Hardness testing essay

Abstract This experiment will explain what the Rockwell hardening test is and why it is used, how the experiment was conducted, data that was found, and the importance of testing the hardness of materials. This experiment explains and proves how the hardness of materials can be increased by alloying and heat treating. Intro – Rockwell Hardness Testing Soft and hard qualities exist in materials. In materials, hardness measures the ability of a material to resist scratching, indentation, or penetration. Hardness cannot be expressed in terms of defined units; it is the result of a defined measurement procedure.

It is a complex material property which cannot be related to basic properties. Tests measuring resistance to bending, cutting, and scratching have been used to assess the hardness of materials. Three separate but standard test methods are used to express the relationship between hardness and the size of the indentation: Brinell, Vickers, and Rockwell. Hardness tests are one of the most commonly used measuring devices to measure mechanical properties because they are relatively easy to perform and typically do not cause destruction. Figure 2: The above figure shows the principle of the Rockwell Hardness Test.

Figure 2: The above figure shows the principle of the Rockwell Hardness Test. The objective of this experiment was to test the hardness of various materials. The Rockwell Hardness Test was used in this experiment and consisted of indenting each of the materials with a steel ball indenter or diamond cone. The indenter is fixed in the testing machine and is forced into the material at a preliminary load that corresponds to the scale in use. When

equilibrium has been achieved, the testing machine follows the movement of the indenter and responds to the change in depth of penetration.

On top of the preliminary load there is the major load. Together the loads create the total load that causes a permanent increase in depth of penetration from the initial load. Removal of the additional load allows for partial recovery, reducing the depth of penetration. Resulting from the addition as well as removal of the additional major load is a permanent depth allows the Rockwell hardness number to be calculated by the testing machine. Figure1: The above figure shows the Rockwell hardness testing machine used. The Rockwell Hardness Test is the best to use when it comes to determining mechanical properties.

This being because this test is the easiest to perform and the hardness value is calculated whereas in the Brinell Hardness Test, the hardness is calculated. A downside to this test is if a material were needed to be tested in between scales; a proper hardness value would not be outputted. Procedure When it comes to testing the hardness of materials, two main tests called upon are the Brinell and Rockwell hardness tests. For our experiment, the Rockwell hardness test was used. This method consists of using a machine to calculate the hardness number.

This machine has a variety of scales that can be used to test a wide range of materials whether they are soft or hard. For our experiment, scales C and F were used. Scale C uses a diamond cone and it used for steels, hard cast irons, case hardened steel and other materials harder that 100 HRB. HRB refers to the hardness test scale B which consists of copper alloys, soft steels, aluminum alloys, etc. Scale F uses a 1/16” steel ball indenter and is typically used for annealed copper alloys and thin soft sheet metals. Each scale has its own minor, major, and total load and needed to be set before beginning.

If not set, the machine would know the material did not categorize in the currently set scale and would not continue until the correct setting was achieved. When everything was set as it needed to be, the various materials were placed in the machine and tested for hardness values. Results Steel Alloy Results: HRC TEST| Material| Value| Average| Stainless Steel CB7 CU1| 40| 40. 4| | 40. 9| | | 40. 4| | 4350 Steel| 30. 2| 31. 0| | 31. 4| | | 31. 5| | Steel 01| 25. 1| 25. 4| | 26. 9| | | 24. 3| | Steel 02| 27. 9| 29. 3| | 29. 6| | | 30. 5| | 1050 Carbon Steel| 30. 3| 30. 5| | 30. 7| | | 30. | | Table 1: The above table displays the HRC hardness values measured for each steel. Three measurements were used and averaged for each specimen because the hardness is not uniformly distributed across the specimen. Assumptions of a uniform load will cause error in final results. By taking three separate measurements at three separate locations on the alloy, an average was able to be determined. Of our specimens, Stainless Steel was determined as being the hardest and 1020 Steel being the softest. Graph 1: The above bar graph show how the different steel specimens compare to one another.

