California State University, Long Beach

Department of Mechanical and Aerospace Engineering

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Lab Report
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Experiment Number: 5
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Title: TENSILE TEST OF METALS AND POLYMERS

Course Number: MAE 361
Section Number: Sec 03
Class Number: Eng 4 125

Instructor: Dr. Shamim Mirza

OBJECTIVE

Clearly state objectives of the experiment. Materials used in the experiment should also be specified. Specify the heat treatment of each material. (4points)

The objective of this experiment is to observe tensile properties of engineering which include the modulus of elasticity, yield stress, tensile stress, rapture stress, modulus of resilience, elongation, and % reduction in area. The materials being observed include brass, steel, and aluminum where their tensile tests are conducted on a tensile test machine and where their experimental tensile property values are compared to their standard tensile values.

PROCEDURE and LIST OF APPARATUS

Materials used in procedure - Steel, brass, aluminum.

A tensile test is done by placing a sample under controlled tension where the load is gradually increased until the sample fractures. This is done to observe the tensile properties previously mentioned in the objective.

1. Measure the initial diameter and length of each specimen using the digital calipers.

2. Turn on the tensile testing machine, computer, and monitor.

3. Press the on switch and start switch on the doghouse of the test machine.

4. Software related set-up on the monitor is done by the professor.

5. Load the specimen into the grip insert where at least 90% of the threads are in.

6. Jog the testing machine to fit the specimen in the grip holder.

7. Attach the extensometer to the specimen and mark the specimen with a marker where it touches the edges of the extensometer.

8. At 3% strain, remove the extensometer, then continue the test until the specimen fractures.

9. Remove the specimen from the grip insert.

10. Put the fractured specimen back together and measure the length between the marks. Also measure the diameter of the smallest cross-section area of the fractured specimen.

11. Retrieve the force vs extension graph seen on the monitor via usb for data use.

12. Repeat the process for each specimen used.

Figure 1: Aluminum, Brass, and Steel Specimen (From Left to Right)

Figure 2: United SMF-120 Tensile Test Machine

Figure 3: Extensometer

Figure 4: Monitor Connected to Tensile Machine

Figure 5: Pittsburgh Digital Caliper

DATA & RESULTS

A. You should give the original diameter and dimensions after fracture. The graph and data table obtained during the experiment should be included in this section, not at the end of the report. B. You should fill out the table given in the lab manual and put it in this section. You have to calculate rupture load using rupture strength from the graph and the original area. Rupture strength is the lowest point of the straight line at 3% strain. (10 points)

Table 1: Raw Data for Steel, Brass, and Aluminum (Where D_o is initial diameter, L_o is initial length, D_f is final diameter, and L_f is final length)

Steel (in)	Brass (in)	Aluminum (in)
D_o=0.505 L_o= 2 D_f=0.403 L_f=2.23	D_o=0.505 L_o= 2 D_f= 0.353 L_f=2.646	D_o= 0.505 L_o= 2 D_f=0.350 L_f=2.443

Figure 4: Fractured Steel, Brass, and Aluminum Specimen After Tensile Test (From Left to Right)

