National Conference on Recent Advances in Mechanical Engineering and Materials
International Journal of Scientific Research in Mechanical and Materials Engineering
2021 IJSRMME | Volume 4, Issue 7 | ISSN : 2457-0435

# Hardness and Wear Characteristics of Al2214/Silicon Carbide reinforced Aluminium Metal Matrix Composites

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## ABSTRACT

The latest in material improve very high achievement in innovations. Advancement of Composite materials is noteworthy advance in streamlining the materials. The MMC'S is reinforced with SiC particles, stated as Al MMC's, it have more developments in their physical and mechanical properties as compared to conventional MMC's. The proposed work is to fabricate and compare the mechanical and physical properties of Al2214/SiC composites. The composites were readied utilizing mix projecting strategy in which measure of Silicon Carbide, is differed independently from 2-10 wt% in strides of 2wt%. The mechanical properties of created composite MMC's are assessed and contrasted and unadulterated compound.

**Keywords-** Silicon Carbide, AL2214, MMCs, Hardness, Wear

## I. INTRODUCTION

Aluminium Alloy 2214 material is used in industrial needs and their applications are in automobile sectors like pistons, piston heads, and bearings, where the friction and wear rate is more important role due to having high wt% copper.

The general criteria to choose this series are:

- High mechanical resistance.
- High resistance to fissure propagation .
- Improves its tenacity.
- Poor corrosion resistance.

The AL 2214 based alloy have physical properties:

- Tension Strength >=425
- Yield Strength >=275
- Hardness 125-145

Table 1: Aluminium alloy 2214 Chemical composition

| Weight % | Al | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti |
|---|---|---|---|---|---|---|---|---|---|
| Al2214 | Balance | 1.2 | 0.3 | 5.0 | 1.2 | 0.8 | 0.1 | 0.25 | 0.15 |


"Fig. 1"Al2214 Ingots

The Al2214 is a hardest aluminum alloy which having manganese, the two parameters like silicon and copper as its major alloying elements. Mechanical properties which enhances the heat treatable alloy as compared to other Aluminum alloys. And it increases high strength, good achievable workability, maintain good machinability and increases resistance to corrosion.

The Silicon Carbide (SiC) particles are in powder form of size 45-50 μm and it is used as reinforcement in this experimental evaluation, and their mechanical properties of Silicon Carbide are shown in table 2.

"Fig.2" Silicon Carbide Particulates

Table 2: Mechanical properties of Silicon Carbide

| Mechanical Properties | Silicon Carbide (SiC) |
|---|---|
| Density | 3.02 gm/cc |
| Molecular weight | 40.20692 g/mol |
| Melting Point | 1380°C |
| Vickers Hardness | 2800 |
| Crystal structure | Hexagonal crystal structure |
| Thermal Conductivity | 120 W/m.K |

Silicon Carbide is an inorganic metal oxide which is mainly used in ceramic materials. Silicon Carbide succeeds tungsten as the compound that most frequently occur in nature

The Silicon Carbide is an inorganic metal oxide, which is mainly used in ceramic materials.

The single support Al lattice may some of the time bargain the estimations of its physical and mechanical properties. Subsequently, it is fundamental to recognize approaches to hold the worthwhile impact of SiC while at the same time taking care of the issues of machining SiC-fortified composites.

Improving the growth in base metal the reinforcement of ceramic particles that are found in fibers, whiskers and particulates and is mixed by using stir casting method to achieve required properties of metal matrix composites.

The Al2214 combination was utilized as network compound and SIC was utilized as fortifications for arrangement of composites. SiC of 2-10 wt. % (span size 2%) the worth is fortified with the Al2214/SiC composites.

The pot containing with the hardened steel impeller was covered with alumina. The charge of about 3kg was liquefied under unadulterated magnesium of high virtue. The Degasser used to make latent environment to evade oxidation and eliminates the slag from the Al2214 slurry.

