Grenze International Journal of Engineering and Technology, July 2015

Microstructure, Mechanical & Wear Characteristics of Al 336/ (0-10) Wt. % SIC_P Composites

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***Abstract*—In the present study, preparation of Al 336/ (0-10) wt. % SiCp composites were done using stir casting method. The microstructure features of Al 336 alloy showed α-aluminium and eutectic silicon. Apart from α- aluminium and eutectic silicon, SiC particles were found to be uniformly distributed in Al 336 - 5 wt. % SiCp and Al 336 - 10 wt. % SiCp composites. Ultimate tensile strength of Al 336 - 10 wt. % SiCp composites (241 MPa) was found to be highest compared to Al 336 - 5 wt. % SiCp (192 MPa) and Al 336 alloy (130 MPa) respectively. The hardness value of Al 336 -10 wt. % SiCp composite (76 BHN) was found to be the highest compared to Al 336- 5 wt. % SiCp composite (64 BHN) and Al 336 alloy (50 BHN) respectively. Wear characteristics of Al 336/ (0-10) wt. % SiCp composites were done using Pin on disc configuration. It was found that as the load increases from 10 N to 30N, the wear loss of Al 336/ (0-10) wt. % SiCp composites were found to increase and is attributed to increased metallic intimacy. As the sliding velocity increases from 1 m/s to 4 m/s, it was noticed that the wear loss of Al 336/ (0-10) wt. % SiCp composites were found to be decreasing, and is attributed to less time of contact between the aspirities of the mating surfaces. The wear resistance of Al 336 - 10 wt. % SiCp composites was found to be better compared to Al 336 - 5 wt. % SiCp composites and Al 336 alloy respectively.**

***Index Terms*— Al 336 alloy, Al 336/ SiC_p composites, Stir casting method, Microstructure, Wear test, Pin on disc tribometer.**

I. INTRODUCTION

Metal matrix composites (MMC) are a range of advanced materials providing properties that cannot be normally achieved by conventional materials. These properties include increased strength, higher elastic modulus, higher service temperature, improve wear resistance, decreased part weight, low thermal shock, high electrical and thermal conductivity, and low coefficient of thermal expansion compared to conventional metals and alloys. The excellent mechanical properties of these materials and the relatively low production cost make them very attractive for a variety of applications in automotive and aerospace industries.
Nowadays Particulate-reinforced metal-matrix composites have attracted considerable attention over other MMC. Silicon carbide, boron carbide and aluminum oxide are the key particulate reinforcements and can be obtained in varying levels of purity and size distribution. In this work SiC particulate was selected as the

Grenze ID: 01.GIJET.1.2.554

reinforcement, due to the excellent combination of its mechanical properties like high strength, low density, low thermal expansion, high thermal conductivity, high hardness, high elastic modulus, excellent thermal shock, superior chemical inertness etc at a lower cost.

Aluminium matrix composites (AMCs) can be used in high-tech structural and functional applications including aerospace, defense, automotive and thermal management areas. Applications of AMCs comes in space shuttles, aircrafts and automobile components like braking systems, Pistons, Cylinder heads, Crank shafts etc. In this work Al 336 alloy is selected as the matrix material. Al 336 alloy finds wide application in automotive and diesel pistons, pulleys, sheaves, and other applications where good high-temperature strength, higher thermal conductivity, low coefficient of thermal expansion and good resistance to wear are required. Thus in this work Al 336 alloy is selected as the matrix material and SiC as the reinforcement material. The main objective of this work is to find out the influence of SiC particle on the wear behaviour of Al 336 alloy matrix composites.

II. Materials and Preparations

A. Al 336 alloy preparation

Al 336 alloy was prepared using 'Oil fired tilting furnace'. The main charge components used for the preparation of Al 336 alloy are Primary aluminum ingot (6063 Aluminum wrought alloy), Al-50wt. % Si, Al-50 wt. % Cu and Al-10 wt. % Ni master alloys. Al 336 alloy have the following chemical composition (in wt. %) .