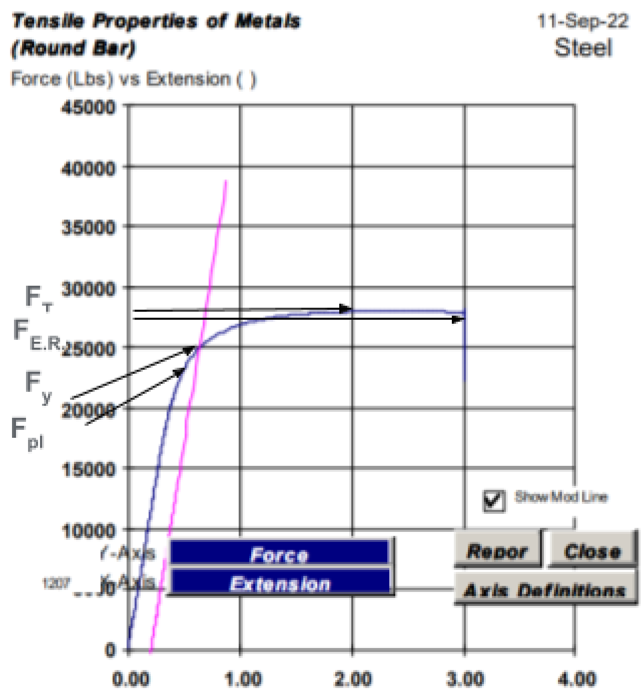

Figure 5: Aluminum Force Vs Extension Graph

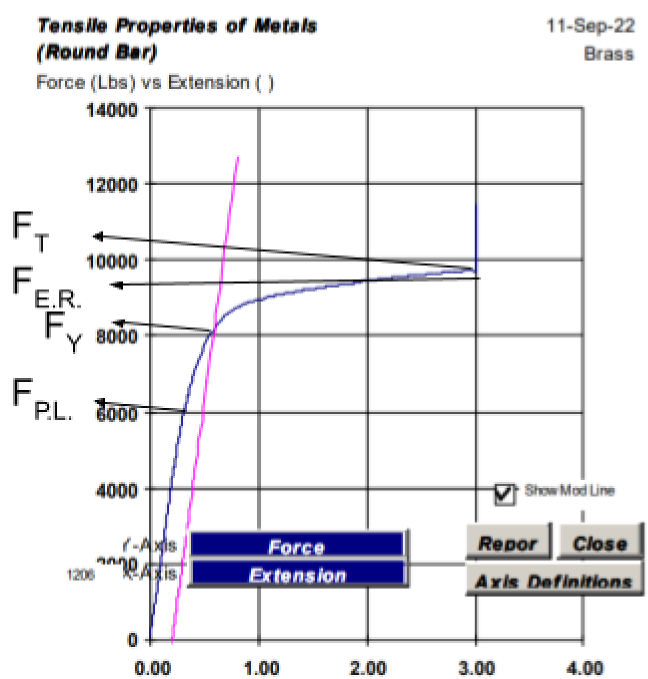

Figure 6: Brass Force Vs Extension Graph

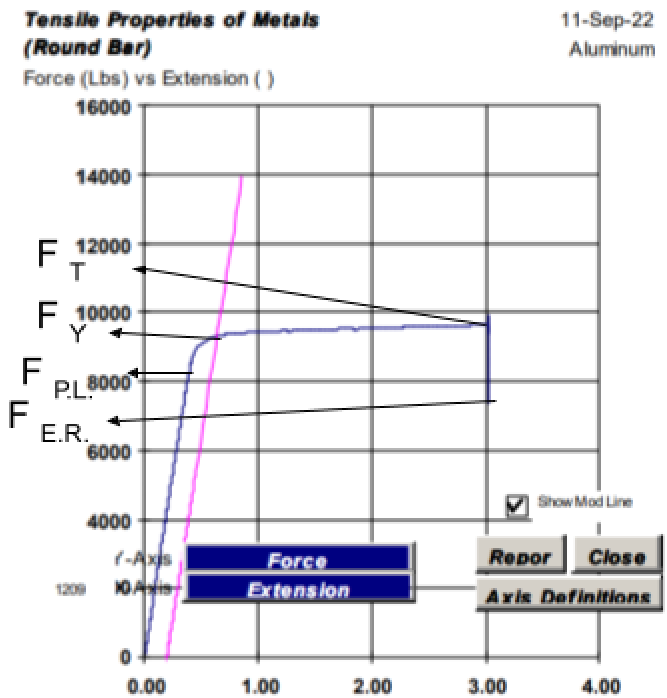

Figure 7: Steel Force Vs Extension Graph

SAMPLE CALCULATIONS FOR STEEL

In this section, you should show how you calculated the amount of ductility, true stress at fracture and modulus of resilience. You should specify which material you are using for the sample calculation and show results for the other materials in the table. (10 points)