The impeller speed was kept up at range between 400-600 rpm. During blending, the preheated SiC was poured in to the liquid metal for blending consistently. Whenever mixing was finished, the heater was inclined and dissolve was filled the cast-iron kick the bucket.

Table 3: Composition of specimens Reinforced

| Specimen | Al2214 (gm) | SiC (gm) | Wt.% |
|---|---|---|---|
| A | 2000 | 0 | 0 |
| B | 1960 | 40 | 2 |
| C | 1920 | 80 | 4 |
| D | 1880 | 120 | 6 |
| E | 1840 | 160 | 8 |
| F | 1800 | 200 | 10 |

Stirring procedure as shown in Figure.3 it shows that the temperature-time bend demonstrating the direction and the temperature trips utilized in these trials. .

There are different periods of the handling plan.

Stage 1 : Maintained liquid metal in heater for 60 min in inactive air condition.

Stage 2 : The liquid metal got to the working temperature up to 7000C.

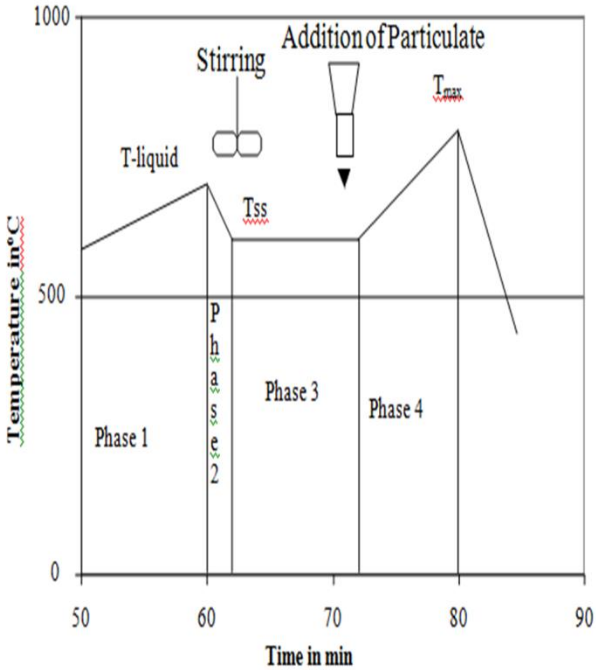
Stage 3 : The fortification stage is brought into the liquid (slurry) in the semi strong stage for 5 min appeared in Fig.3.

Stage 4 : From the temperature time twist, the composites were re-mellowed to a temperature over the liquidus temperature (Tmax = 700-7200C). For 10 min of length.

Table 4:Stirring Parameter

| Stirring Temperature | Stirring Speed | Stirring time |
|---|---|---|
| 700C | 500 rpm | 600 Seconds |

Stage 5 : Stage 5: The liquid metal Poured into the shape cavity and permit to cool in room temperature for 15




"Fig 3" Schematic representation of the temperature-time sequence for Composite preparation

To develop the taking care of huge scope and microstructure relationship the planning conditions are as demonstrated in Table 3.

## II. CHARACTERIZATION OF AL 2214 SIC MMC'S BRINELL HARDNESS TEST (ASTM E10)

ASTM E10 technique covers the assurance of the Brinell hardness of metallic materials by the Brinell space hardness standard.

In our work we have conducted hardness test by using Rockwell and Brinell hardness testing machine in accordance with ASTM E10 standard.

- Place the example on the iron block so its surface will be ordinary to the bearing of the applied burden.
- Note the sort and size of the indenter
- Adjust the loads on the unclogger as indicated by the sort of test whether it is Rockwell or Brinell appeared in diagrams by load determination circle keep the switch at position "A"

- Raise the iron block and test example by turning the hand wheel clockwise with the goal that example will push the indenter and the little pointer in the dial begins to move
- Continue to raise the example until the little pointer comes to SET (red spot) position.
- This shows that the minor heap of 10 kgf is following up on the example Turn the switch from position "A" to "B" gradually so the all out burden is gotten to activity with no bastards.
- The indenter begins to go down into the example and the long pointer of the dial measure arrives at a consistent position when spaces total
- Take back the switch to position "A" gradually
- Read the situation of the pointer on the chose scale. Which gives the number according to the chose kind of test Turn back the hand haggle the example
- Carry out similar methodology to acquire three free hardness judgments on every example.

