Hardness Examination of ZA 27/MoS2 Hybrid metal matrix composite using Vicker and Brinell hardness test

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Abstract: ZA 27 is a family group of Zinc Aluminium alloy which possess excellent mechanical and tribological properties. In present work, Vicker and Brinell hardness examination of ZA27 is carried out after reinforcing it with MoS2 particle in proportion of 0%, 1% and 2% using the stir casting method. Casted material is machined and turned surface that can be placed in a hardness testing machine. Before placing in a machine, flattened surfaces of both reinforced and unreinforced materials are mirror polished using sandpaper. Examination of both Vicker and Brinell hardness test results is carried out for both unreinforced and reinforced ZA 27/MoS2 hybrid metal matrix composites. Result revealed that as the percentage of MoS2 increased, the hardness of ZA 27 alloy also increased but a different range of result observed for Brinell and Vickers testing machine which is discussed in this paper.

Keywords: ZA 27, MoS2, Vicker hardness, Brinell Hardness

1. Introduction

Definition of harness according to The Metals Handbook is "Ability of the metal to resist plastic deformation, generally by indentation. However, the term hardness may also refer to stiffness or temper or abrasion or cutting to resistance to scratching. It is the one of mechanical characteristic of a metal, which gives it the ability to resist being permanently, deformed (bent, broken, or have its shape changed), when a load is applied. The **more** the hardness of the metal, the**more** resistance it has to deformation.

Hardness is one of the most characteristic properties of materials and also plays a key role in the development of humanity, as it has made it possible to build increasingly more sophisticated devices and machines. The first modern method for measuring metal hardness is credited to Brinell, who used a hard steel ball as the indenter to measure the hardness. Instead, several other hardness tests, including the Vickers, Berkovich, Knoop and Rockwell tests, were developed.

Hardness test may provide valuable metallic material details such as tensile strength, hardness resistance, and ductility. The test is typically useful for the collection of components, for process and quality assurance and for commercial product acceptance testing.

Even hardness one of characterization of metal, many researchers studied and analysed various parameter of hardness and various hardness testing machine was used to study the hardness. Samuel R. Low [1] discussed Rockwell

hardness testing methods, it's significance, procedure and conducted some case studies of obtained result in detail. Shakeel [2]A analysed and written research article on Hardness measured with traditional Vickers and Martens hardness method, in which comparison between both hardness method was carried out. P. Zhang[3] explained the relationship between strength and hardness. B Y R. Hill [4] researched on the theoretical aspect of Brinell hardness test.

M. Tiryakioğlu[5] conducted detailed research regarding hardness strength relation for Aluminium Alloy and developed empirical relationship between the strength and hardness D.Tabor [6] enlighten various hardness testing methods and their significance in his review article. G SANGAIAH [7] studied the microhardness testing of alum crystals. ZA27 stands for zinc containing 27 percentage of aluminium.ZA27possesses good mechanical and tribological properties as well as low initial cost[8][9].

In present work, the Vicker hardness test and Brinell hardness test are conducted for za 27/ MoS_2 hybrid composite which is prepared after the stir casting method. till now no literature found for the comparative study of these two hardness result for mentioned composite. So aim of present work is to determine Brinell and Vicker hardness of ZA 27 base metal and 1% and 2 % MoS2 reinforced ZA 27 alloy.

2. Preparation Of Materia

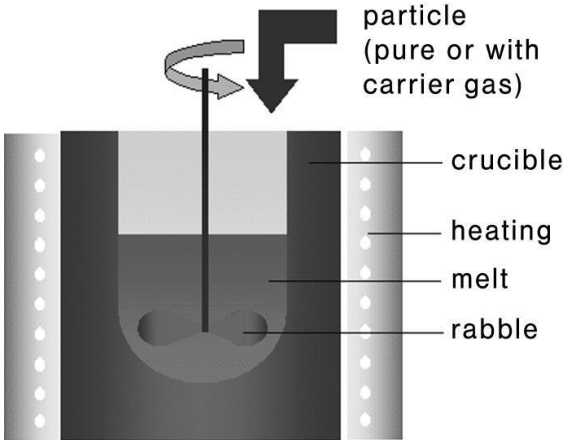

Figure 1 Schematic operational sequence during melt stirring.

