1]

4.3 Mild Steel Sample

Figure 4: Data collected from Mild Steel destruction.

The young's modulus is represented graphical using the trend line function.

Hooke's Law;

$$F = \frac{0.800}{11} = 0.072mm \quad (5)$$

Tensile Stress;

$$UTS = \frac{0.072}{2.11} = 0.034N/mm^2 \quad (6)$$

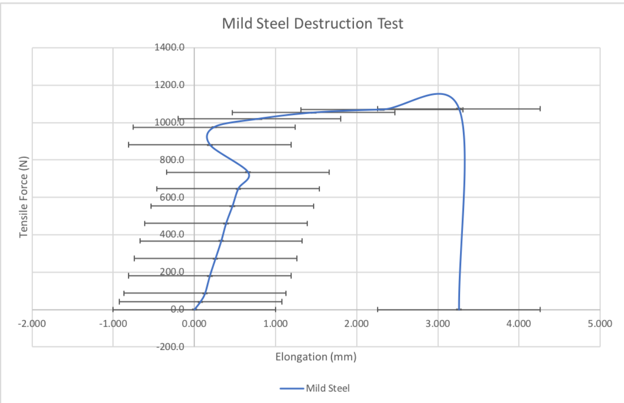

Figure 5: Data collected from Mild Steel destruction with error.

4.4 Aluminium Sample

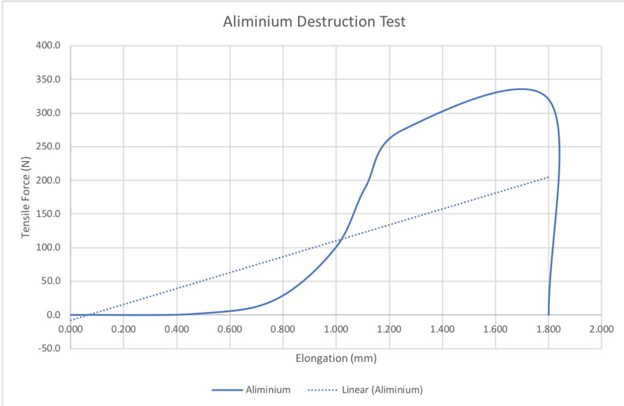

Figure 6: Data collected from Aluminium destruction.

The young's modulus is represented graphical using the trend line function.

Hooke's Law;

$$F = \frac{1.800}{5} = 0.360mm \quad (7)$$

Tensile Stress;

$$UTS = \frac{0.360}{2.2} = 0.163N/mm^2 \quad (8)$$

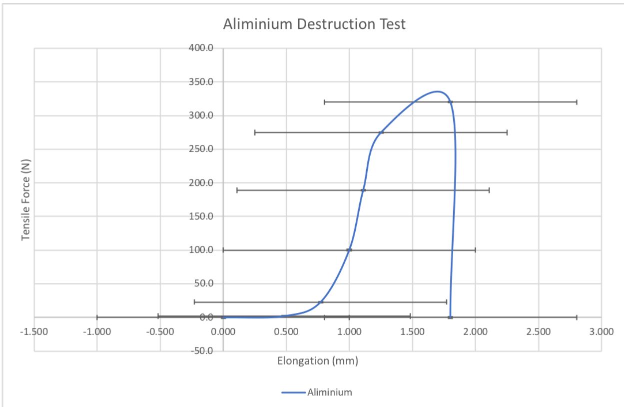

Figure 7: Data collected from Aluminium destruction with error.

4.5 Duralumin Sample

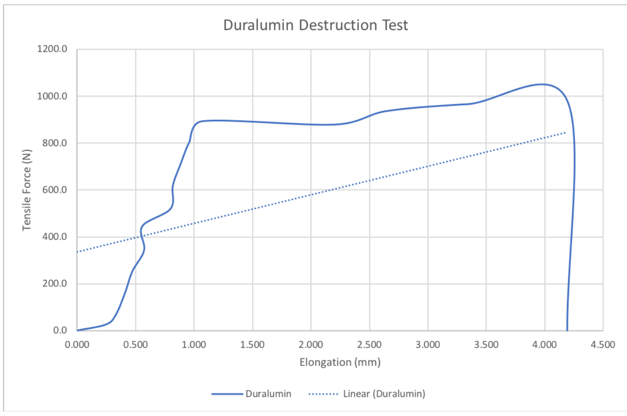

Figure 8: Data collected from Duralumin destruction.

The young's modulus is represented graphical using the trend line function.

Hooke's Law;

$$F = \frac{3.340}{13} = 0.257mm \tag{9}$$

Tensile Stress;

$$UTS = \frac{0.257}{2.0} = 0.129N/mm^2 \tag{10}$$

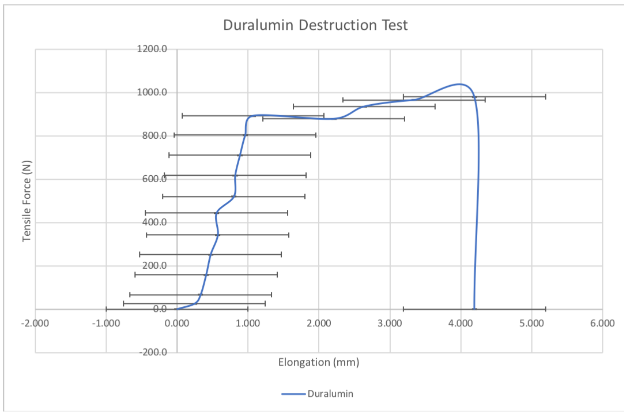

Figure 9: Data collected from Duralumin destruction with error.

5 Analysis

Through analyzing the graphs, it can be said that PVC is a very elastic material making PVC very malleable thus it has a high fracture point compared to the three metals that are have increased hardness making them brittle, thus proving why aircraft would use Duralumin instead of PVC as fuselage. Atomically the metals and PVC are both laid in a lattice structure but due to the elasticity of the PVC it stretches more than the metals as it more brittle and thats why the three metals reaches its fracture points faster than the PVC material.

References

[1] G. Roch. Llr.2 stress & strain. University of Kent Moodle 2017, June 2017. LLR.2 Lab script.