**Wear Test (ASTM G99)**

To contemplate the wear of materials, on various examples with a similar test conditions. One approach to play out the wear test is with a ball or pin on circle Tribometer (ASTM G99). With this test, a reference test is mounted on a pivoting stage and a pin or ball (object of study) interacts with the example surface with a known applied burden. A ball or pin for the assessment of wear misfortune gives a few particular focal points.

Assessing the wear of the ball or pin gives wear data at the contact point which stays under burden during the full term of the test. This contrasted with the base material that solitary encounters wear during a similarly brief timeframe.

The wear models are attempted under dry status, by use of pin-on-disc is used to determine the wear characteristics. The regular procedures are taken considered to evaluate the wear, are loss of mass in the material, expulsion methodology, insufficiency of weight strategy and wet wear test. The model is weighed from the outset and make a note of weight keeping the sliding distance as in steady state; the sliding squeezing factor can vary by increasing loads and coordinating test. At last weight to be recorded. The gadget includes a turning plate of broadness 200 mm. Strategies are used to hold and load on the models.

The models were cut immovably the model hold against turning steel circle. The models were cleaned through and through and weighed unequivocally using an incredibly trustworthy and a tricky harmony to a precision by three decimals. The surfaces of the work models were seen using a looking at electron amplifying instrument.

As wear properties of the steel plate are not considered for examination because disc wear volume was very small. The cylinder wear test instances of width and length of 10 mm and 50 mm were cut, ground and cleaned to the essential size preceding testing. The wear tests were finished pin-on-disc wear testing machine according to ASTM G99 rules. The test tests were supported in the holder and held against the rotating wheel far off of 60 mm from the Center. In the current assessment, customary loads of 15N, 30N, 45N, 60N and 75N independently were applied on the model and the speed of the turning wheel are changed from 200 to 500 rpm in steps of 100 rpm.

A framework is used for test model:

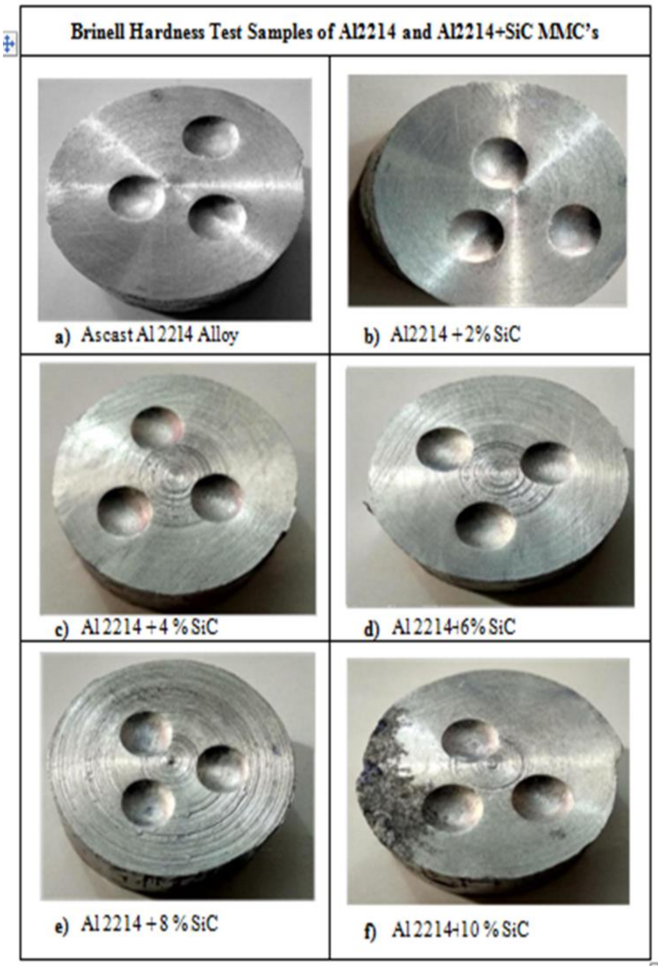
- The size of 10 mm width and 50 mm length was balanced by electronic balance to a precision level of 0.01 mg to choose the fundamental weight.
- The illustration of size 10 mm expansiveness and 50 mm length was first said something an electronic harmony to an accuracy level of 0.01 mg to choose the basic weight.
- The models fixed in wear testing machine for different loads and rates for 15 minutes.
- The models were reverified after the tests for decrease in weight .

