Lab 1 – Thermo-Mechanical Processing of Aluminum

Assessment Performance Criteria

By the conclusion of this investigation you should be able to:

1. Describe the basic principles of and be able to perform hardness test using and automated indentation instrument.
2. Be able to describe the change in mechanical properties due to both cold rolling and thermal annealing.
3. Use an optical microscope to observe and qualitatively describe changes in metallographic due to cold rolling.

Procedure

1. Heat Treatment of Aluminum Sample

The TA will give each group a sample of cold rolled Aluminum 3003 or 6061. Using the Rockwell HRH Hardness Testing Machines, test the hardness of the sample 5 times. Test the hardness in different areas of the sample; do not test in the same location twice. After the hardness measurements were taken, place the sample in a furnace at 450˚C for at least one hour.

After the hour has passed, remove the sample from the furnace. Allow the sample to air cool; do not quench. After the sample is sufficiently cooled, repeat the hardness measurements. Do not test the sample in the same location as previous tests. (Hint: use the other side of the sample). Observe the change in hardness after annealing.

2. Cold Rolling of Aluminum Sample

The TA will give each group a known sample of either 3003 or 6061 aluminum. Measure the dimensions of the sample, paying close attention to the thickness. Test the hardness of the sample five times. Make sure to record this data on the Google Doc spreadsheet for your section. After the hardness measurements have been taken, roll the sample to reduce its thickness.

After the rolling, repeat the hardness measurements. Do not measure hardness in the same location as a previous test. Also record the new dimensions, paying attention to the thickness. Roll the sample three more times, for a total of four rolls. Measure the hardness, and dimensions of the sample. Record all the measurements on the Google Doc. Make sure to put the completed table in the lab notebook.

3. Observation of Rolled Samples

The TA will provide samples of cold rolled Aluminum 4% Silicon. One sample will be ‘as cast’, and the other will be ‘50% reduction’ or ‘40% reduction’. The percentage is the reduction in thickness of the sample. Using the microscopes provided, observe the samples at two different magnifications. Take images of the samples at the highest magnification and observe the shapes of the grains, and how they are different for the samples observed.

Items for Lab Report

1. [Results] Include a detailed table describing the hardness measurements for your specimen in the various states of cold rolling. Calculate the percent of cold work (%CW) for each state of cold rolling using the provided equation: where t_0 is the initial thickness of the as received specimen and the t is the thickness following each successive rolling step. Include both the individual hardness measurements, as well as, the average and standard deviation of at each step of the rolling process.

$$\%CW = \left(\frac{t_0 - t}{t_0}\right) * 100\%$$

2. [Result] Develop a graph of average hardness versus %CW for the both the alloys. Plot the data on the SAME graph (one trend line per alloy). Use your data as well as the data of other three groups to develop the graph.

3. [Result] Include a data table showing the change in hardness of the pre-cold worked sample before and after annealing. Can you identify the % CW of your sample prior to annealing using the trendline from previous section?

4. [Result] Include digital images obtained of the provided metallographic samples before and after cold rolling. Make sure to include a clear scale bar on each published image. (Observations) Using the scale bars as a reference, characterize the shape and size grains in both the as cast and cold rolled specimens.

5. [Discussion] What differences do you observe between the two alloys? How does annealing and cold working affect the specimen hardness?

6. [Discussion] How did the shape of the grains change during the cold rolling process? Do you think this change in grain shape is related to the observed changes in hardness?