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# Evaluation of Mechanical and Wear Properties of Vortex Stir Castal6061 Alloy

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**Abstract:**This paper presents an experimental study on silicon carbide and Zirconium oxide reinforced with the Al 6061 fabricated with a process such as Stir Casting. The Metal matrix composites are reinforced by nanoparticles. The main objective to present this work is to form the reinforcing particles with aluminum melt by adding silicon carbide and zirconium oxide into base metal into the liquid state. Firstly, thecomposite is prepared and then the evaluation of the mechanical and the physical properties of the composite material are done. An improvement in hardness and wear property has been reported.

## Introduction:

Composite generally have better characteristics and property than those of individual material. Composite is multiphase material that exhibits significance properties of both the material. Different types of metal matrix composites are: dispersion, particle and fiber reinforced. On the basis of temperature during the fabrication process, metal matrix composite aredivided into three parts:

1. Liquid state phase process.
2. Solid state process.
3. Two phase process (Solid-Liquid).

In liquid state phase process, the ceramic particles are included into molten metallic matrix with the help ofdifferentways followed by mixing and casting the resulting MMC's quality. The stir casting method of MMC's is liquid state of the fabrication process for fabricating the composite materials.The ceramic particles are distributed andadded with molten metal by mechanical stirrer.A cast is then prepared with the help of conventional casting methods.Research has been conducted to fabricate the Aluminum metal matrix composites [1], [2]. [3]haveAMC with help of stir casting process. For this fabricated Aluminium (6061) based composite reinforced withSiC, Alumina and Graphite and studied the parameters of stir casting process.Meenaet. Al[4] studied about the aluminum alloy metal matrix composite of Al 6063 with three different mesh size 220,300 and 400 reinforced with silicon carbide with a weight fraction of 20% and found improved microstructure and mechanical properties.Jayaseelan[5] observed that stir casted samples exhibit better strength in comparison to samples prepared using powder metallurgy technique. [6]have fabricated particulate aluminium metal matrix composite (PAMC) havingvariable percentage of reinforcement such as graphite, $Al_2O_3$ and silicon carbidewith stir casting technique. They concluded that increase in amount of silicon carbide resulted in reduced wear rate and good improvement in UTS. As the amount of reinforcement increases ductility of the PAMC reduces and hardness of PMAC goes on increasing.

**Experimental details:** The first reinforcement material selected is SiC. It is used in the fabrication of the aluminum metal matrix composite it increases the strength of the composite and wear resistance of the composite material. The density of silicon carbide is close to the density of Al-6061 which makes the silicon carbide a good reinforcement. The second reinforcement material $ZrO_2$ has been selected as it forms mono clinical crystal structure at normal temperature or room temperature. The reason why it is used with the composite material is very simple because it provides a protective layer to the composite material.

At the initial stage, aluminum was taken on the matrix of the experiment so that oxidation of aluminum would produce a fine particle of $Al_2O_3$ within the matrix of composite material. Starting results with pure aluminum matrix shows that the uniformity of the aluminum particles cannot be obtained with the pure aluminum melt the reaction was also small because a lot of particles are left in the crucible of the furnace. To increase the wettability of the particle and to produce uniform distribution we add a small amount of magnesium into the aluminum melt. The aluminum metal matrix composite was prepared using the vortex stir casting method. For this, we take 5 kg of Al 6061, 1kg of zirconium oxide powder, and 1kg of silicon carbide powder of mesh size 200. For our first composition we take 1.5 kg of aluminium and melt into the furnace and the melt temperature was increased to 800 °C then the melt was stirred using mild steel turbine stirrer.The stir was rotated for 5 minuteswith an impeller speed of 200 rpm and then we add silicon carbide and zirconium oxide with a preheating temperature of 500 °C for 3 hours to remove the moisture content from them and again the mixture for 5 minutes and maintain the melt temperature of 800 °C and then we add magnesium to increase wettability then we pour the melt into a permanent sand mold and the pouring temperature was sustained at 720 °C and finally, the melt was leave tosolidified into the mold. Again the similar step was taken to make another composition of the metal matrix composite. Three compositions have been prepared.