## III. RESULTS AND DISCUSSION

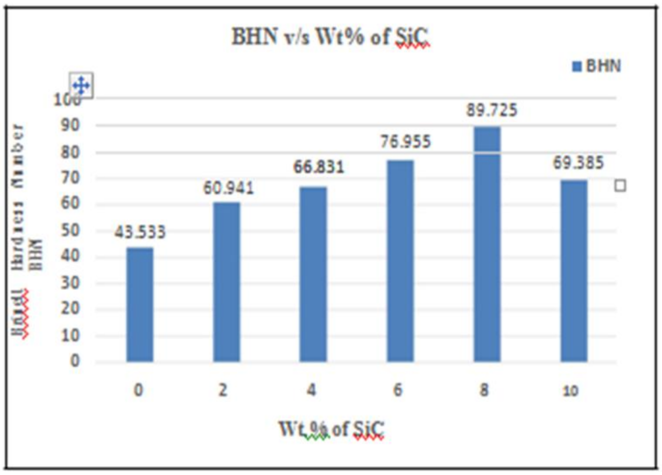
### Brinell Hardness Number

Table 5: Brinell hardness number (BHN) for Al2214 and Al2214/ SiC Metal Matrix Composites.

| Sl No | % of Reinforcement | BHN |
|---|---|---|
| 1 | Al 2214 | 43.533 |
| 2 | Al2214 + 2% SiC | 60.941 |
| 3 | Al 2214+ 4% SiC | 66.831 |
| 4 | Al 2214 + 6% SiC | 76.955 |
| 5 | Al 2214 + 8% SiC | 89.725 |
| 6 | Al 2214+10% SiC | 69.385 |




"Fig. 4" Brinell Hardness Test Specimens Test Specimens of a) Ascast Al 2214 Alloy,b)Al2214 + 2% SiC, c) Al 2214 +4 % SiC, d) Al 2214 + 6% SiC,e)Al 2214 + 8 % SiC, f) Al 2214 + 10 % SiC



