MSE170 | U. Washington

Fundamentals of Materials Science

LAB V
MECHANICAL TESTING

Study Questions:

1. The following engineering stress-strain data points were obtained for a 0.20% C plain-carbon steel:

Stress (MPa)	0	207	379	414	469	496	510	524	517	503	476	448	386	352
Strain (%EL)	0	0.1	0.2	0.5	1.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	19 fracture

   a. Plot the stress strain curve.
   b. Determine the ultimate tensile strength of the alloy
   c. Calculate the elastic modulus of the alloy
   d. Determine the 0.2% offset yield stress of the alloy
   e. Determine the percent elongation (%EL) at fracture
   f. What kind of behavior is demonstrated – ductile or brittle?

2. Using the ASM and ASTM handbooks online or in the engineering library, compare the values you calculated in question 1 above to the reference values.

3. Sketch your approximation of the stress strain curves of the following materials on one plot.

   - 1018 Steel
   - 2024 Aluminum
   - Carbon Fiber
   - Nylon 6,6
   - 360 Brass
   - 316 Stainless Steel
   - 4340 Steel

   From your sketch, it should be easy to compare the yield strength, ultimate tensile strength, ductility, and elastic modulus of the materials. Label the stress/strain curves with the names of the materials.

Mechanical Testing

I. Purpose:

- To observe a tensile test and be able to analyze the results.
- To explore the relationship between a material's yield strength, ultimate tensile strength, and ductility and the underlying microstructures.
- To apply your knowledge of materials properties to a specific application choice.

II. Sample Preparation

Each lab group will test four materials: steel (one of 304 stainless, 1018, or 4340), 360 brass, Aluminum 6061 and high density polyethylene (HDPE) during the lab period. In addition, each lab section will receive data for the samples that they did not test, as well an additional carbon fiber sample, to form a complete set.

1. Using calipers, measure the initial gauge length and cross sectional area of each sample.

III. Experimental Procedure:

Using the Instron, you will generate a stress/strain curve for each sample by applying a tensile load to the sample, and steadily increasing the load until the sample fractures. (To help achieve consistent and meaningful results, your TA may perform 1 or more of the following steps for you.)

1. Using the proper mounting pins, attach the grips to the load cell and the base, and then zero the load cell.
2. Mount your first sample into the grips with the proper gauge length (the length of material placed under tension). This should be the length you measured previously.
3. Apply a small 1-10N load using the fine adjustment. This will take the slack out of the system. Re-tighten the grips. Zero gauge length using the fine adjustment (not the software!).
4. Using a 2.5mm/min strain rate, separate the two cross heads in order to apply tension to the sample. Load the sample until fracture. Note any necking that occurs. Note any surface appearance changes during testing.
5. Without damaging the sample, remove it from the Instron. Note the type of fracture (brittle or ductile) and the fracture geometry (cup and cone or flat)
6. Make sure that the full set of class Instron data is emailed to you.

IV. Analysis and long format report (due Friday 5/28 at 12:00 pm):

In your long format lab report, you will discuss which of the materials you tested (as well as those tested by the other labs) would be best suited for use in a functional component. Choose a component from the following list:

- Airplane bolts and bridge bolts
- Bicycle frames
- Outdoor building supports for buildings in Arizona and in Maui
- Car frames
- Drill bits

- Offshore oil well piping operating at 1000 psi and indoor plumbing operating at 50 psi
- A nuclear reactor shell for a reactor operating at 2000 psi

To help you choose the best material for your component, you should first perform the following analysis:

1. During the lab, you generated tensile stress and strain data, a stress/strain curve, and an estimate of modulus of elasticity for each material you measured.
2. Using your data, determine the yield strength, ultimate tensile strength and % elongation at fracture for each material in the full set.
3. Using your book, the ASM handbook, the ASTM handbook, Matweb and the engineering library resources, compare your measured values in question 2 above to reference values. Explain any differences you find.

Armed with the above information, you should be able to make an informed decision about your component. If you wish, you may also consider additional materials, not tested in the lab. Locate the relevant properties for any additional materials from respectable references, such as those listed in 3 above. However, you MUST perform the properties analysis for the materials you tested and present the data in your report.

Remember, there are specific formatting guidelines for the long format lab report. These are detailed on the course website. There is also a set of grading criteria that may help guide you while you write. **Please do not hesitate to ask your TA if you have any questions about formatting your report!**

VI. References:

1. E.C. Subbarao, et al., **Experiments in Materials Science**. *McGraw-Hill*, New York, (1972).
2. George L. Kehl, **The Principles of Metallographic Laboratory Practice, 3rd ed.** *McGraw-Hill*, New York (1949) 232-240.
3. L. Van Vlack, **Elements of Material Science and Engineering, 6th Ed.** *Addison Wesley*, Reading, MA (1986) pp. 257-262, 292-304.