

Study of Mechanical and Wear Characteristics of Hybrid Aluminum Metal Matrices

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ABSTRACT: Hybrid metal matrix composites have a huge demand in automotive, aerospace, and other applications because they contain high specific strength, low density, and better mechanical properties compared to metal matrix composites. Specimens were prepared by stir casting method and they are machined to required shapes, and sizes. Sic+ Graphite, Sic+TiO₂ are added to the MMC to get the hybrid composites. The mechanical and wear properties of the hybrid metal matrix composites were investigated in this paper. Hardness will increase with increasing wt. % to the material, tensile strength will decrease with addition of wt. % to the material, wear rate will increase.

KEYWORDS: Aluminum metal matrices composites, stir casting, Hardness, Tensile test, Wear test

I. INTRODUCTION

Aluminum metal matrix composites have a huge demand in the present generation because they are widely used in marine industries, aerospace, automobiles due to they have good mechanical properties like hardness, density, wear resistance, stiffness. Ceramic particles are added to the reinforcement the aluminum metal matrix composite will get strengthened and the reinforcements like Sic, fly ash, red mud, mica etc., from that it will improve the mechanical properties and physical characteristics. The AMCs were manufactured by different methods, the methods are stir casting, powder metallurgy, squeeze casting. After fabrication it will generate mechanical and tribological behavior of the AMCs and the AMCs require some good bonding between with ceramic particles to achieve better mechanical properties and wear properties. There are two types of casting process and from that 1.liquid state processing 2.solid state processing and the liquid state processing is the best way because of its processing, simplicity. So stir casting method is employed for liquid state processing which can melt the aluminum matrix completely.



Fig.1. Stir casting

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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In this paper the work has been carried out on the aluminum metal matrix composites reinforced with Sic+TiO₂ and Sic+Graphite with the stir casting method. Sic has some good mechanical properties, TiO₂ has some good properties compared to Sic and Graphite. The tribological properties were conducted on the following specimens prepared and from that hardness, tensile strength, wear rate was observed.

II. EXPERIMENTAL DETAILS

Specimen preparation:

Aluminum metal matrix composites were fabricated using these reinforcements (Silicon Carbide, Graphite, and Titanium dioxide) and Aluminum 6061 alloys ingots, by using Stir casting method under 700⁰c temperature. The components were fabricated with different compositions.

Table 1. Chemical composition of Aluminum alloy (AA6061)

Elements	Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Al
% by Weight	0.64	0.293	0.261	0.095	0.88	0.033	0.089	0.032	Balance

Properties of Aluminum alloy:

- Medium to high strength
- Good toughness
- Good surface finish
- Can be anodized

1. Pure aluminum metal was taken in to the cavity with some weight and melted with 700⁰c after that, the Sic+TiO₂ reinforcement with 5%, 7.5% weight was taken which is corresponds to the weight of aluminum is poured into that hot molten metal and then it is mixed with the help of mechanical stirrer.
2. Pure aluminum metal was taken in to the cavity with some weight and melted with 700⁰c after that, the Sic+Graphite reinforcement with 5%, 7.5% weight was taken which is corresponds to the weight of aluminum is poured into that hot molten metal and then it is mixed with the help of mechanical stirrer.

In this way the components with different compositions were fabricated by using Stir casting method.

Tests conducted

Rockwell hardness test:

The hardness of the composites was conducted by Rockwell hardness tester. Prior to testing, test specimens cut out from each composite were polished to obtain a flat and smooth surface finish. Rockwell hardness is determined by taking the indenter into the contact with the specimen and after that some load is applied to the specimen and kept constant for a set time after which the load is removed, returning to the preliminary force level. Then the preliminary force is holded for a set time period, the depth of indentation is measured second time, followed by the removal from the specimen.

The measured difference between first and second indentation depth is calculated. Multiple hardness tests were conducted on each sample and the average value taken as a measure of the hardness of the specimen.

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Tensile test by Tensometer:

The tensile strength of the composites was evaluated by tensometer. The shape of the specimen to be tested must conform to ASTM standards and it is prepared. As the force is applied on the specimen the material begins to stretch or extend, and the force applied is kept constant and the readings of force and extension are noted until the specimen finally breaks. These readings are plotted on the graph to show the overall performance of the material.

