Good report on heat treatment lab

Technology, Development

Objective

Purpose of this laboratory is to inspect the effect of precipitation hardening in Aluminum and steel alloys.

Theory

Hardness is a property of a material which delineates resistance to permanent or plastic deformation. For metals, hardness is generally defined as the resistance to indentation. One way to attain hardness is to look into the effect of precipitation hardening. This type of hardening helps to detain the yield strength in the material. There are four methods used to test hardness of a material: Rockwell, Brinell, Vickers, and Knoop. The Rockwell hardness test measures the depth of indentation, while the other three measure the size of the indentation. All the test methods necessitate pressing an indenter of standard dimensions on to the surface of a sample with a known force for a certain length of time. Vicker and Knoop test are microhardness tests, used to measure the local hardness of individual components of the microstructure of the material. Whereas, Rockwell and Brinell tests are macro hardness tests used to determine average hardness over a large portion of the material.

- HV= FA= 1. 8544*FD2

where d is the average length of the diagonal left by the indenter in millimeters, F force in the kgf. Rockwell Hardness test is a process of procedures and the use of a triangular indenter to calculate the hardness. The Rockwell Superficial Hardness measurement is based on the distance the indenter penetrates the surface upon loading with a major load and then removing the major load. In Knoop Hardness test, an elongated rhombus pyramidal indenter with a diagonal ratio of 7: 1 is usually used. The Knoop hardness test is given by:

- HK= loadkgfimpressionareamm2= PCPL2

where L is the length of the indentation along its long axis. Cp is the correction factor related to the shape of the elongated rhombus indenter and P is the load.

Pure aluminum is very soft. So, to make it to be used in structural application it is usually alloyed with several elements to improve its corrosion resistance, inhibit grain growth and of course to increase the strength. Alloying and heat treatments that advance the formation of small, hard precipitates, which interfere with the motion of dislocations, attain the optimum strengthening of aluminum. Aluminum alloys that can be heat treated to form these precipitates are considered heat treatable alloys. Precipitation hardening strengthens virtually all heat treatable aluminum alloys and it raising the temperature of the alloy into the single-phase region so that all of the precipitates dissolve. Then the alloy is rapidly quenched to form a supersaturated solid solution and to entrap surplus vacancies and dislocation loops which can later act as nucleation sites for precipitation. The precipitates can form slowly at room temperature (natural aging) and more quickly at slightly elevated temperatures, typically 100C to 200C (artificial aging). The degree of hardening obtained depends on the size, number and relative strength of the precipitates. These factors are evaluated by the composition of the alloy and by the tempering temperature and tempering time. A hardness measurement delineates strength of a material and because strength is related to the number, type and spacing of precipitates, hardness measurements is used to monitor the precipitation process. In this experiment the aging process of 6061 is investigated. Effect of the aging treatments is evaluated by hardness testing.

Two metals, aluminum and steel, was tested and compared to demonstrate the effects of precipitation hardness.

Experimental Procedure

In this experiment, six metal samples i. e. three aluminum samples and three steel samples were provided. For identification each sample was stamped and labeled Al1, Al2, Al3, St1, St2, St3 for aluminum and steel respectively. Samples were then sanded on both sides to ensure a flat and smooth surface free of discontinuities. A base line hardness measurement was taken as well as recorded three times on each side on all six samples. Samples were then placed in a furnace at 200oC.

After 30 minutes, Al1 and St 1 were removed and quenched in a bucket of water at room temperature. Hardness were then measured and recorded. After this, samples were placed back in the furnace. After 60 minutes of heating, Al2, Al1, St1 and St2 were removed, quenched in the same way as before, their hardness were measured and placed back in the furnace. After 90 minutes of heating, same operations were carried out for all six samples.

Results and Discussion

An evident trend, found out in the figures, was increment of hardness of all samples with time. The number of cycles of reheating and quenching had also a considerable effect on the increment of hardness. For instance, Al1 and St1 samples had the highest rate of change of hardness possibly due to more numbers of cycles of reheating and quenching than others. However, the magnitudes of change of hardness for both materials were much less than expected. The maximum change in hardness for either material was HRB three. On the basis of phase diagrams of both the aluminum and steel it was presumed that the microstructure would remain the same. The microstructure of aluminum would remain in the α+Mg_2Si phase as the maximum temperature for the experiment did not go above 200°C. Though it was possible to get a phase change with the aluminum, it was presumed that the weight percent Mg_2Si was greater than approximately 0. 2. It was completely impossible for steel to change the microstructure as the experiment was limited to 200°C, far below the 723°C phase change line. Few things might have affected the results of this lab such as human error i. e. error inherent in all types of experiments performed by humans, mechanical error etc. Human error may have occurred in placing the samples in furnace i. e. placing by side up or side down in the furnace. A few mechanical devices such as the furnace and the hardness tester were used in this experiment. There was fluctuation of temperature in the furnace while opening the door of the furnace to get the samples and this can be treated as source of mechanical error. An error might be occurred due to poor calibration of hardness tester. The materials might also contain error themselves, such as the material not being homogeneous throughout the sample.

Conclusion

Appendix