Schematic diagram of stir casting shown in Figure 1 The stir casting method is used to prepare specimen for the hardness checking. A calculated amount of ZA 27 was weig hed, based on the crucible size of the furnace, and placed in the crucible. Crucible heating was performed at a constant te mperature of 600^{O}C before the solid ZA27 is converted into liquid phase.It was cool down to 490^{O}C mixing temperature, at which molten metal stirring was performed with the help of a stirrer that operates at a speed of 1 to 500 rpm. Based o n the weight of molten ZA27, 1% of MoS2 particles were w eighed and then poured into stirring liquid operated at 200 r pm stirrer speed gradually to a range of 320 to 350 rpm after mixing of reinforcement material. The Stirring of molten metal was continued for 5 minutes before pouring molten metal, in cast iron pre-sized mould than heated molten metal was poured in the pre-heated mould.The molten metal stirring was continued for 5 minute s before pouring molten metal, in presized cast iron mould a s heated molten metal was poured in preheated mould This p rocess was repeated for reinforcement of 1 and 2 percent of MoS2 particle. Mould was allowed to cool at roo m temperature , resulting in solidified molten metal inside t he mould.Cast metal was removed from the mould and mac hined to finished surface with a polished mirror.

3.Procedure Of Vicker And Brenell Hardness Test:

- Clean the surface of the specimen whose VHN is to be found
- Fix the appropriate indenter and place the specimen on the anvil table underneath bthe indenter
- Check the clarity of the swpecimen on the screen adjust if necessary by rotating the knob provided
- Rotate the indexing disc so as to bring the indenter over the specimen
- Press the start button and keep pressing the same until dwell light glow
- Apply the load on the specimen wait for a while for automatic removal of load
- Measure the diagonals of the impression using the image projected oin the screen
- Determine the VHN using the formula VHN=1.854p/d^{2} Equation 1

Following procedure followed for Brinell hardness test

• Place the specimen at the anvil in order that its floor q may be ordinary to the path of the implemented load.

• With the hand wheel, adjust the height of the anvil till the specimen simply makes touch with the ball.

• Select the ball diameter (indenter) depending upon the weight and time of utility of the weight in keeping with the material to be examined as given withinside the load check table.

• Apply the weight progressively and hold it for 15 seconds.

• Release the weight and take away the specimen. Measure the diameter of impression (indentation) left

through the ball indenter.

• Make 3 trials for every specimen for calculating the hardness number

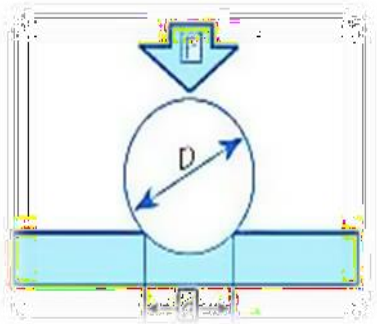

Figure 2 Indentation of brinell hardness test

……Equation 2

$$BHN = \frac{2P}{\pi D(D - \sqrt{D - d}}$$

D = Ball diameter

d = Impression diameter F = Load

HB = Brinell result.

4.Result And Discussion

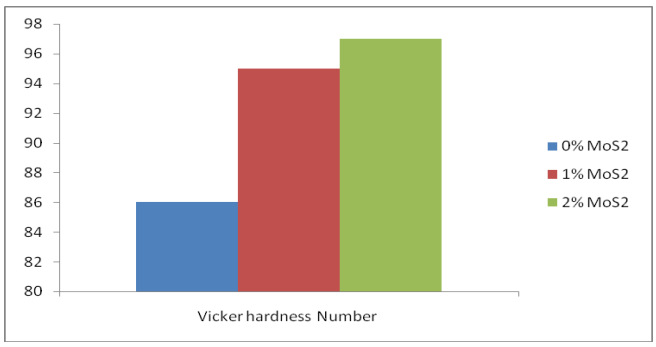

Figure 3 Chart of vicker hardness result for unreinforced and reinforced ZA27 /MoS_2 composite.

Table 1 Vicker hardness result for unreinforced and reinforced ZA27 /MoS2 composite.

