MSE170 — U. Washington

Fundamentals of Materials Science

LAB III
COLD-WORKING AND ANNEALING OF BRASS

Study Questions:

1. Using a stress-strain curve, define and describe the following terms:
   a. yield stress
   b. tensile strength
   c. ductility
   d. toughness
2. Consider a piece of metal being deformed in tension
   a. Shown is a typical stress-strain curve for this material (Fig 1). Label the yield stress and ultimate tensile stress.
   b. Show how you would calculate the ductility from the stress-strain curve.
   c. Rank the values of the hardness for the following strains: 0.005, 0.01, 0.025, 0.045, and 0.075.
3. Lead remains ductile if worked at room temperature, while copper hardens significantly. Explain.
4. Draw comparative stress-strain curves for a soft and ductile metal like Cu, a mild steel, and a cast iron.
5. Consider a FCC unit cell. Identify a slip plane and slip direction. Together they make up a "slip system". How many equivalent slip systems does the FCC structure have? Why are slip systems important?

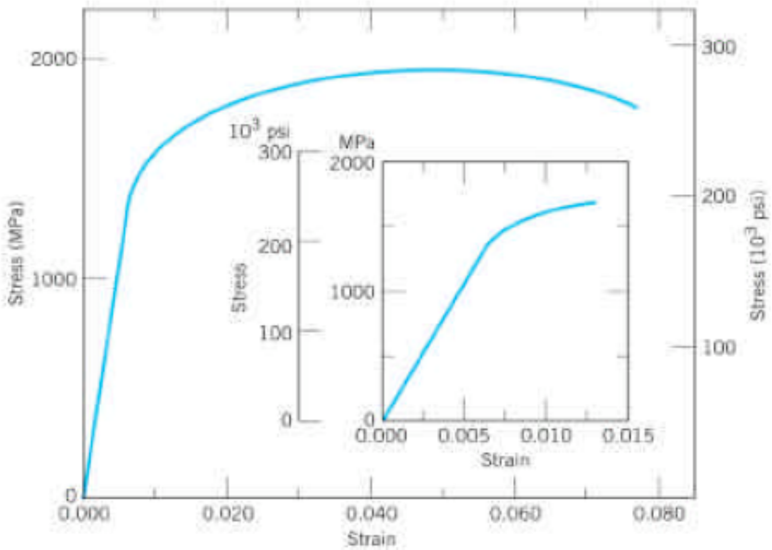

Figure 1. Stress strain curve for high strength steel

Effects of Work Hardening and Heat Treatment on Brass and Steel

I. Purpose:

- To observe the effect of cold working on the mechanical properties of a metal by measuring the hardness before and after cold working.
- To determine the relation between the hardness and degree of cold work by plotting the measured hardness values as a function of the amount of cold rolling.
- To investigate the effect of cold working on the microstructure.
- Investigate the effect of the annealing process on the change of mechanical properties.

Cold Working of Brass

Six different examples will be tested during each lab period, with the samples to be divided amongst the different groups. At the end of the period all of the data will be pooled together. (Note that you will prepare only 4 samples, two of which will be measured before and after annealing)

Samples:

- As Received (no cold working)
  - Annealed (with no cold working)
- 20% Cold Worked
- 40% Cold Worked
- 60% Cold Worked
  - 60% Cold Worked, then annealed

II. Experimental Procedure:

1. Measure the initial dimensions of all the samples using the calipers provided in class.
2. Perform cold working to prepare three samples: 20%, 40%, 60% cold worked.
3. Measure the final dimensions of the cold rolled samples. The as received sample refers to the state in which the samples were when initially purchased.
4. Measure the hardness of all the samples on the Rockwell tester, using the "B" scale. Take at least 5 measurements on each sample and average the value. Be careful not to place indents too close together as it may affect the results. Include a plot of hardness versus percent cold work in your lab. You should see a trend in the hardness you measure for your samples that reflects how they were processed.
5. Anneal the "as received" and 60% CW samples (after first measuring their hardness) in the molten salt pot. The salt is Potassium Nitrate, and is heated to ~935F. After annealing and quenching in water, measure their hardness again.
6. Polished samples of each type have been prepared and photographed so you can observe their microstructure. The samples were polished to a 1 micron finish and then chemically etched to reveal their grain boundaries. The photos are available in a single document on the course website. Look at each of the samples and comment on their microstructures in your lab report. You may use these images in your lab report with proper citations.

III. Analysis: (Please answer these questions in your lab note book)

1. What is the composition(s) of ALPHA-brass? Look up the appropriate phase diagram in the text. What is the crystal structure of ALPHA-brass? What other metals share this structure?
2. Which properties of metals are improved through cold working? Which are not? Explain.
3. How is the percent of cold work calculated?
4. When the samples are rolled they get thinner and longer. Did the width (i.e. the dimension transverse to the rolling direction) increase? Did the volume of the bars change with cold working? Would you expect it to? Why or why not?
5. Were there any noticeable changes in the microstructure with cold working? How did it change? What happened to the microstructure during the annealing? How did the annealed as received sample compare to the annealed 60% cold worked sample? What conclusions can you draw between hardness data and the microstructural observations?
6. How would you expect the microstructure to change with cold rolling? How would an annealed sample look? Sketch the side, top and end on views of the structure for the rolled and annealed samples.

IV. Lab Report

The lab report should address all the questions above but should not consist only of these questions only. Please follow the procedures outlined on the homepage and in the lab packet. Look under **short report** grading criteria for point distribution and requirements.

V. References:

1. E.C. Subbarao, et al., **<u>Experiments in Materials Science</u>**. *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.
4. R.E. Smallman, **Modern Physical Metallurgy, 4th Ed.**, *Butterworths*, London, (1985), pp. 335-379.