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Report 2 - Uniaxial Compression Test

* **Objective**
  - To perform compression test and determine
    - a) The machine compliance
    - b) The Young's Modulus ~~of Aluminium in compression~~ in compression and the complete true stress vs true strain.
    - c) The compressive flow strength at around 10% strain of aluminium sample

* **Experimental Methods:**

The instruments used are

a) The Universal Testing Machine (UTM):

This machine measures the load on the specimen during the experiment. The machine has two flat platens on the top and bottom between which the sample is sandwiched. Load cell is integrated with the top platen to calculate reaction force of the system. We could input the limiting parameter to be load or displacement as needed. Finally, it has an output device to display the results

b) Vernier Caliper:

Used to measure diameter of specimen before and after compression

c) Grease: Used to reduce friction and avoid buckling.

* **Results**

Compliance is the reciprocal of stiffness, the property of being flexible and easy to distort.

$$\boxed{C = \frac{\text{Displacement}}{\text{Load}}}$$

During the test, since ~~platen~~ platens and specimen are in series, $\boxed{C_{system} = C_{platens} + C_{specimen}}$

For steel: $m_{ms} = C_{machine} + \frac{L_{ms}}{Y_{ms} A_{ms}}$

where $L_{MS} = 0.01\ m$

$A_{MS} = 5.14 \times 10^{-4}\ m^2$

$Y_{MS} = 210\ GPa$

Slope of displacement vs load

$= 1.97 \times 10^{-8}\ mN^{-1}$

On calculating we find

$$\boxed{C_{machine} = \cancel{2.065 \times 10^{-8}}\ mN^{-1}}$$

$$\boxed{1.95 \times 10^{-8}\ mN^{-1}}$$

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The compressive flow strength at around 10% strain of Aluminium sample

$$\epsilon_{Al} = \frac{19.03 - l}{19.03} = 0.1 \Rightarrow \boxed{l = 17.127}$$

$$\text{Compressive Strength} = \frac{\text{Load}}{\text{Area}} = \frac{34310.22}{1.21\times10^{-4}} = \boxed{283.55\ GPa}$$

* True stress and true strain

$$\text{Engineering stress } (\sigma_e) = \frac{\text{Load}}{\text{Initial Area}} \quad \text{and} \quad \epsilon_e = \frac{\text{Elongation}}{\text{Length}}$$

$$\text{True stress} = \sigma_e(1+\epsilon_e) \qquad \text{True Strain} = \ln(1+\epsilon_e)$$

* Observations

Final Results : $C_{machine} = 1.95\times10^{-8}\ mN^{-1}$

$Y_{Al} =$ ~~86.3 GPa~~ 68.8 GPa

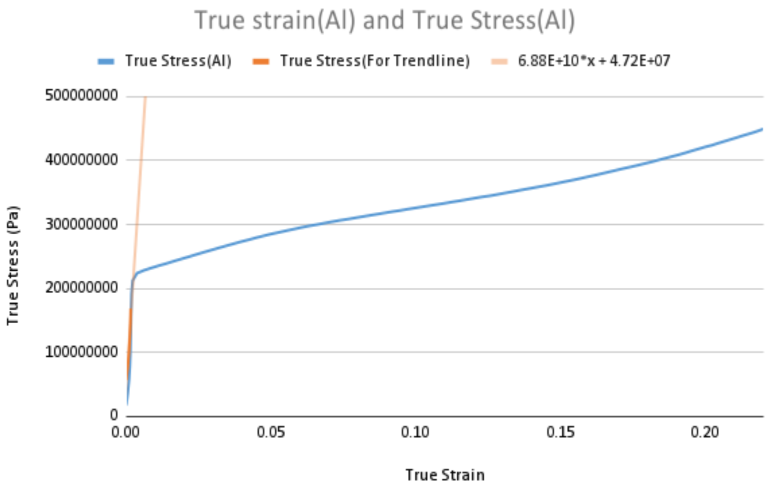
Compressive flow strength at 10% strain = 283.55 GPa

