Cold Working of 70-30 Brass

Introduction.

Cold working a metal is conducted for several reasons. One it to “homogenize” the material by moving atoms within the structure after pouring of ingots. A second is to control the grain size of the material by a subsequent full anneal. A third is to work harden the material to improve strength in service by increasing the yield strength at the expense of ductility. A fourth is to change the shape of the material. This can be to produce a final shape, such as railway lines, or as part of a general decrease in one dimension, for example to produce sheet or plate from larger pieces of metal. Rolling, forging, extrusion, drawing are some of the more common cold working techniques. These are not exclusive to cold working and these techniques can used to “hot” work a metal. Hot working is conducted at temperatures above half the melting point when measured in degrees Kelvin.

A two high rolling mill is shown which as the name suggests has two rolls, one on top of each other. Two steel rollers are driven in opposite directions to grab and then squeeze a piece of metal as it moves through the rollers. The amount of deformation is determined by the difference between the thickness of the metal placed in the rollers and the gap between the two rollers. The final thickness will not only depend on the gap between the rollers, but the elastic deformation recovered after the material was rolled.

On large systems, the rolls are not parallel but slightly barrel shaped to take into account roll deformation during the process. In this experiment 70-30 brass will be rolled to a variety of thicknesses and hardness measurements taken to characterize the amount of cold working taking place.

Equipment and Materials

One annealed 70-30 brass sample, 0.108in thick x 4in long by 1.25in wide.
One measuring caliper.
Five pre-rolled samples of various thicknesses.
Instron hardness tester on R30T scale and 1/16" steel ball indenter.
Experiment

One sample will be rolled as an example, reducing the thickness from 0.108 to approximately 0.1 in. Around 1/8th of a turn on the threaded rods which set the roll gap is required for this. The thickness of the annealed brass sample is measured using the calipers. The four inch long sample is placed in the roll gap. The roller is then switched on so rolls pick up the sample and roll it, with the samples coming out of the opposite side of the machine. The rolling mill is then switched off. When the roll mill has come to a complete stop the sample can be removed, thickness measured along with a hardness measurement. Pre-rolled samples will be used to measure thickness and hardness test. A data table should be constructed. The lab report should show a graph of hardness against % cold work.

\[%\text{cold work} = 100 \times (\text{Initial Thickness} - \text{Rolled Thickness}) / \text{Initial Thickness}\.\]

Typical data is shown below.

\[
\begin{array}{cccccccc}
% \text{Cold Work by Rolling} & 0 & 10 & 20 & 30 & 40 & 50 \\
\text{Hardness R30T} & 30 & 40 & 50 & 60 & 70 & 80 \\
\end{array}
\]

Discussion.
The data indicates that as cold working increased the hardness of the 70-30 brass also increased. As the hardness is proportional to the yield stress, then the yield stress is also increasing with the degree of cold work. Work hardening processes are occurring. These include dislocation motion being blocked by intersecting slip planes in the FCC structure, \{111\} planes in <110> directions. As one set of slip planes becomes blocked, an applied stress increase be required to increase the resolved shear stress on another set of slip systems which will then allow dislocation motion when its critical resolved shear stress is exceeded by this increase in applied stress. Internally, the shape of the grains will be changed from an equiaxed shape to an ellipsoidal one. Slip lines can be seen after cold working on metallographically prepared, polished and etched samples by optical microscopy. This is part of a two part lab, the second part being Annealing.