Aluminum Alloy Results: HRF TEST| Material| Value| Average| Material| Value| Average| 6061 HT 500°C (14 mins)| 81. 2| 83. 7| 2017 Al| 99. 9| 100. 0| | 83. 9| | | 100. 2| | | 86. 1| | | 99. 9| | HT 6061 (72 hours)| 71| 73. 3| 6061 HT 450°C (8 mins)| 73| 73. 7| | 74. 5| | | 77. 1| | | 74. 4| | | 70. 9| | 6061 HT 450°C (3 mins)| 74. 3| 73. 8| 6061 HT 450°C (30 mins)| 88. 4| 85. 9| | 71. 8| |

| 87. 7| | | 75. 3| | | 81. 7| | 1045 Steel (not heat treated)| 105. 1| 107. 2| Brass 1| 96| 96. 2| | 107. 4| | | 96. 3| | | 109. 1| | | 96. 4| | 1020 Steel (not heat treated)| 109. 5| 107. 0| Brass 2| 77. 5| 77. | | 109. 2| | | 77. 2| | | 102. 4| | | 77. 4| | 6061 HT 450°C (7 mins)| 73| 80. 1| 6061 (as is)| 87. 9| 88. 6| | 77. 1| | | 88. 6| | | 90. 3| | | 89. 3| | Table 2: The above table displays the HRC hardness values measured for each aluminum. HT means heat treated. For many of the aluminum alloys used, they were heat treated prior to hardness testing to show how materials are going to react to penetration depending on how long they were heated. Like that of the steel specimens, aluminum alloys do not have a uniform load across the specimen so three measurements for each specimen were taken and averaged.

It can be seen that as the time of heat treatment increased, so did the hardness of the material. Graph 2: The above bar graph show how the different aluminum specimens compare to one another. Analysis From the hardness tests performed it can be seen how steel and aluminum alloys compare when undergoing their specific scale. The HRC scale is used for steels, hard cast irons, case hardened steels and other materials harder than 100HB thus the diamond cone was required so that theses harder materials are able to be penetrated.

In our experiment, four separate steels and one stainless steel were used and hardness values were calculated; stainless steel being the hardest at 40HRC and 1020 steel being the softest at 25HRC. Alloys added to steel increase its strength, like carbon, nickel, and tungsten. Carbon can play a large role in determining hardness. The material will have a higher hardness when more carbon is added, as long as the amount is less than two percent.

Higher carbon content existed in the stainless steel than that of the 1020 steel which is why we see stainless steel having higher hardness. The HRF scale is used for annealed copper lloys and thin soft sheet metals. For our experiment, soft steel, aluminum, and brass alloys were used and were penetrated by the 1/16” steel ball indenter. Many 6061 aluminum alloys were tested to compare between different heat treating adjustments and non-heat treated. Aluminum has a melting temperature of 660°C and a recrystallization temperature of 150°C. Since each of the heat treated aluminum alloys were heated well above its recrystallization temperature, the grains within the aluminum were able to mend themselves and reduce dislocations, producing higher tensile strengths.

As seen in Table 2, the hardness of the aluminum alloys increased as the time of heat treatment increased. Conclusion As stated previously, hardness measures the ability of a material to resist scratching, indentation, or penetration. Depending on the material used, hardness is going to be different. Base materials, non-heat treated, will determine the hardness and with alloying and annealing comes increased tensile strength and increased yield strength.

This experiment proves such as well as the concept of heat treating a metal will cause for more resistance to fracture. With these values, practical purposes for specific alloys can be determined. Future experimentation could be conducted to determine more hardness values at different temperatures and time durations. Appendix Askeland, D. R. , Fulay, P. P. , & Wright, W. J. (2011). Strain Hardening and Annealing. The Science and Engineering of Materials (pp. 291-316). Cengage Learning.