Wear test on Pin on Disc:

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact. It is one of the cause of material wastage and loss of mechanical performance. Wear test is carried on pin on disc machine as shown in fig. 2, test specimens as shown in fig. 3, and were machined into pins with a length and diameter of 20mm and 8mm respectively. Initially test specimens were weighted by using electronic weighing machine and then fix it to the test machine holder up to 300sec and weight loss is measured. Then the procedure is repeated for other samples keeping the speed constant and the load changes, then the readings are noted according to it.



Fig2. Wear Testing machine

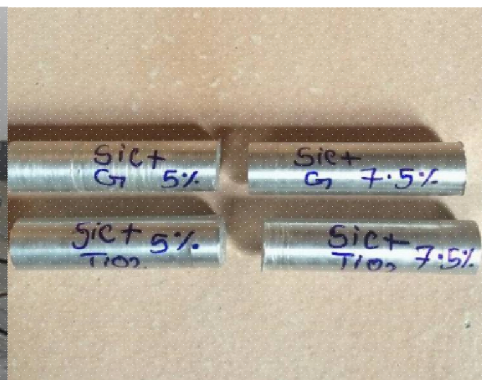


Fig.3. Wear testing specimen

III. EXPERIMENTAL RESULTS

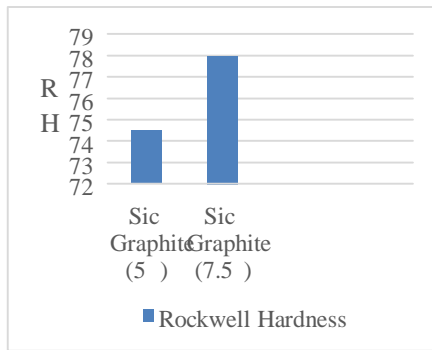
Rockwell hardness testing results

The Rockwell hardness of the composites (Aluminum6061 95% + (SiC +Graphite) 5%) and same as 7.5% are plotted in fig 4. and again (Aluminum6061 95% + (SiC +TiO₂) 5%) and same as 7.5% are plotted in fig 5.

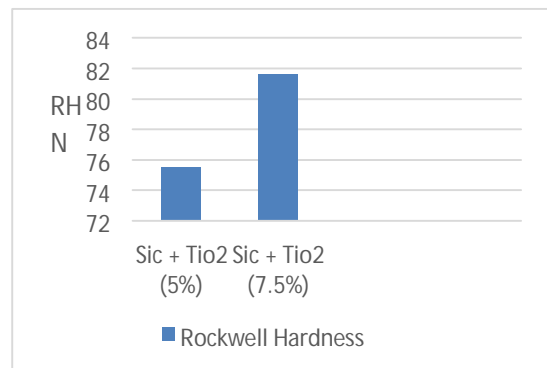
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(4)



(5)

Fig 4, 5. Rockwell Hardness Test Results

From the above graph it can be observed that the hybrid composite material is showing hardness and with Sic+ Graphite 5% having least hardness compared with 7.5% because with increase of weight % it will increase the hardness. This could be the reason for increasing of the hardness. On the other hand same material with TiO₂ is added to ingots and Sic with 5% weight it will show the hardness but when compared with 7.5% Wt. it is less. In that way the hardness will increase in hybrid composite material.

Tensile test by tensometer:

The tensile strength can be carried with composites (Aluminum6061 95% + (Sic +Graphite) 5%) and same as 7.5% are plotted in fig 6. and again (Aluminum6061 95% + (Sic +TiO₂) 5%) and same as 7.5% are plotted