**Table 1: Composition 1**

| Aluminum % | SiC % | Zirconium Oxide % |
|---|---|---|
| 90% | 5% | 5% |

**Table 2: Composition 1**

| Aluminum % | SiC % | Zirconium Oxide % |
|---|---|---|
| 85% | 5% | 10% |

**Table 3: Composition 1**

| Aluminum % | SiC % | Zirconium Oxide % |
|---|---|---|
| 85% | 10% | 5% |

The hardness test of the composite material done on the Vickers hardness testing machine and the indentor used for testing are diamond indentor and the load applied for the testing is 10 kg for 5 minutes. The tensile strength of aluminum alloy is measured by the ultimate tensile testing machine. The standard size of the test specimen is 52mm holding length from both side and holding diameter is 15mm and gauge length is 100 mm with diameter 10 mm. The test result was compared to the tensile strength of pure aluminum. The wear behavior of the composite material is done in Ducom lab of Bangalore on a pin on the disk wear testing machine. The test was carried with different load and different sliding velocity. The standard of the pin is diameter 10 mm and length of the pin are 30 mm and the dimension of the rotating disk is 10-100mm which is made up of carbon steel. The weight of the sample is measured before and after the test to check the weight loss and calculate the abrasive wear of the test sample

## Results and discussion:

The tensile test and hardness test results for the samples have been shown in Table 5.

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**Table 4: Hardness details**

| Sr. no. | Sample designation | Hardness (HV) |
|---|---|---|
| 1 | Pure Aluminum alloy 6061 | 107 |
| 2 | Al 6061 90% +SiC 5%+ $ZrO_2$ 5% | 210 |
| 3 | Al 6061 85% + SiC 10% + $ZrO_2$ 5% | 240 |
| 4 | Al 6061 85% + SiC 5% + $ZrO_2$ 10% | 310 |

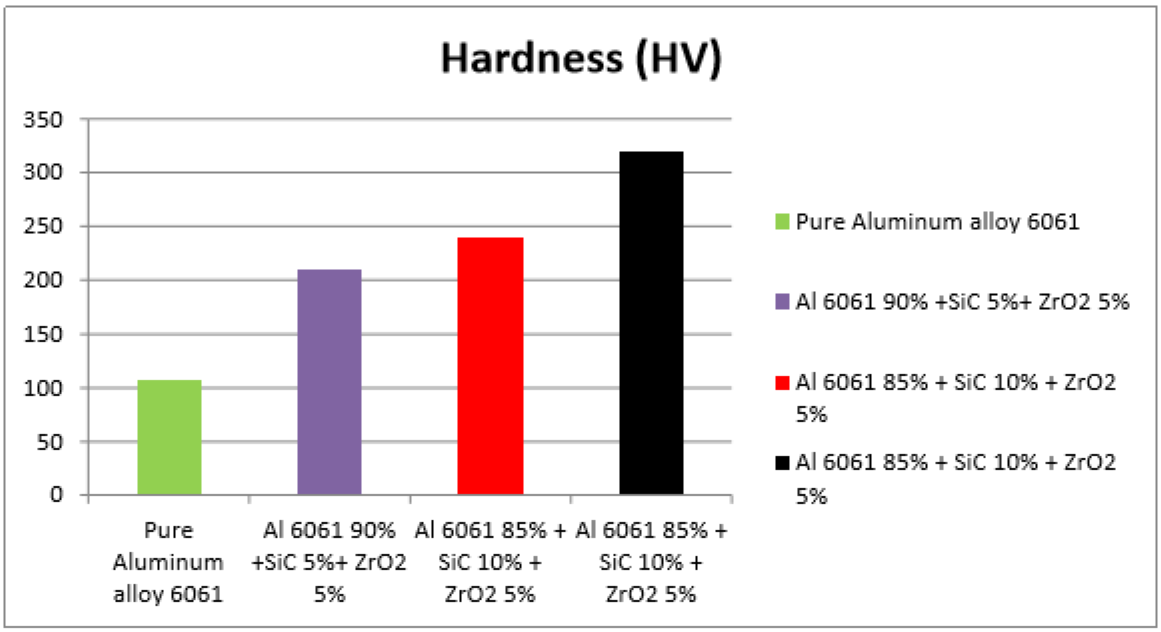


**Figure 1: Hardness Bar Graph**

**Table 5: Tensile test and hardness results**

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| Sl No | Sample Designation | Hardness (HV) | Ultimate Tensile strength (MPS) | % Elongation |
|---|---|---|---|---|
| 1 | Al 6061 90% +SiC 5%+ $ZrO_2$ 5% | 210 | 127 | 2 % |
| 2 | Al 6061 85% + SiC 10% + $ZrO_2$ 5% | 240 | 137 | 1% |
| 3 | Al 6061 80% + SiC 5% + $ZrO_2$ 10% | 320 | 139 | 1% |

The wear behavior of the composite material studied on the following factors like applied loads and the sliding velocity of material the result of each test. For all the specimen material the sliding velocity is 1m/sec and the total load applied is 10 N and total time of rotation is 30 minute.