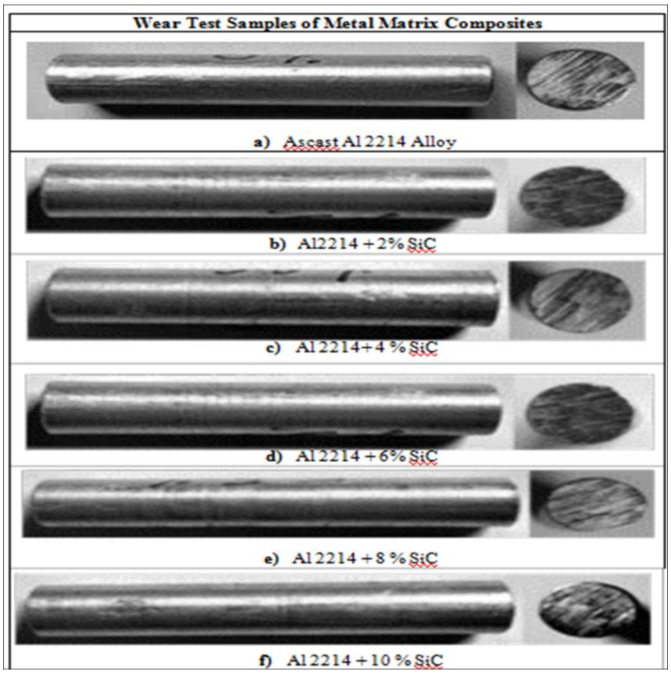

"Fig.5" The effect of Wt.% SiC on Hardness of Al 2214and Al2214/SiC composites

The Table 5 presents the normal of three hardness (BHN) perusing estimations of combination and its composites. Figure 5. shows the charts for the impact of support content on brinell hardness number of the prepared Al 2214 amalgam and Al 2214 + (2 - 10 wt.% of Silicon Carbide) composites. Each estimation of hardness is a normal of 3 readings (tests).

From the graphs is seen that increases in hardness was refined up to 8 wt.% SiC. As increasing in SiC from 0 to 8 wt.% the hardness extended by about 51.48 %. The augmentation in hardness can be credited the content of Silicon Carbide offer fortitude the organization mix, thusly giving improved insurance from space or scratch.

From the diagram it is seen that there is an abrupt diminishing in hardness of the composite at 10 wt.% of Silicon Carbide support, which is supposed to be diminished by 22.6 %, its because of the groups development and primarily in view of disengagement and de-holding between the framework and fortification.

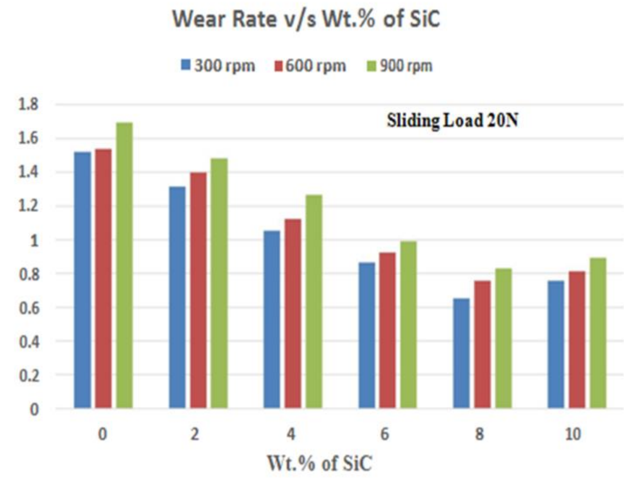
## WEAR TEST



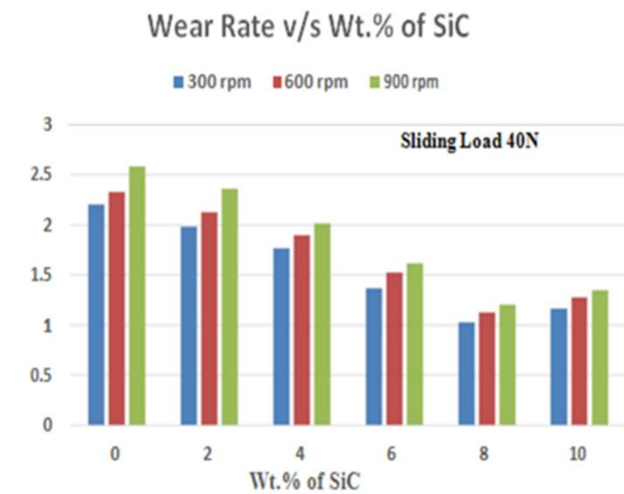

"Fig. 6" Wear Test Specimens of a) Ascast Al 2214 Alloy, b) Al2214 + 2% SiC,c) Al 2214 +4 % SiC, d) Al 2214 + 6% SiC, e) Al 2214 + 8 % SiC,f)Al 2214 + 10 % SiC