Initial Cross Sectional Area = $A_o = \pi(D_o/2)^2 = \pi(0.505/2)^2 = .2003\ in^2$

Final Cross Sectional Area = $A_f = \pi(D_f/2)^2 = \pi(.403/2)^2 = .1276\ in^2$

% Elongation = $(\Delta L/L_o) * 100 = (L_f - L_o)/L_o * 100 = (2.23 - 2)/2 * 100 = 11.5$ %

% Reduction in Area = $(\Delta A/A_o) * 100 = (A_o - A_f)/A_o * 100 = (.2003 - .1276)/.2003 * 100 = 36.3$ %

Modulus of Elasticity = $E_{exp} = \sigma_{PL} / \mathcal{E}_{PL} = 8{,}200/0.2003 / ((2*0.3/100)/2) = 13{,}646$ ksi

% Error = $(E_{st} - E_{exp}) / E_{st} * 100 = |(29007-13{,}646)|/29007*100 = 53\%$

Yield Stress = $\sigma_y = F_y / A_o = 9300/(.2003) = 46{,}431$ Pa

Tensile Stress = $\sigma_T = F_T / A_f = 9{,}600/(.1276) = 75{,}261$ Pa

Engineering Rapture Stress = $\sigma_{ER} = F_{ER} / A_f = 7{,}500/(.1276) = 58{,}797$ Pa

% Diff. Between σ_T and σ_{ER} = (σ_T - σ_{ER}) / σ_T *100 = (75,261-58797)/75,261*100= 21.88%

Modulus of Resilience = U_r = (b*h) /2 = ((2*.6/100)*(46,431))/2= 279

Table 2: Calculated values for each sample

	Steel	Aluminum	Brass
Initial XA	0.200	0.200	0.200
Final XA	0.128	0.098	0.096
%Elong	11.500	32.300	22.150
%RedArea	0.363	0.511	0.520
Modulus of E	13646.459	39940.854	9985.214
%Error	52.955	42.942	65.577
Yield Stress	46431.243	124815.170	40440.115
Tensile Stress	75261.221	286100.581	101859.164
E.R. Stress	58797.829	275882.703	98741.026
%Diff T.S. E.R.S.	21.875	3.571	3.061
Mod. of Res.	278.587	748.891	242.641

DISCUSSION

Make a Table and compare values of tensile strength, yield strength, ductility, and modulus of elasticity with published values and specify the percent of error. Discuss different types of fracture seen in each specimen. Specify possible sources of error. Compare ultimate tensile strength with true fracture strength. (10 points)

Table 3: Comparing experimental values to references

Material/Values	Exp. Al	Ref. Al (7068)	% error	Exp. Brass	Ref. Brass	% error	Exp. Steel	1060 Steel	% error
Tensile Strength (psi)	286,100	93	207	101,859	71,500	42	75,261	89,900	16
Yield Strength (psi)	109,837	85.7	28	40,440	45,450	11	46,431	70300	56
Ductility (%)	32.3	8	300	22.2	50	56	11.5	10	15
Modulus of Elasticity (ksi, Average of range)	39,940	70,000	42	9,985	17,000	41	13,646	30,079	54.6

In terms of tensile strength, aluminum by far had the highest, and when compared to known values the percent error for aluminum was 207 %, 42 % for brass, and 16 % for steel. Aluminum again had the greatest yield strength over double the other materials. The aluminum had a percent error of 28 %, brass had 11 %, and steel had 56 %. Aluminum had the greatest ductility and had a percent error of 300 %, brass having 56 %, and steel 15 %. Finally, aluminum had the greatest modulus of elasticity, resulting in a percent error of 42 %, 41 % for brass, and 54.6 % for steel.

A possible source of error could have been misaligned specimens when loaded into the machine. This would result in an uneven distribution of the load. Another possible source of error is not threading the specimen into the holders far enough. If this was the case, the threads in the specimen would start to yield before the intended portion of the material, resulting in a seemingly weaker material. All three materials had long neckings and the ultimate tensile strength of all 3 materials was nearly identical to the true fracture strength.