**Figure 2: Composition Al 90% +SiC 5% +ZrO2 5%**

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**Figure 3: Composition Al 90% +SiC 10% +ZrO2 5%**

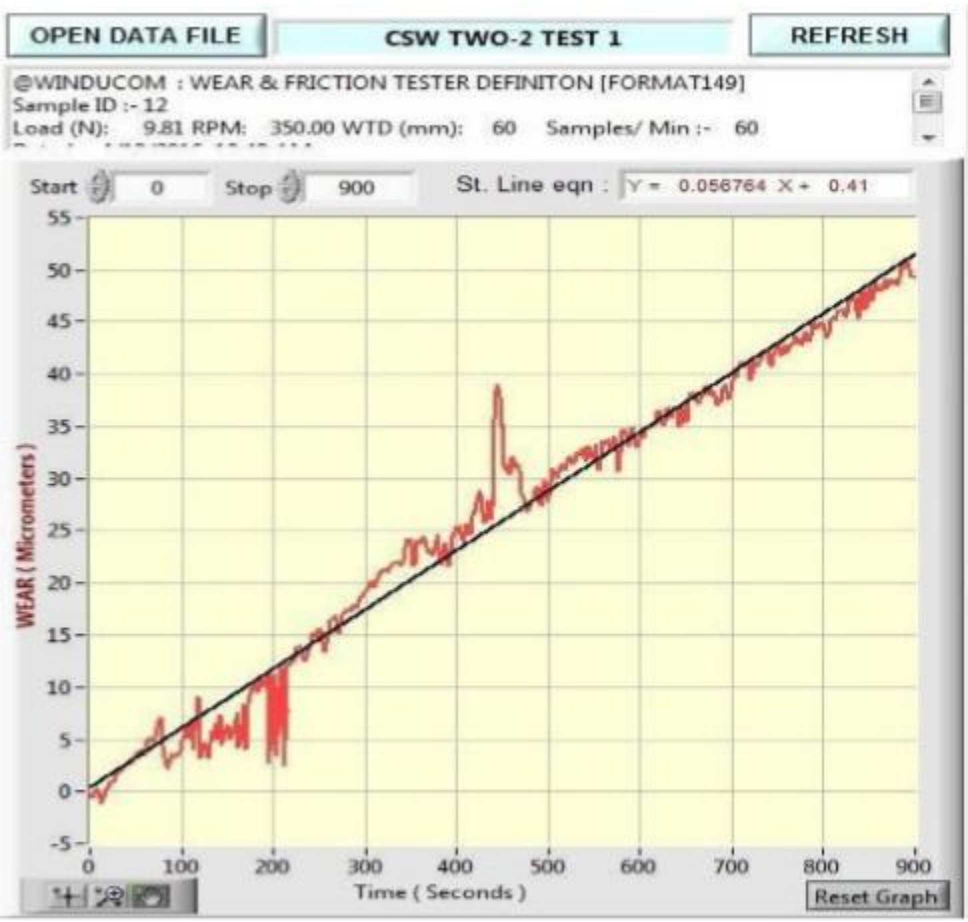


**Figure 4: Composition Al 90% +SiC 5% +ZrO2 10%**

From Figure 2, Figure 3 and Figure 4, it can be concluded that the wear rate of the composite material is improved with an increase in the composition of the silicon carbide and zirconium oxide. But the there is a great improvement in the result of the third graph of composition (Al 90%+SiC 5% +$ZrO_2$ 10%) the wear loss of this composite is very less as compared to the other two composite. This change occurs because of increase in the composition of zirconium oxide.

From the Figure 5, Figure 6 and Figure 7, we can clearly see that the coefficient of friction reduces with rise in the composition of zirconium oxide and silicon carbide but the graph of the composition (Al 90% +SiC 5% +ZrO2 10%) shows very less coefficient of friction as compared to the other two compositions because of increase in composition of zirconium oxide. So we can say that with an increase in the composition of zirconium oxide there is a decrease in coefficient of friction of the material.