Table 6: Wear rate (mm3/m) of Al/ SiC MMCs of different Loads and speed Condition

| Load N | Sliding Speed RPM | Wear Rate in $10^{-3}$ mm³/m | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wt.% of SiC | | | | | |
| | | 0 | 2 | 4 | 6 | 8 | 10 |
| 20 | 300 | 1.5189 | 1.312 | 1.0526 | 0.865 | 0.652 | 0.756 |
| | 600 | 1.538 | 1.397 | 1.1206 | 0.923 | 0.756 | 0.812 |
| | 900 | 1.6919 | 1.482 | 1.2639 | 0.989 | 0.827 | 0.891 |
| 40 | 300 | 2.198 | 1.982 | 1.762 | 1.368 | 1.026 | 1.159 |
| | 600 | 2.326 | 2.125 | 1.892 | 1.521 | 1.123 | 1.276 |
| | 900 | 2.581 | 2.361 | 2.012 | 1.612 | 1.198 | 1.345 |




"Fig. 7" Effect of wt. % of SiC and sliding speed on wear behavior of the Al 2214/SiC composites at 20N




"Fig. 8" Effect of wt. % of SiC and sliding speed on wear behavior of the A2214/SiC composites at 40N

Keeping other conditions same, Al 2214 shifting level of Silicon Carbide particulate scattered in various ways were evaluated for wear obstruction contrasted with the base network without scattering. From Table 6 as shown that the cast models were furthermore included the testing of wear rate in terms decrease in weight in a composites of 0, 2, 4, 6, 8 and 10 wt.% of Silicon Carbide independently ascast.

Information recorded on wear speed of Al2214/SiC fortified MMC's at various loads of 20N and 40N, various paces of 300, 600 and 900 rpm at various Wt.%

of Silicon Carbide added to the Al Alloy as fortification is introduced in table 6. The wt.% of Silicon Carbide added to the Al Alloy helps the wear speed of the composite material and decreases expanding of load and sliding rate up to 8 wt.% of Silicon Carbide (SiC). Nevertheless, there is expansion in the wear rate for 10 wt% of Silicon Carbide.

The impact of Silicon Carbide (SiC) content on wear attributes of Al 2214/SiC particulate for the wear test of rotational speed of 300, 600 and 900 rpm and loads of 20, and 40N is appeared in Figs 7 and 8 which are the specialist charts plotted subject to wear rate results.

Coming up next to uncovered the assessment of wear speed of Al 2214/SiC composites rely on the % of Silicon Carbide (SiC) scattering. Wear rate was found to reduce with the expansion in SiC content from 2 to 8 wt. %. There is an inevitable result for expansion in wear rate for the 10 wt.% of Silicon Carbide (SiC), when separated and the 8 wt.% maintain.

The weight rate is least for the composite containing 8 wt.% SiC .The wear rate remains constant at lower loads.

Wear rate was occurred at Al2214 yet dependably this diminished. Maybe, by virtue of hard particles of SiC scattered in the base association there is all around speedy accomplishment of steady quality in the wear opposition, as seen.

## IV. CONCLUSION

It is seen that the hardness is drastically increased at 8 wt.% SiC. As the Silicon Carbide from 0 to 8 wt. % the hardness of the material is increased about 51.48 %. The presence of Silicon Carbide particulates will improve the hardness that present fortitude to the matrix blend, in this way giving improved insurance from space or scratch.

From the diagram it is seen that there is an abrupt diminishing in hardness of the composite at 10 wt.% of Silicon Carbide fortification, which is supposed to be diminished by 22.6 %, its because of the bunches development and essentially due to separation and de-holding between the lattice and support.

The weight rate by wear is least at 8 wt.% of composite. The SiC dispersoid is main role. The wear rate remains less at lower loads by increase in rpm.Also, light wear rate ar show up at Al2214 without dispersoid anyway reliably adversity reduced. As a result of hard particles of Silicon Carbide (SiC) dispersed in the base organization there tolerably fast accomplishment of solidarity in the wear resistance, as seen.

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