

ENGR 240 – Science of Materials Laboratory

LAB H COLD WORK AND RECRYSTALLIZATION

Background

Because heat treatment procedures used for ferrous materials (e.g., quenching to make martensite) are not generally applicable for non-ferrous alloys, increases in the hardness and strength of these materials are often achieved by strain (or work) hardening. In such a process, the metal is made harder as a result of plastic deformation. The mechanism of hardening is explained by dislocation theory--in particular, as the material is deformed, dislocation tangles are produced which inhibit further slip or deformation in the material. To be effective, the deformation or work must be conducted at a temperature low enough so that thermal energy does not alter the effects of plastic deformation. Because of this, the process is referred to as *cold work*.

The increase in hardness and strength as a result of cold work can be erased by *annealing* at a temperature above the material's *recrystallization temperature*. Above this temperature, new crystals form, which are free of lattice strain and dislocation tangles. This phenomenon is of great importance in industries where fabrication involves considerable shaping. Each time the material becomes too strong to continue easy working or is in danger of cracking, it can be annealed to make it softer and more ductile, thereby making it possible to conduct additional plastic deformation and shape changes.

In this experiment, you will examine the effects of strain hardening and annealing on a non-ferrous alloy of copper and zinc (brass).

Procedures

You will be given four annealed, disk-shaped brass samples. Measure the hardness of each sample using the Rockwell Hardness Tester. Each sample should then be worked in the hand roller to different extents. The percent cold work (%CW) for the samples should range from 5% to 60%. Percent cold work for this cold rolling process is defined as the change in disk thickness divided by the original disk thickness. Measure hardnesses of the worked samples to determine hardness as a function of %CW for your alloy.

You are now going to try to determine the recrystallization temperature for your material (which may depend on amount of cold work). Anneal the samples in the oven at an initial temperature of 400 °C for five minutes, and remeasure their hardnesses. Then, repeat this annealing/testing at incrementally higher and higher annealing temperatures (try 50 °C increments), so that you can follow hardness for each sample as a function of annealing temperature. A substantial reduction in hardness (not necessarily to initial values) after a five-minute annealing treatment indicates that the temperature was above the sample's recrystallization temperature. (For each annealing treatment, samples should be quickly quenched in water after being removed from the oven.)

After all of the samples are recrystallized and if time permits, use the optical microscope to observe cross-sectional specimens of cold worked brass, partially recrystallized brass, and fully annealed brass.

Report

Your report should include graphs of (i) hardness as a function of % CW (don't forget the 0% cold worked initial sample hardness on this graph), (ii) hardness versus temperature for all four specimens, and (iii) recrystallization temperature vs. % CW.

Discuss the effects of cold work and annealing on the mechanical properties of the brass and the correlation between mechanical properties and microstructure in the brass specimens.

Reference:

Callister: sections 6.10, 7.10, 7.12