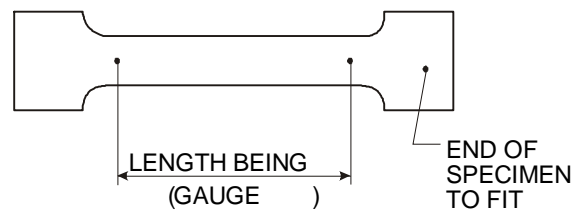


Fig (6). Dumbbell shape specimen model

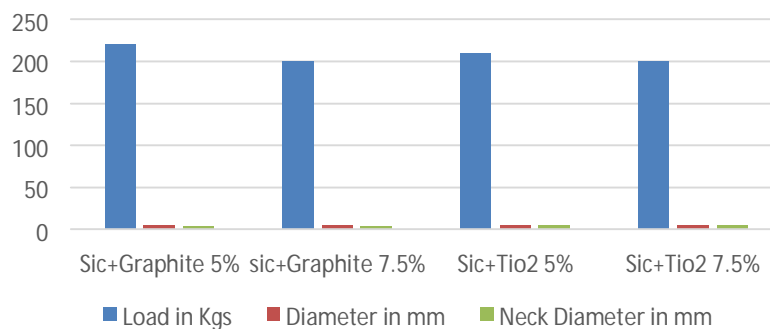


Fig 7. Tensile test results

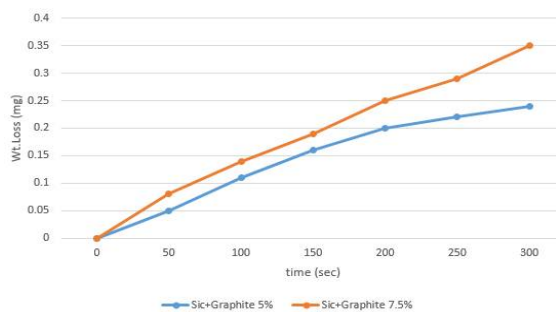
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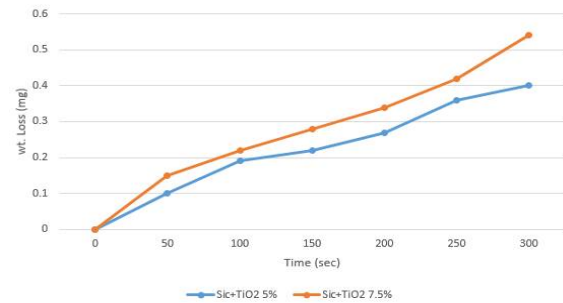
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From this graph it is observed that hybrid composites showing tensile strength with ingots Sic+ Graphite 5% will increase the tensile strength and when wt. % increases to 7.5 it will decrease due to the hard phase of the reinforcement that is responsible for the localized crack formation. In the same way when the MMC are mixed with Sic+ Graphite 5% will increase the tensile strength and when wt. % increase to 7.5 it will also decrease due to the formation of grain structure in the material and the fractures will also cause.

Wear test Results:



(8)



(9)

Fig 8, 9. Wear test results

Weight losses recorded on composites with added Sic+ Graphite 5%, Sic+ Graphite 7.5%, Sic+TiO₂ 5%, Sic+TiO₂ 7.5%, with different loads 10N, 20N and making RPM as constant, the above graph with load 10, 20N are applied and 300 RPM kept constant. Dry sliding wear tests revealed that Sic+ Graphite 5%, 7.5% will both improve the wear resistance of the alloy but when compared to each other Sic+ Graphite 7.5% gradually increases with adding of wt.%. And the same way Sic+TiO₂ 5%, 7.5% wear tests revealed that both improve the wear resistance but when compared to each other Sic+TiO₂ 7.5% gradually increases with adding of wt.%. The beneficial effect of enhanced wear resistance was better in HMMC than MMC. The wear rate decreases due to wt. % differences, unstable worn surfaces also.

IV. CONCLUSION

From the present investigation the following conclusions are made

1. Hybrid aluminum alloy metal matrix composites are fabricated by stir casting method.
2. For fabrication of hybrid composites by stir casting method, speed, temperature, particle-preheating temperature, shape, and size for the mold are the important process parameters.
3. Hardness, tensile, wear tests were conducted on the prepared specimens.
4. From the hardness test it is proved with adding the reinforcement wt. % to the material it will improve the hardness.
5. With adding the reinforcement wt. % to the matrix composite it decreases the tensile strength.
6. But when compared to wear test adding of reinforcement wt. % to the matrix composite it will improve wear resistance.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

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