MEEN 160

MATERIALS SELECTION IN MECHANICAL DESIGN

EXPERIMENT #4

COLD WORK AND ANNEALING OF BRASS AND THE SELECTION OF WORK HARDENED AND ANNEALED ALLOYS

by

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I. INTRODUCTION

Cold working or strain hardening is one of the most important methods for strengthening some metals. For example, pure copper and aluminum can be strengthened significantly only by this method. Cold working changes their shape, increases their strength and decreases their ductility (Smith). This increase in strength resulting from cold plastic deformation is referred to as work hardening and results from the drastic increase in dislocation density during plastic deformation. Upon cold plastic deformation the grains are shared relative to each other by the generation, movement, and rearrangement of dislocations. With increased cold rolling the grains are more elongated in the rolling direction as a consequence of dislocation movements. According to micrographs, the dislocation density increases with increased cold deformation. Therefore, the greater the amounts of cold work, the higher the number of dislocations caused to the metal or alloy, and greater the stress required to continue moving the dislocations to cause more plastic deformation. In this experiment students will learn the effect of cold work on the hardness of a single phase alloy, cartridge brass. Students will perform the experiments with various cold worked tempered and will determine the percent reduction in thickness by cold rolling. The microstructures of the cold rolled tempers of brass will also be characterized.

II. EXPERIMENTAL PROCEDURE

Each lab group has four pieces each of one or more cold worked tempers of cartridge brass (C260) to study the annealing behavior at that temper. The lab group measured Rockwell hardness test A for all pieces of cartridge brass. The group chose one piece out of each packet that was the hardness at room temperature for 0 hour annealed. The group annealed rest pieces of cartridge brass in a salt bath at a given annealing temperature and given time. In this experiment, the given temperature were 200, 265, 305, 352, 396, 453, 499, 542, 604, 641 Celsius degrees and 0, 0.25, 0.5, 1 hour for given time. After finished annealing process, the group quenched them in water, performed five hardness tests for each category. All specimens of a given cold worked temper and annealing temperature with different time should be mounted. After that, the specimen should be grain polished and etched. With results, students analyzed data to understand the cold worked and annealed microstructures.

