Annealing of 70-30 Brass.

Introduction.

After cold working, metals will consist of a distorted grain structure and a high dislocation density compared to annealed material. Mechanical properties will be a high yield stress, and a low ductility, so further cold work is not possible. For example, brass will crack if cold worked up to 70% reduction in area, see figure below. It is possible to recover ductility at the expense of yield strength by “Annealing”, which consists of a three stage process, *recovery, recrystallization and grain growth.*

Equipment.

Five samples consisting of 10, 20, 30, 40, and 50% cold worked 70-30 brass
Three furnaces at temperatures at 350°C (α to α+L solidus at 920°C for 70-30 brass)
Tongs to handle hot samples.
Beakers containing water to cool the samples.
Instron hardness tester set to R30T scale and 1/16\textsuperscript{th} ball indenter.

Experiment.

Samples after cold work will be placed in furnaces at 350 C, and hardness tested using an Instron hardness tester on the R30T scale and a 1/16\textsuperscript{th} of an inch steel ball indenter. Data will be plotted as hardness against time. The hardness measurement will be used to quantify the degree to which full recrystallization has occurred in the brass.

Discussion.

Data indicated that some samples did not change hardness with time while other rapidly decreased in hardness value. When the energy required for recrystallization from both the cold working process and externally applied thermal energy is insufficient, the cold worked structure cannot rearrange itself to form new grains. New, smaller grains require surface energy for their new boundaries, and this energy must be provided. At elevated temperature, the energy for the processes is available, the surface energy for new grain boundaries is provided and the cold worked structure is rearranged. As the figure shows, there is a critical amount of cold work required before recrystallization can start. If the amount it only slightly exceeded, a very large grain size will be present after annealing, but if substantial cold work is conducted, then a finer grain size will be present after annealing. Considering this along with the Hall-Petch relationship, the combination of cold work and annealing can be used to control the mechanical properties of a metal.

![Hardness v Time for 70-30 Brass after 25.9% Cold Work](image)

From the data, recrystallization is temperature and time dependent.
Recrystallization is also cold work dependent, see figure below.

Final Grain Size
After Annealing

% Cold Work to Material