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 knowledge of materials properties to specific application choices.
- To organize and present your knowledge and understanding of these concepts in an oral presentation.

II. Sample Preparation

Seven different tensile testing samples will be tested during each lab period. At the end of the period, all of the data will be pooled together and emailed to you.

1. Using calipers, measure the initial gauge length and cross sectional area of each sample.
2. Mount the samples in the proper grips.

III. Experimental Procedure (Day 1):

1. Place the first sample into the Instron. Using the pins, attach the grips to the load cell and the base.
2. Once the load cell and gage length are re-zeroed, apply a small 1-10N load using the fine adjustment. This will take the slack out of the system. Re-zero the load cell and gage length.
3. 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.
4. 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).

III. Wrap Up (Day 1)

Make sure that the class Instron data is emailed to you and everyone in your group.

At the end of the first lab day, your group will select one of the following components. In two weeks your group will give a 10 minute oral presentation on which of the materials tested should be used for your component.

1. Airplane bolts and bridge bolts
2. Bicycle frames
3. Outdoor building supports for buildings in Arizona and in Maui
4. Car frames
5. Drill bits
6. Offshore oil well piping operating at 1000 psi and indoor plumbing operating at 50 psi
7. A nuclear reactor shell for a reactor operating at 2000 psi

No two groups in the same lab section should have the same component.

IV. Analysis (due one week after Instron day):

1. Using the class data, convert the tensile extension to strain. Convert the force to stress.
2. Plot the stress strain curves for each material. Determine the yield strength, ultimate tensile strength, elastic modulus, and % elongation at fracture for each material.
3. Using your book, the ASM handbook, the ASTM handbook and the engineering library resources, compare your measured values in question 2 above to reference values. Explain any differences you find.

V. Computer Lab research (Day 2)

Use this time to research other properties of your materials and prepare your ten minute presentation.

Properties Research:

- What properties are important for your component?
- What materials are you going to find the properties for?
- What are reliable reference sources for this information?
- Find images which show the expected microstructure for the materials that you select for your component.

Prepare your presentation:

- Make sure you have a title side at the beginning and a reference slide at the end.
- Construct between 8 and 15 slides. Remember the presentation is only ten minutes long.
- Organize your presentation with an outline and conclusion
- Practice and prepare notes
- Be prepared to explain the microstructures seen and explain their morphological features.

V. Presentation (Day 3)

Imagine that you are giving a presentation to your boss to explain how and why you selected a specific material choice for the component that you were assigned to design.

Your presentation will discuss what your component is and the stresses/ environment it is exposed to during service. You will then present your material selection (from the materials tested in class). Explain why you selected the material you selected. Explain how you would order the material you selected. What microstructural features would be desirable to maximize the materials performance? How much would this material cost?

As a guide for your presentation, look to answer the following questions:

- Why is the material of selection preferable to the other options?
- What material properties or other criteria make this the appropriate selection?
- Why does the material you selected have the properties that you desire?

- What is the expected microstructure for your selected material?
- How does the microstructure create the desired combination of properties?

Your group will give your presentation on the last day of lab to your TA and to the other lab teams in your lab section. The presentation should be at least ten minutes in length. Each group member should share responsibility for part of the presentation.

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.