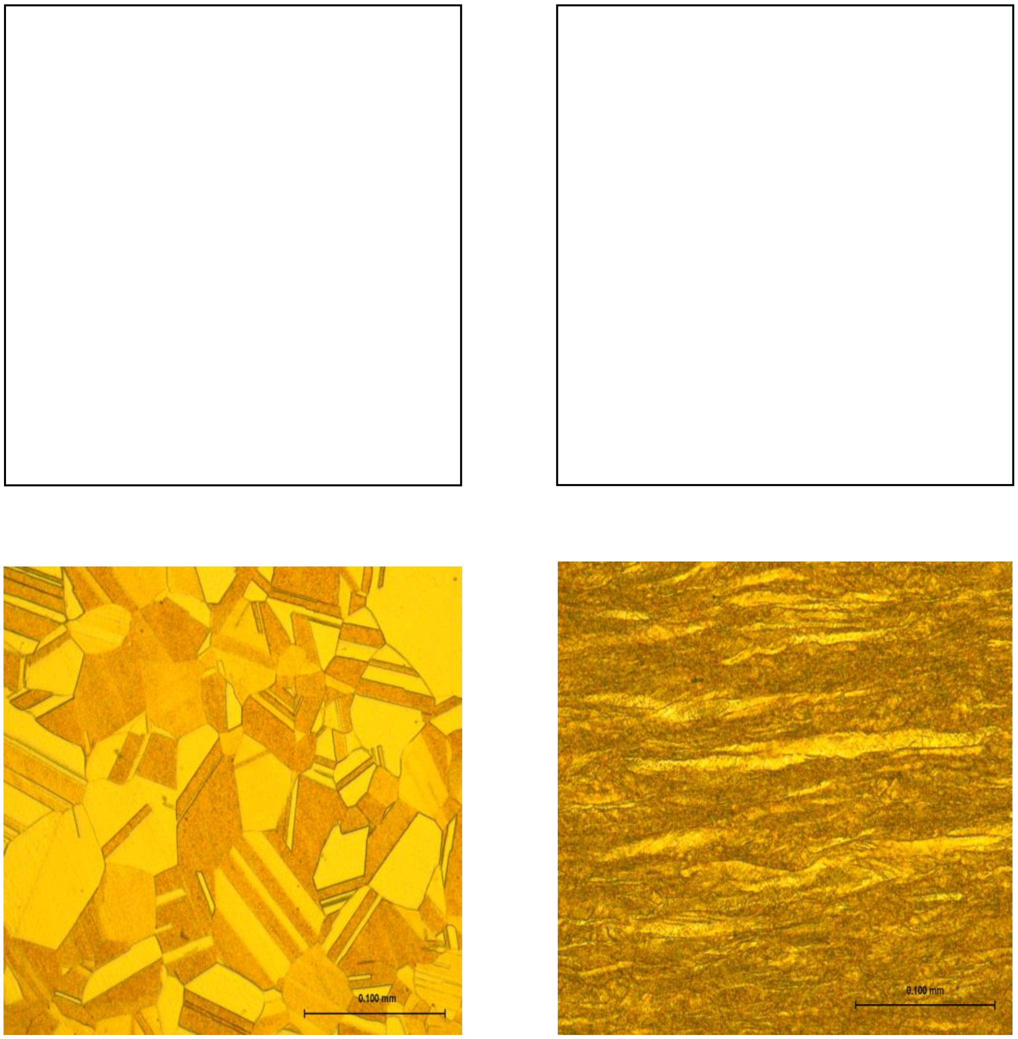

Figure 7. Schematic diagrams of (a) the as-annealed microstructure of the brass and (b) a typical as-annealed and cold rolled microstructure.

The as-annealed microstructure shows twins and distinguishable grain boundaries. However, the typical as-annealed and cold rolled microstructure has elongated grain shape which does not have clear grain boundaries. Also dislocation occurred in a typical as-annealed and cold rolled microstructure.

