ANALYSIS OF HARDNESS OF ALUMINUM ALLOY 6082 AT DIFFERENT THICKNESS LEVELS

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ABSTRACT

From post twentieth century use of aluminum alloys increases drastically in automobile and aerospace industries. The demands for lightweight automotive parts are soaring tremendously in the quest for energy efficiency. The aluminum alloy takes the advantage of strength to weight ratio and corrosion properties over other structural element such as steel and its alloys. The altered mechanical properties are achieved in aluminum alloy by using different strengthening techniques such as age hardening etc. The favorable mechanical properties are explained by revealing the microstructure of corresponding alloy and intermediate phase compounds during formation of corresponding alloy. Hence study of hardness and strength of aluminum 6082 alloy is essential. In this paper, the study of analysis of hardness of aluminum alloy 6082 at different thickness levels is done. The hardness of aluminum alloy 6082 is measured by Brinell hardness scale.

Keywords:microstructure, strengthening , intermediate

1 Introduction:

Aluminum is the mostly abundant element on the earth and it became a strong competitor for all the Engineering application by the end of the 19th century. One of the most potential characteristics is its versatility. Aluminum and its alloys are extensively utilized in many industries such as automotive, shipbuilding, aircraft, structural applications, appliances, food packaging and transportation industry [1-7] due to their high strength to weight ratio and corrosion resistance and for their attractive mechanical properties achieved by thermal treatments. Thus it becomes all the more vital to study the tribological characteristics of aluminum alloys and its composite materials. Upon addition of Silicon to Aluminum gives low thermal expansion coefficient, high strength to weight ratio, and high wear resistance. These hybrid Composite material show improved hardness, strength and wear properties as the silicon content is increased beyond eutectic composition. Such properties warrant the use of these materials as structural components in automotive industries [8].

From being a material mainly used in drink cans and cooking foil aluminum alloys now ranks second to steel as the important structural material. Aluminum based alloys show good resistance to general corrosion and has better stiffness and strength properties than steel. The dominant use of aluminum alloys is in building industry and construction, e.g., panels, roofs and frames. The use of aluminum alloys in transport industries replaces steel and cast iron.

6000 series alloys are more and more important for the automotive industry due to their high strength to weight ratio and their elevated ductility; they are used for exterior panels and structural parts of automobiles [9]. 6082 is one of the most used alloys; it is used for the manufacturing of automotive parts such as brake housings and others[10].

Most of the structural components of airships and aerospace vehicles need different machining operations during their manufacturing process, mainly for the assembly requirements. Generally, they have to present both a high dimensional precision and a quality surface high level. These factors are required in order to obtain an adequate performance of the overall device. The aforementioned components are usually made of light alloys, mainly based on aluminium or titanium. This is due to their very good relationship between their weight and their mechanical properties[11-29].

Aluminum 6082 is an alloy of wrought aluminum magnesium silicon .It is one of the more popular alloys in its series. Alternate names and designations include AlSiMgMn, 3.2315, H30 and A96082.Aluminum 6082 is a medium strength alloy with excellent corrosion resistance .It has the highest strength of the 6000 series alloys. In plate form, 6082 is the alloy most commonly used for machining. As a relatively new alloy, the higher strength of 6082 has seen it replace 6061 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy.

2 LITERATURE REVIEW

The various work regarding the hardness of aluminum alloys are briefly described below:

Dhanasekara R SaiKrishna N Santosh M Pallavi Sreenatha Reddy S [30] studied the metal matrix composite of aluminum alloy reinforced with alumina, graphite and silicon carbide. The hardness of the aluminum composite increases with increase in silicon carbide content. Upon excess addition of the silicon carbide decreases the hardness .Moreover, addition of graphite in excess quantities decreases the hardness.

C.Parswajinan, B, Vijaya Ramnath, S, Abhishek, and B.Niharishsagar[31] :studied that the composition of Al+3%SiC+0.2%CNT withstands more impact load compared to other compositions but at the same time there is a huge drop in the hardness of the material which may be due to its plasticity. There is a stable increase in hardness upon the addition of SiC but if the same is added more, hardness decrease gradually after attaining a peak value. Thus the optimum addition of SiC in proper base metal aluminum yields a metal matrix composite that have a superior balance between high hardness and impact load.

M.E. Abd El-Azim, O. E. El-Desoky, M. R. El-Koussy[32] : investigated the artificial aging behavior of 6061 alloy on hardness and tensile properties by varying the aging temperature from 120°C to 260°C and aging time from 0.5 to 64 h. The natural aging for 100 h followed by artificial aging resulted higher yield and ultimate tensile strength. Pre-aging at 100°C for 5 min followed by artificial aging at 160°C for 18 h(peak aged condition) resulted in higher yield strength and ultimate tensile strength as compare to artificial aged samples only. Hardness of the 6082 alloy increases with increasing heat treatment temperature. Hardness of 6082 alloy is more sensitive to cooling conditions then to the duration of homogenization.