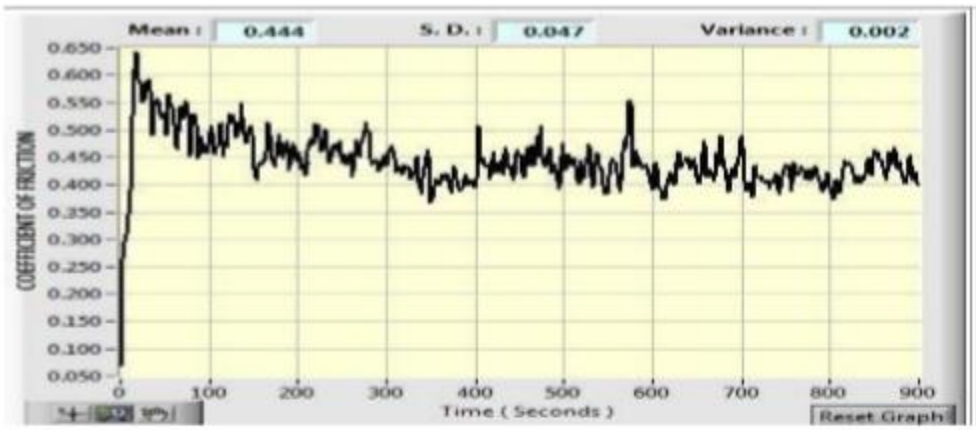


**Figure 5: composition Al 90% +SiC 5% +ZrO2 5%**

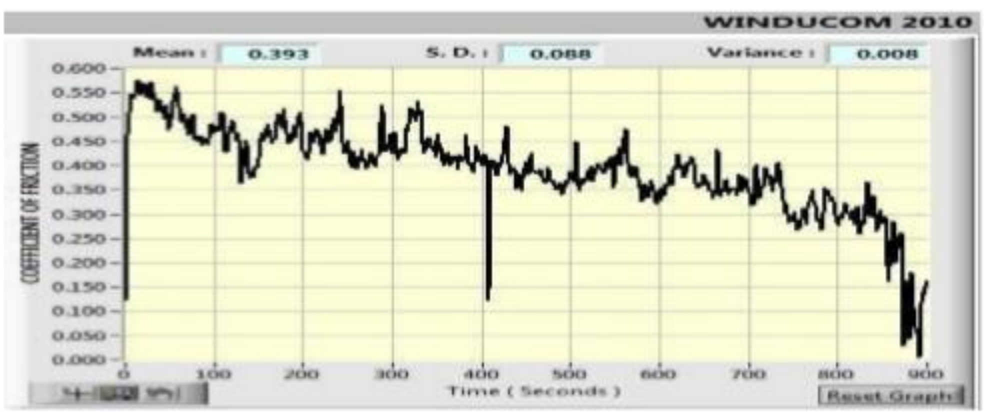


**Figure 6: composition Al 90% +SiC 10% +ZrO2 5%**


**Figure 7: composition Al 90% +SiC 5% +ZrO2 10%**

**Table 6: Wear Calculation Table**

| Sl | LOAD (N) | WEAR TRACK (mm) | SPEED (RPM) | TIME (Min) | WEAR (microns) | Initial weight of sample (gm) | Final weight of sample (gm) | Weight loss of the sample (gm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 60 | 350 | 30 | 195 | 9.01452 | 9.01194 | 0.00258 |
| 2 | 10 | 60 | 350 | 30 | 57 | 8.67158 | 8.66934 | 0.00224 |
| 3 | 10 | 60 | 350 | 30 | 51 | 8.869899 | 8.86831 | 0.00158 |

## Conclusion:

Following conclusions can be drawn:

1) The hardness of the Al6061 composite increase with the increase in the composition of silicon carbide and zirconium oxide but it give more hardness with the increase in the volume % of zirconium oxide.
2) The tensile strength of the Al6061 composite material is improved with the increase in the composition of silicon carbide and zirconium oxide but it better with zirconium oxide but the ductility of the composite material reduces with the increasing composition of silicon carbide and zirconium oxide.

 

3) From this paper, we can say that 15 % weight of silicon carbide and zirconium oxide can be successfully added to the Aluminum by using stir casting process.
4) By adding the magnesium to the composite material the wettability of the composite material is improved.
5) By using the vortex stir casting there is a uniform distribution of the composite material.
6) The wear rate of the composite material is improved to a great extent it gives a better result with the increased composition of zirconium oxide than silicon carbide.

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