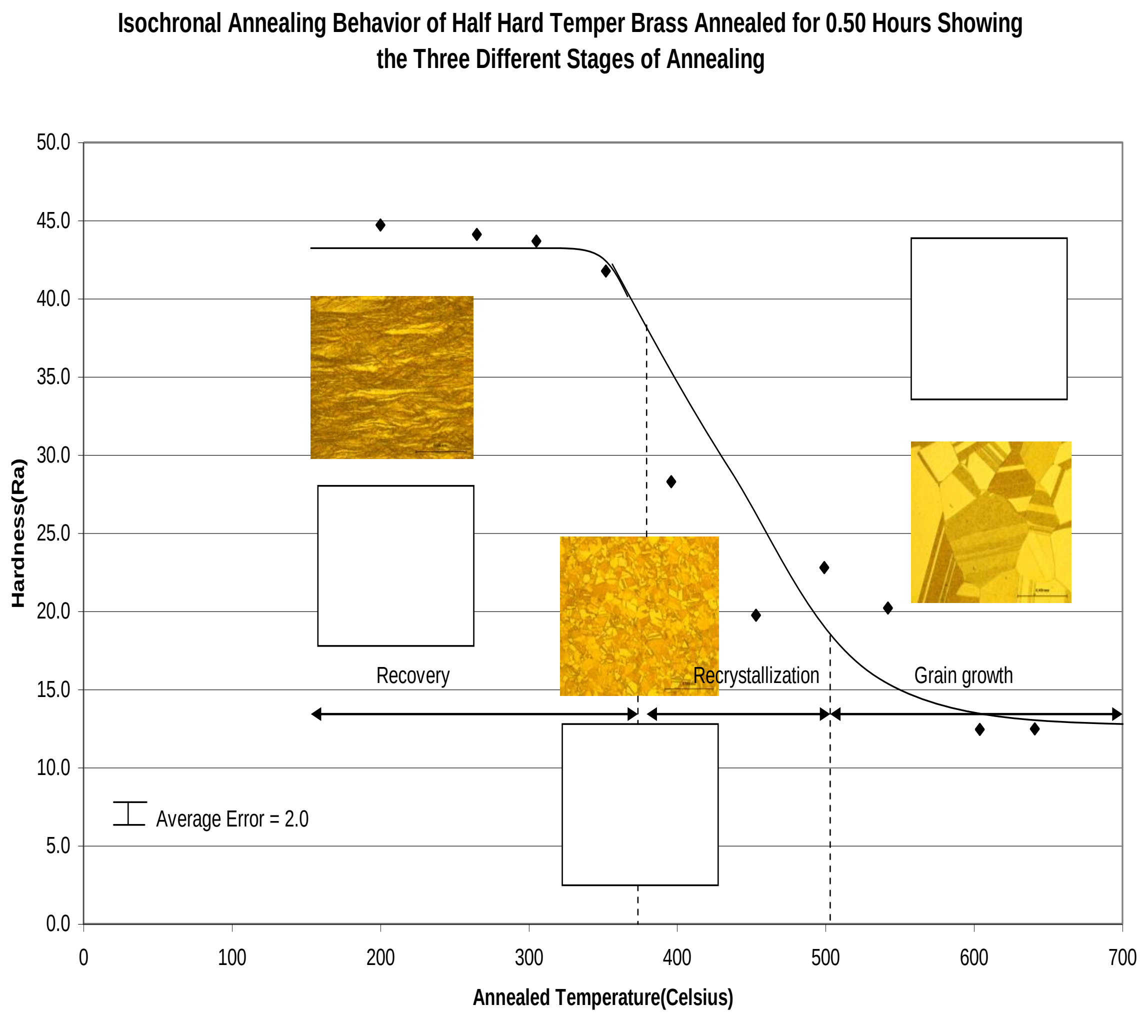

Figure 8. 0.50 Hours Showing the Three Different Stages of Annealing. Schematic diagram of the microstructure for the three different stages are also shown.

When the metal is reheated to a sufficiently high temperature for a long enough time, the cold-worked metal structure will go through a series of changes called recovery, recrystallization and grain growth. In the figure 8, these three stages are shown schematically as the temperature of the metal is increased along with the corresponding changes in mechanical properties. When recrystallization starts, the cold worked structure is completely replaced with a recrystallized grain structure as expanding with a deformed grain and an original high angle grain boundary can migrate into a more highly deformed region of the metal. Grain growth region definitely shows the larger size of grain than recrystallization or recovery regions. Therefore, as temperature increase after recrystallization region, the grain size increases.

V. DISCUSSION

1. During recovery, sufficient thermal energy is supplied to allow the dislocations to rearrange themselves into lower energy configurations. Recovery of many cold worked metals produces a subgrain structure with low angle grain boundaries. This recovery process is called polygonization, and often it is a structural change that precedes recrystallization. The internal energy of the recovered metal is lower than that of the cold worked state since many dislocations are annihilated or moved into lower energy configurations by the recovery process. During recovery the strength of a cold worked metal is reduced only slightly but its ductility is usually significantly increased.

2. According to the result of this lab, spring temper brass parts by brazing at 800 °C makes the mechanical strength significantly decreases.

3. According to the result of this lab, spring temper brass parts by soldering at 250 °C makes the mechanical strength does not change that much.

4. According to temper designations for cold worked tempers of copper and copper alloys table in the lab manual, H08, spring temper has 60.5 % reduction. Therefore, the thickness is 0.5 inch X 0.605 = 0.3025 inch. Then the resulting sheet is given a recrystallization anneal and rolled further to a hard (H04) temper, which has 37.1% reduction. Therefore, the new thickness is 0.3025 inch X 0.371 = 0.1122 inch, the final thickness of cartridge brass. According to results of this lab, R_A hardness of cartridge brass of spring temper is approximately 53 and the hardness of cartridge brass of hard temper is approximately 58.

References

[1] Smith, W. F. and Hashemi, J., 2005, Foundations of Material Science and Engineering, 4th Ed, McGraw-Hill, New York.

[2] Metals Handbook, 8th Ed., Vol 7, Atlas of Microstructures, 1972, Amer. Soc. Metals, Metals Park, Ohio.