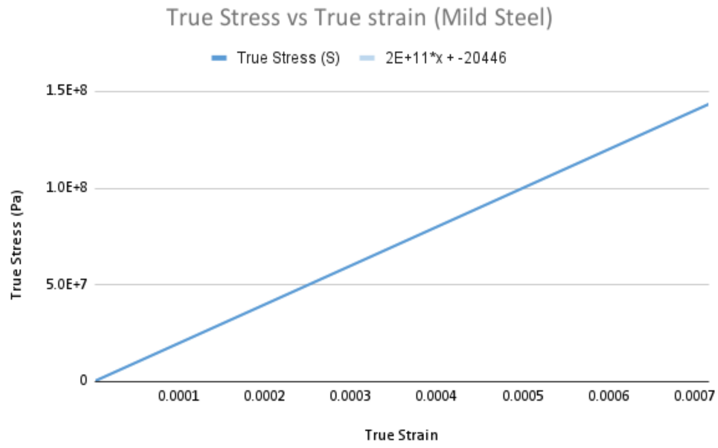
$$\text{Percentage Compression} = \frac{\text{Initial length} - \text{Final length}}{\text{Initial length}}\times 100 = \boxed{29.01\%}$$

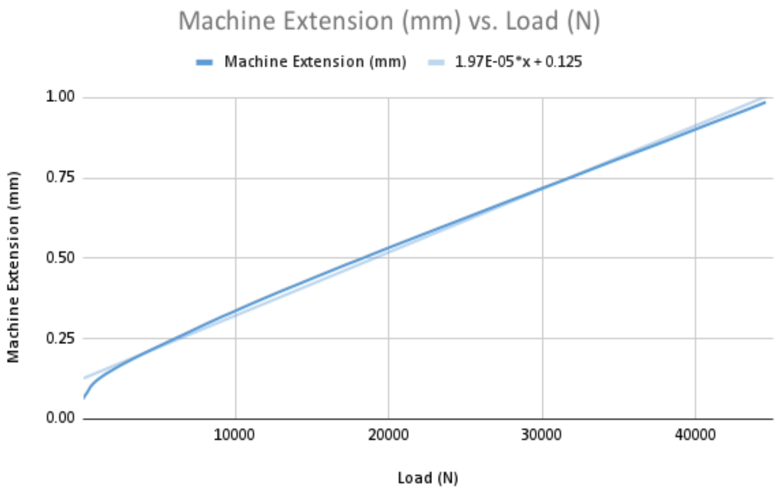
$$\text{Percentage increase in area} = \frac{\text{Final Area} - \text{Initial Area}}{\text{Initial Area}}\times 100 = \boxed{40.88\%}$$

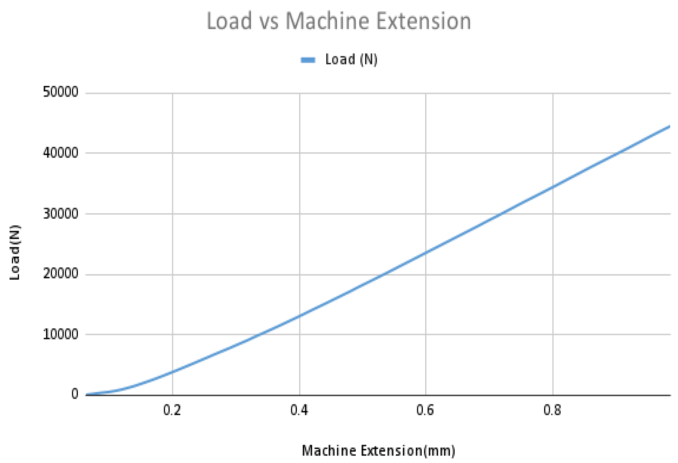
$$\text{Percentage error in } Y_{Al} = \frac{70 - 68.8}{70}\times 100 = \boxed{1.71\%}$$

We observe a significant change in the Aluminium specimen after the test. It compresses and bulges out, while no change is observed in the steel specimen. This is as steel was compressed within it's elastic region. The difference between experimental and theoretical values of ~~the~~ Y_{Al} may be due to crystal structure


True strain(Al) and True Stress(Al)
True Stress(Al)
True Stress(For Trendline)
6.88E+10*x + 4.72E+07
True Stress (Pa)
500000000
400000000
300000000
200000000
100000000
0
0.00
0.05
0.10
0.15
0.20
True Strain


True Stress vs True strain (Mild Steel)
True Stress (S)
2E+11*x + -20446
True Stress (Pa)
1.5E+8
1.0E+8
5.0E+7
0
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
True Strain


Machine Extension (mm) vs. Load (N)
Machine Extension (mm)
1.97E-05*x + 0.125
Machine Extension (mm)
1.00
0.75
0.50
0.25
0.00
10000
20000
30000
40000
Load (N)


Load vs Machine Extension
Load (N)
Load(N)
50000
40000
30000
20000
10000
0
0.2
0.4
0.6
0.8
Machine Extension(mm)