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EMCH 316
Lab #2

Tensile Behavior of a Ductile Metal

OBJECTIVE: To study the tensile behavior of a ductile metal under tensile stress. (Copper alloy)

PROCEDURE

1. Use the metric micrometer and the initial gauge-length of the specimen to measure the diameter of the dog bone specimen at the middle of the reduced section.
2. Install the specimen into the MTS Criterion testing machine grips and make sure that at least ¾ of the gripping clamp are in contact with the dog bone specimen.
3. Install the extensometer and place the zeroing pin on the sample. Take note of the initial gauge length of the extensometer.
4. Begin the test according to the instructions and ensure that while removing the zeroing pin doesn't disturb the extensometer's position when prompted.
5. When the sample has crossed the proportional limit, replace the zeroing pin and remove the extensometer.
6. After the sample fails remove it from the contraption. Measure the final diameter.
7. Finally, draw the sketch of the failed specimen and include the details of the fracture surface.

DATA AND RESULTS

Table 1 Copper Alloy Dimensions.

Quantity	Dimension (mm)
Initial Length, L_i	**91**
Sample Gauge Length, l_0	**91**
Extensometer Gauge Length, l_e	**25.44**
Thickness, t	**1.4**
Notch Width, w	**12.87**

Table 2 Load, Elongation, Stress and Strain Data.

Load N	Crosshead Elongation, ΔL_{CH}	Extensometer Elongation, ΔL_{EX}	Stress MPa	Crosshead Strain, ε_{CH}	Extensometer Strain, ε_{EX}
43.38699	0.005002923	0.000614313	2.407713	5.50E-05	2.41475E-05
66.32717	0.007385267	0.000962144	3.683077	8.12E-05	3.78201E-05
86.32717	0.009886728	0.001299087	4.790631	0.000108645	5.10647E-05

Figure 1. Fracture Surface

Figure 2. Full Data Plot (Crosshead)

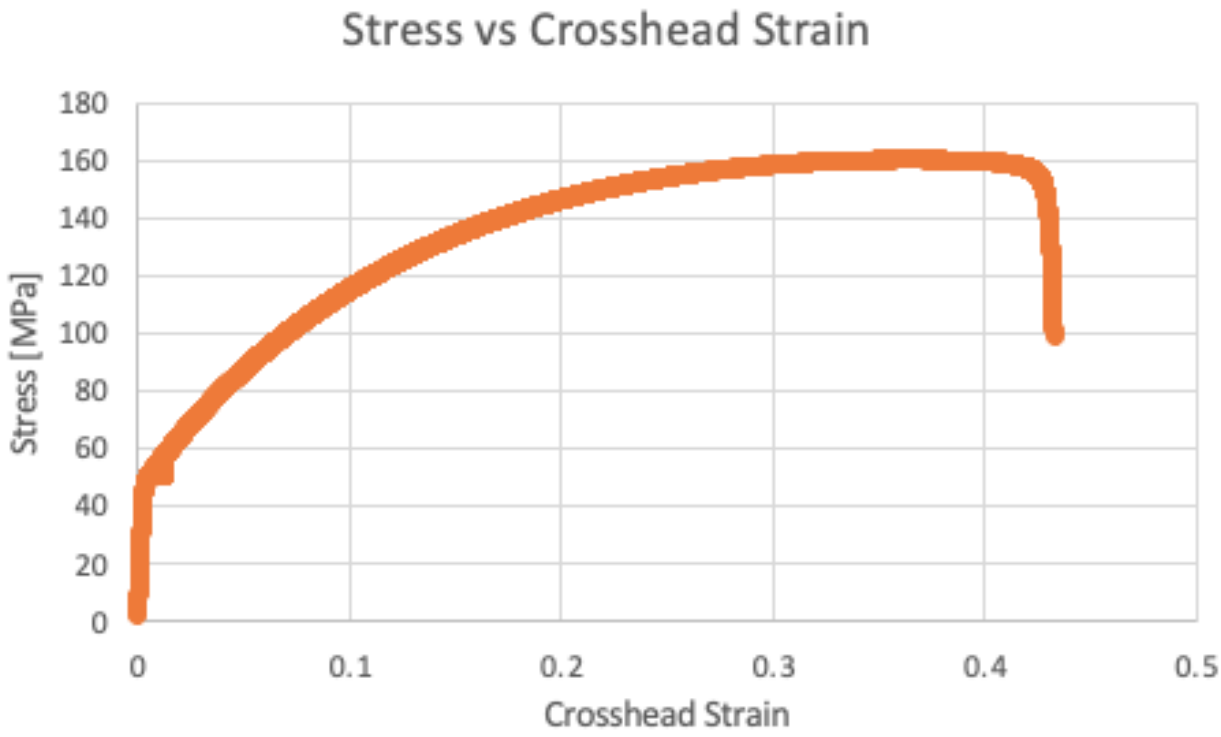
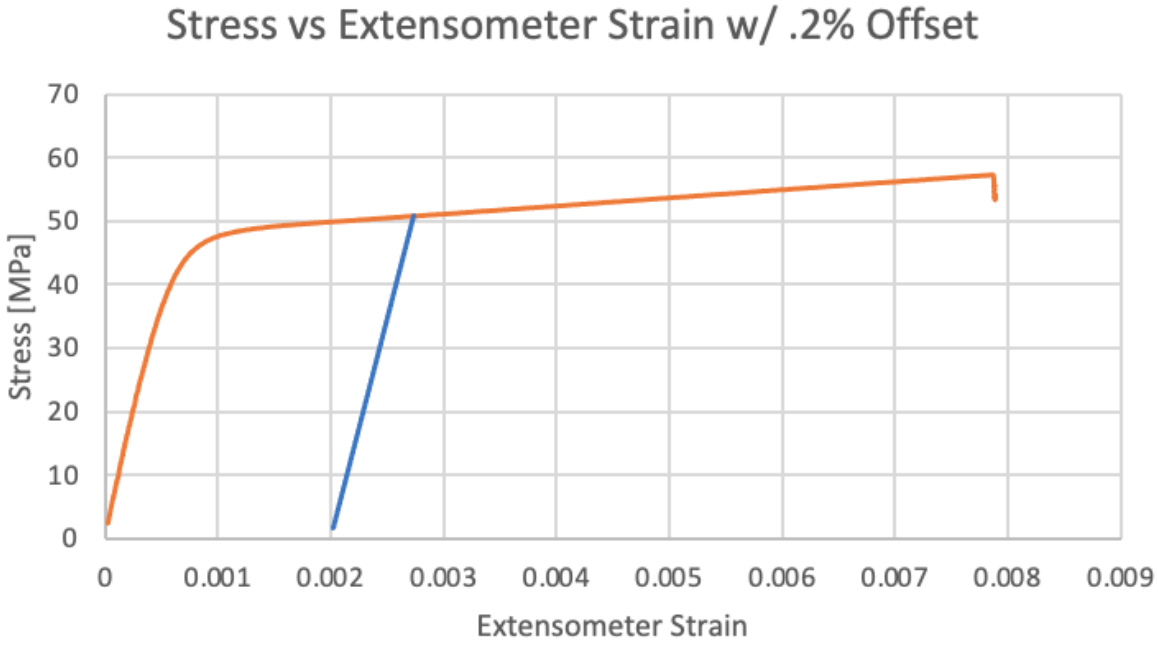