SL. NO	MATERIAL	Vicker's Number
1	ZA 27 /0%MoS_2	86
2	ZA 27 /1%MoS_2	95
3	ZA 27 /2%MoS_2	97

Table 2 Brinell hardness result for unreinforced and reinforced ZA27 /MoS2 composite

SL. NO	MATERIAL	Brinell's Number
1	ZA 27 /0%MoS_2	57
2	ZA 27 /1%MoS_2	63
3	ZA 27 /2%MoS_2	69

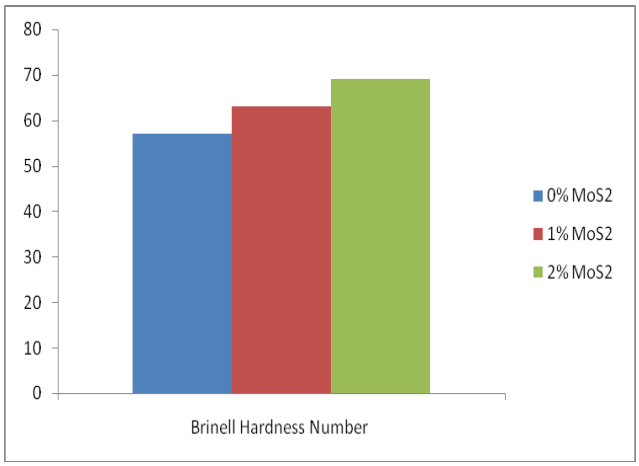

Figure 4 Chart of Brinell hardness result of reinforced and unreinforced ZA27 /MoS_2 composite

The Vickers diamond pyramid hardness number, HV, is defined as the ratio of the applied load, P, to the pyramidal contact area, A, of the indentation

$HV=P/A=\alpha P/d^2$ ·····Equation 1

where d is the length of the diagonal of the resultant impression, and α= 1.8544 for Vickers indenter

Investigations have confirmed that the hardness number calculated with above equation is usually load — dependent

.When a very low load is used, measured hardness is usually high; the measured hardness decreases with an increase in test load. Such a phenomenon is often referred as an indentation size (ISE) effect, the presence of ISE will certainly hamper. But in present investigation constant load of 20kgf and constant time of 15 seconds is kept for checking hardness of MoS_2 reinforced and unreinforced ZA27 alloy using vicker hardness testing machine and brenell testing machine . It can be observed from the figure 3 and 4 as the composition of MoS_2 increased in ZA27 alloy hardness number also increased, for both brenell and vicker hardness test. But variation of result also observed from the table 1 and table 2 . It may be due to limitation in objective lens and sensitivity of load cell and including elastic indentation recovery, hardening during indention , dislocation of the surface pinning[10].

Figure 3 and 4 represent the bar chart of the result of hardness test conducted on ZA-27 alloy and fabricated composite specimen. Detailed result of each sample is shown in table 1 and table 2. It is seen from the results that, higher the hardness number indicates a lower dimension of

indentation. During the surface hardness of the specimen testing, an increase in micro deformation on the surface of the material which implies lesser hardness of the material. Similarly, if the indentation dimension of the specimen is less, it means that the surface of the specimen is hard, as results high hardness resistance. From the bar diagram it can be observed that as the percentage of Molybdenum disulfide increased in ZA-27 alloy, Brinell hardness number of composite material also increased in comparison with unreinforced ZA-27 alloy. It is showed that as the percentage of Molybdenum disulfide increased in ZA-27 alloy, hardness resistance, surface strength and hardness of composite increased.

Above result show the test result conducted on ZA-27 alloy and ZA-27 composite with 0, 1 and 2 percentage of MoS_2. Property and characterization of Molybdenum disulfide are in contrast with graphite in many aspects. In case of graphite-reinforced composites as it same for the Molybdenum disulfide. It will show better frictional performance and increased in hardness. The Hardness of ZA- 27 Alloy increased with an increased in the percentage of MoS_2.Same explanation holds good for the Vicker Hardness result.

5.Conclusion

In this research paper, comparative study of hardness results obtained in Vicker and Brinell hardness testing machine for MoS_2 reinforced and unreinforced ZA27 alloys specimens which are prepared by stir casting method. From the above result, it can concluded that as percentage of MoS_2 increased in the composition of ZA 27 , hardness of ZA 27 is increased And also Vicker hardness test is a more significant and more clear result will obtain as compare to the Brinell hardness test for calculating hardness.

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