Grazyna Mrowka-Nowotnik, Jan Sieniawski [33]: investigated the influence of aging duration on hardness of Al 6005 and 6082 alloy. The microstructure changes of the aluminium alloys following aging for 120 h were investigated by metallographic observations. Al 6005 and 6082 samples were preheated in induction furnace at temperature 570°C and hold for 4 to 6 h and then cooled using different cooling rates (quenching in water, oil and air cooling or slow furnace cooling). Water cooled samples were subjected to T4 (solution heat treatment and natural aging). The influence of solution heat treatment temperature on 6005 and 6082 alloys was investigated from temperature range 510°C to 580°C and then natural aging in the room temperature to 120 h. The Tensile and Brinell hardnell tests were conducted. It was observed that hardness of the 6082 alloy increases with increasing heat treatment temperature. It was concluded that solution temperature does not affect the hardness of 6005 alloy. It was concluded that the hardness of 6082 alloy was more sensitive to cooling conditions then to the duration of homogenization.

Mindivan H, Kayali ES, Cimenoglu H [34] :studied the tribological behavior of Al alloy of the grade 2618, 6082, 7012,and 7075) all these alloys are squeezed cast. And reinforced with SiC particle (50 vol%). The 10mm diameter Al_2O_3 ball rubbing for the wear test. This was observed that at low test load the tribological performance of the composites was not influenced by the properties aluminium base alloy.

3 EXPERIMENTATION

The various equipments which are used to perform the experiment are Brinell hardness machine, Milling machine, scale, marker.

3.1 Brinell Hardness test:

The Brinell hardness testing method was the first hardness testing method to be used in the industry. Usually, this testing process takes between 10 to 30 seconds and is accomplished by pressing a spherical indenter of a certain diameter against the testing surface of the material sample. The load applied is not superior to 3000 kgf and the hardness value is provided in HB (Hardness Brinell) units. The Brinell hardness testing uses indenters made of steel to test materials with hardness values of up to 350 HB, or of hard metal (tungsten) to test materials with hardness values from 350 to 650 HB. The choice of the indenter to be used is directly related to the mechanical properties of the material to be analyzed.

Generally, the Brinell hardness testing uses spheres with diameters of 2.5 (the most common value that corresponds to a load of 187.5 kgf), 5 and 10 mm. To carry out Brinell testing, the material which is to be analyzed must present a testing surface which is free from oxidation, roughness, lubricants and other contaminations. This surface must also be flat and well finished so the operator can be certain of the quality of the obtained values. One should also ensure that deformations are not made on the opposite surface and therefore, the sample to be tested must possess a thickness eight times superior to the indentation diameter. In addition, vibrations and impacts on the testing equipment must be avoided at all costs.

In manual Brinell hardness testing, the diameters of the indenters' impression on the material test sample must be measured in the testing machine's display and the obtained values must be converted into the associated Brinell hardness using the ASTM E92-82(2003)e2 standard table.

$BHN = 2P/\pi D(D - \sqrt{D^2 - d^2})$

Where P is load in kgf

D is diameter of indenter in mm and

d is diameter of impression in mm.

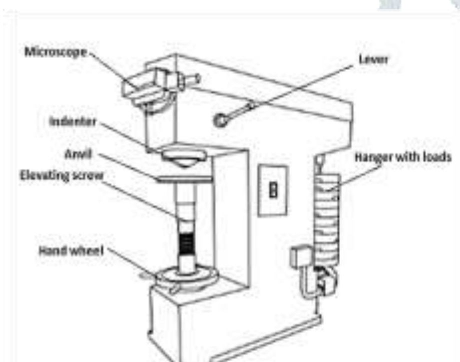


Figure 1 Brinell hardness Testing Machine

3.2 Milling Process:

Milling is a metal removal operation. In milling operation metal is removed by a rotating multipoint cutter which is fitted on the arbor of the milling machine. The varieties of features are formed by milling machine on a part by cutting away the unnecessary material. Milling machine is having certain main components, which are its column, saddle, its Base, table, knee, arbour, over-arm and spindle. In milling process, certain aspects plays a very important role such as work-piece, fixture, and cutter which are needed in milling machine. The work held in a fixture, attached to a table of milling machine.

3.3 Experimental Procedure:

In this present method, the aluminum alloy 6082 sheet is taken of thickness 24mm, then horizontal and vertical lines are drawn (marked) on the sheet of aluminum alloy 6082 at regular intervals. The points where the vertical and horizontal lines meet are marked and the hardness is measured by Brinell hardness method at these points. The average of all the nine readings is taken.

Now 4mm of the material is removed by the help of milling machine and the rest sheet of thickness is 20mm. Mark again same points without disturbing the plate or sheet and note the hardness of the sheet at these points by means of Brinell hardness machine. Take the average of all.

Again remove 4mm of material on the sheet and the rest thickness will be 16mm, mark points again and note the hardness at these points and take the average of all.

Similarly repeat the process at the thickness levels of 12mm after removing 4mm thickness material, mark points again and measure the hardness at these points and take the average.

Remove 4mm thickness again as the rest of thickness will be 8mm, mark points again and measure the hardness at these points and take the average of these values.

At last remove 4mm material again and the rest of the thickness will be 4mm,mark points again and measure the hardness at these points and take the average value.

