NPRE 332 (borrowed from ME 231)

Fall 2003

Laboratory 3: Cold Work and Annealing

Analysis of Results and Points for Discussion

1. For the data generated in this laboratory (*i.e.*, at room temperature), plot the hardness (y-axis) versus the percent cold work (x-axis), including the hardness of the undeformed material as a point for 0% cold work. Also show the data for the heat treated samples (400ºC) on this plot using a separate symbol. How do hardness and %CW correlate for each group (room temperature and 400ºC anneal)?

2. Using the data from the brass load-unload tensile demonstration in laboratory #2, plot the yield strength versus %CW relationship for the brass without heat treatment. Use this graph to estimate the strength of the most severely cold worked section (2.5 IV) in this laboratory. What is the percent strength increase (see equation below) that can be obtained via cold work for this brass alloy?

$$\%\text{increase } \sigma_{\text{y}} = \left(\frac{\sigma_y^{@\max\%\text{CW}} - \sigma_y^{\text{original}}}{\sigma_y^{\text{original}}} \right) * 100$$

3. Utilizing both the annealed data generated in this laboratory and the additional data posted on the lab data web site for heat treatment temperatures from 350 to 500ºC, plot BHN or R_B hardness (y-axis) versus annealing temperature for sections 5.0-II, 5.0-IV, 2.5-II, and 2.5-IV (thickness-section designation). Is there a critical temperature for annealing to have a substantial effect on hardness? Compute the critical homologous temperature (ratio between this temperature and the melting temperature of the brass).

4. Consider the one hour heat treatment time to be common among all specimens. Create a "mechanism map" with the y-axis being percent cold work (%CW) and the x-axis to be heat treatment or annealing temperature. From the microstructural observations, denote which %CW-Temperature combinations are dominated by the following three categories: i] recovery only, ii] recovery and partial recrystallization, or iii] recovery with 100% recrystallization and possible grain growth. Associate common points to form the mechanism map. Associate one microstructure picture with each region, and also show the original microstructure as a reference.

   Explain the relationship between grain size and hardness for these regions. Micrographs (50x) for sections 5.0-II, 5.0-IV, and 2.5-II in the as-rolled and 400ºC heat treated have been posted on the web site, as well as the 2.5-IV heat treated micrograph.

5. At the end of the lab, the two wedges rolled to 2.5mm were rolled to failure. Based on the original wedge dimensions, what is the percent reduction of the annealed and as-rolled brass? Comparing these two, what significance does this have in metal forming processes?

6. The photomicrographs show elongated grains in the direction of rolling, especially for those not heat treated. What differences in elastic modulus, strength, and ductility would be expected for loading parallel and perpendicular to the rolling direction? How about samples with an equiaxed grain structure?