ANSWER TO INSTRUCTOR'S QUESTIONS

1. Compare and contrast the set of graphs. Discuss the differences in: a. Modulus of elasticity. b. Proportional limit. c. Yield point or yield strength. d. Ultimate Strength e. Modulus of Resilience Write down the definition of each term and put the values in a Table (10 points).

The aluminum sample had the highest calculated modulus of elasticity which matches with it having the highest percent elongation.

2. What properties, if any, of the material, are altered in this test? How and why does this occur? (4 points)

The tensile test affects the elasticity of the material being tested. This happens because the tensile test forces the material to surpass its elastic limit. The tested material will no longer hold the original modulus of elasticity once it has been permanently deformed.

3. Discuss the type of fractures which occurred in the different material. Discuss the variation of the load with deformation, yield point, and type of fracture in each specimen. (6 points)

The steel sample underwent a ductile fracture with the biggest load of 286,100 psi and highest yield of 109,837 psi. The brass sample underwent a ductile fracture with the smallest load of 71,500 psi and lowest yield of 40,440. The aluminum sample underwent a shear fracture with a load of 89,900 psi and a yield of 46,431 psi.

4. What additional measurements in the experiment would have been necessary to calculate Poisson's Ratio? State a suitable value for steel. (4 points)

In order to determine Poisson's ratio it would be necessary to measure the lateral strain on the material samples.

5. What is understood by the terms “elastic” and “inelastic” behavior? Give examples from the experiment. (4 points)

Elastic behavior is when the material returns to its original state (width, length) in comparison to inelastic behavior where the material maintains permanent deformation from the forces inflicted.

6. Compare the stress in the bar at rupture as computed from the area at the break with the ultimate strength obtained for the material. Explain your results. (3 points)
The rupture stress was extremely close to the ultimate strength. This is because the ultimate strength is literally the limit to what the material can hold. Going above that strength is precisely why the rupture occurred.

7. A member whose diameter is 15mm elongates 0.39mm in a gage length of 100mm under a load of 30kN. Find the modulus of elasticity and the strain energy per unit volume at this load. (6 points)

$\sigma = F/A = 30000 / ((\pi/4) * .015^2) = 169{,}765{,}272.6$ Pa

$\mathcal{E} = \delta L / L = .39/100 = .0039$

$E = \sigma / \mathcal{E} = 169765272.6 / .0039 = 4.353*10^{\wedge}10$

S. E. per unit vol. $= 0.5 * \sigma * \mathcal{E} = 0.5 * 169765272.6 * .0039 = 331{,}042.28$

8. Why is extensometer required for the tensile test of metals and alloys? Why did we not use extensometer for the tensile test of plastics? (4 points)

An extensometer was required for metals and alloys because their length changes by very small amounts when under controlled tension that may be difficult to notice without the device. Although plastics were not part of the experiment, their changes under tension are more drastic which is why they may not need the device. Because they break with little force, the extensometer would not have been able to measure accurately.

RECOMMENDATIONS AND CONCLUSIONS

The experiment would be better if students were given the alloys ahead of performing it, along with their theoretical modulus of elasticity, yield stress, and tensile stress. Even though it defeats the mystery, it helps the students know if their calculations are incorrect or if there is instrumentation or human error instead. Thus, inconsistencies can be caught earlier and be fixed accordingly.

REFERENCES AND ACKNOWLEDGEMENT

Ehsan Barjasteh and Parvin Shariat (Editors), *MAE 361 Materials and Properties Laboratory Manual*, Mechanical and Aerospace Engineering Department, CSULB, January 2018.

William D. Callister, Jr. & David. D. Rethwisch, *Materials Science and Engineering: An Introduction*, any Edition, Wiley.

Aluminum chosen: https://www.azom.com/article.aspx?ArticleID=8758

Brass chosen: https://www.azom.com/article.aspx?ArticleID=6409

Steel chosen: https://www.azom.com/article.aspx?ArticleID=6542