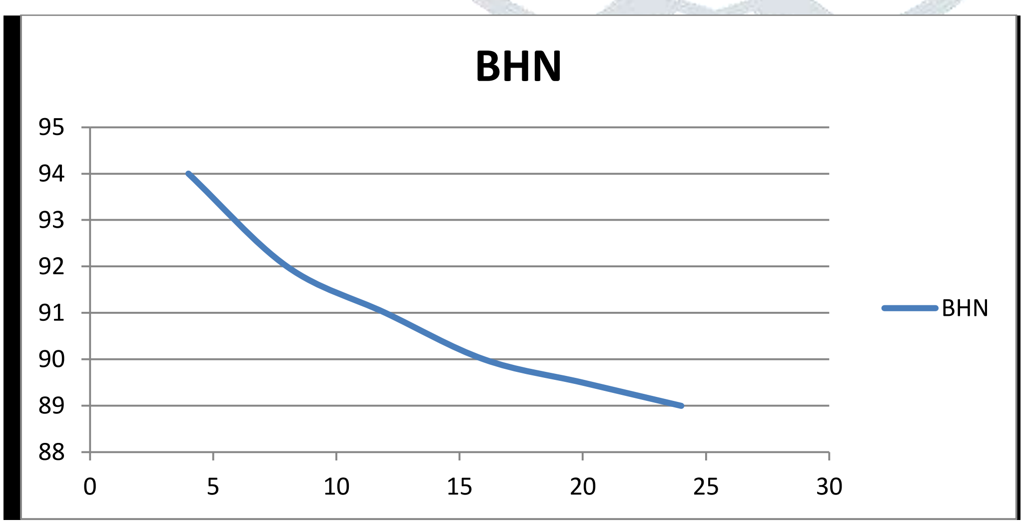
Tabulate these readings and draw the graph, observe the variation of hardness at different thickness.

4 Result and Conclusion

From the above experiment, the variation of Brinell hardness number gets increased with decrease in the thickness, that means the Brinell hardness number is larger for the small thickness. These observations are given below in the form of a table as below:

Average Variations of BHN v/s Thickness in mm:

S.No	Thickness of sheet (mm)	AVERAGE BHN
1	24	89
2	20	89.5
3	16	90
4	12	91
5	8	92
6	4	94



The graph of the above tabulated data BHN vs Thickness

On observing and analyzing the above data, the hardness of the aluminum alloy 6082 gets increased due to the decrease in the size or thickness of the strip. This is due to the formation of magnesium silicates in aluminum alloy 6082 as they contain magnesium and silicon which effects the bonding of the alloy and grain structure.

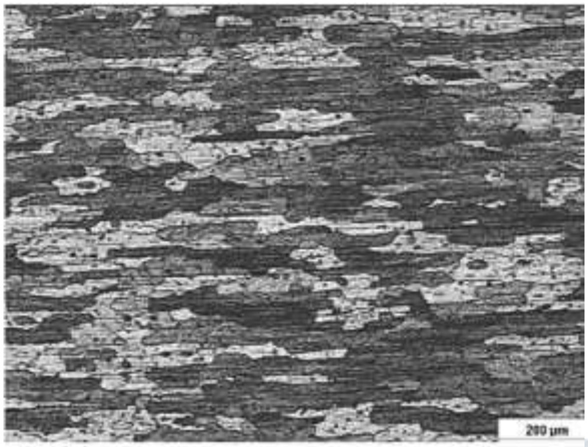


Figure 2 Microstructure of aluminum alloy 6082

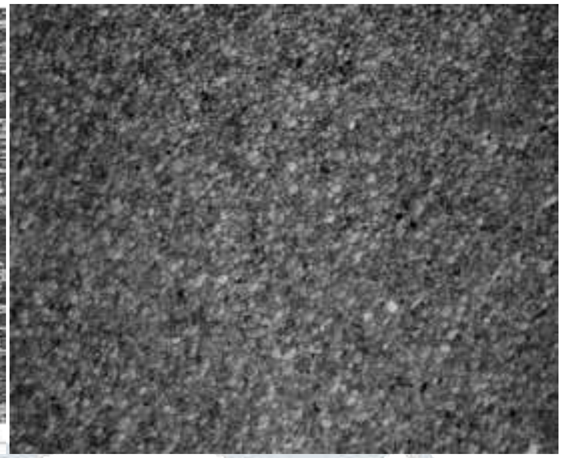


Figure 3 Grain size of aluminum alloy 6082

From the above data obtained on hardness test results as given in the table and the graph, it is observed that the hardness of the aluminum alloy 6082 gets increased with decrease in thickness,This is due to the effect of addition of magnesium and silicon towards the bonding or grain structure with which the hardness of aluminum alloys 6082 gets decreased than the rest of the alloys of aluminum. The main reasons behind this are formation of magnesium silicates, Grain structures (Figure 3) and Porosity. The size of magnesium silicate grain is large, with this the interatomic spaces gets increased that means voids are large .With increased thickness, the interatomic space gets increased and porosity gets increased which results in decrease in the hardness.

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