Figure 3. Yield Strength Plot (Extensometer)



ANALYSIS OF DATA

- **Determination of specimen Area:**
  Area = w*t = 12.87*1.4=18.02mm^2
- **Sample Calculation of Stress & Strain:**
  σ=P/Ao = 43.38699/18.02=2.408 MPa
  $\varepsilon=\Delta L/L$ = 0.005002923/91=5.4977*10^{-5}

- **Determination of Modulus of Elasticity, E**
  Stress/Strain = 2.408/(5.4977*10^{-5})=43800MPa

- **Determination of 0.2% Offset Yield Strength, σy:**
  From the graph = 51MPa
- **Determination of Ultimate Tensile Strength, σu:**
  From the graph = 159.3MPa
- **Determination of Percent Elongation, ε%:**
  E_f*100=(0.4327*100)=43.27%
- **Determination of Modulus of Resilience, Ur (estimate σP first):**
  σP = 49MPa
  $U_r = (\sigma_p^2)/(2E)=(49*49)/(2*43800)=0.274086$
- **Determination of Modulus of Toughness, UT:**
  $Ut = (\sigma_u + \sigma_y)* \varepsilon_f/2=(159.3+51)*0.4327/2=45.5$ MPa
- **Determination of Toughness, T:**
  blocks from the graph =58.15 MPa
- **Determination of Percent Reduction in Area:**
  N/A

DISCUSSION OF RESULTS

1. Was the deformation of the specimen entirely uniform? Explain.
   a. No, the deformation of the specimen was not uniform because from the graph we can deduce that the stress and strain curve behave differently with different loads. The stress v/s strain curve was linearly going up till the proportional unit, after the yield stress the curve started curving downward and became flat.

2. Was ratio of the gauge length to diameter ratio appropriate by ASTM standards? (at least 4:1 ratio)
   N/A

3. Does Copper Alloy work harden? If so, to what degree. Explain in detail.
    a. Yes, it does, as the specimen elongates the size of the grain decreases which makes the material harder but brittle which is why it breaks. The hardening is very minimal.

4. How did the Modulus of Toughness compare with the Toughness? In what type of material is the Toughness exactly equal to the Modulus of Toughness?
    a. The modulus of toughness was calculated to be 45.5MPa and the toughness was 58.15MPa which makes the modulus of toughness lesser than toughness. The material which can deform infinitely will have the toughness equal to modulus of toughness.

5. Describe the fracture surface of the specimen? Is this expected? Be sure to refer to Figure 1
    a. As we can observe in figure 1, the specimen fracture, the surface of the fracture was lighter reddish brown, and we can see the fibers of Copper at the fracture surface.

CONCLUSIONS

This experiment demonstrated how metals behave to tensile load. We plotted the stress strain curve from the data given by the MTS Criterion Model 43. The experiment showed how a sample of Copper Alloy yields under load.