Table I. Chemical composition (in wt. %) of Al 336 alloy

	Al	Mg	Si	Fe	Mn	Cu	Ni	Zn
Al 336 alloy	82.77	0.72	12	0.65	0.22	1.5	2	0.14

B. Al 336/ (0-10) wt. % SiCp composite preparation using Stir casting method

Liquid phase stir casting method was used for the preparation of Al 336/ (0-10) wt. % SiCp composites. Initially the temperature of stir casting furnace was set to 900 ºC. Here the Al 336 alloy, which was selected as the matrix alloy was charged on to the furnace, when the furnace temperature reaches the set value of temperature. The SiCp reinforcement was preheated at 500 ºC for 5 hours using heating furnace. After the required molten condition was achieved, the temperature of stir casting furnace was lowered to 720 ºC. When the molten Al 336 alloy reaches 720 ºC, lumps of magnesium (1-2 Wt. %) wrapped in aluminium foil were plunged into the melt. This was done to improve the Wettability and fluidity between the matrix and SiC reinforcement. Stirrer was inserted inside the graphite crucible containing molten Al 336 alloy which was driven by a speed variable motor and their by creating a vortex in the melt. After the formation of vortex in the melt region, preheated SiC particles were added at a uniform rate using injecting gun. The stirring of composite slurry was performed at 450 rpm and the mixture was stirred for 5 minutes. Upward and downward feed was given to stirrer rod for getting uniform mixing of SiC reinforcement in Al 336 alloy matrix. After thorough stirring, molten Al 336/ SiCp composite mixture in the crucible were taken out and poured onto a metallic mould.

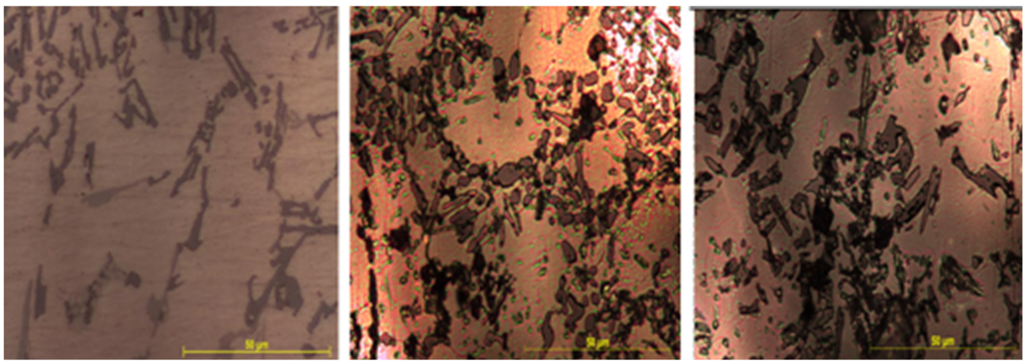
III. Results

A. Microstructure characteristics of Al 336/ (0-10) wt. % SiCp composites

Microstructure study of the aluminium is very important in predicting the nature of interaction between the molecules in the alloy. The microstructure of prepared Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites were obtained and analyzed. The microstructure of Al 336 alloy consists of mainly α-aluminium dendrites and needle shaped eutectic silicon. The morphology of eutectic silicon, namely size and shape plays an important role in determining the mechanical properties of this alloy. Apart from α-aluminium and eutectic silicon, SiC particles were found to be uniformly distributed in Al 336/ 5 wt. % SiCp and Al 336/ 10 wt. % SiCp composites.

B. Mechanical and physical characteristics of Al 336/ (0-10) wt. % SiCp composites

Densities of prepared Al 336 alloy, Al 336/ 5 wt %SiC and Al 336 10 wt % SiC composites were measured using Archimedean principle. Their density values were found to be 2.64 g/cc, 2.49 g/cc and 2.32g/cc respectively. Brinell hardness tester was used to measure the hardness of Al 336/ (0-10) wt. % SiC composites. The hardness of Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites after heat treatment conditions were obtained as 50 BHN, 64 BHN and 76 BHN respectively. Thus the hardness value of Al 336/ 10 wt. % SiCp composite (76 BHN) was found to be the highest compared to Al 336/ 5 wt. % SiCp composite (64 BHN) and Al 336 alloy (50 BHN). Also the Ultimate tensile strength of Al 336/ 10 wt. % SiCp composites (241 MPa) was found to be highest compared to Al 336/ 5 wt. % SiCp (192 MPa) and Al 336 alloy (130 MPa).



(a) (b) (c)

Figure 1. Microstructures of : (a) Al 336 alloy, (b) Al 336/ 5 wt. % SiCp and (c) Al 336/ 10 wt. % SiCp composites at 1000 X magnification

C. Wear test

The wear tests are carried out using Pin on disc tribometer. Pin samples for Wear test are made from Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites as per ASTM standard. During wear test, the test specimens were made to slide against a rotating disc for the given amount of time and there after the specimens are removed, cleaned and weighed to determine the weight loss due to wear under dry sliding conditions. The wear test is carried out at room temperature. Wear test was performed in order to find out the wear characteristics of Al 336 alloy, Al 336- 5 wt. % SiC and Al 336- 10 wt. % SiC composites. Effect of variation in sliding distance, applied load and sliding velocity on wear loss was analyzed for each samples prepared.

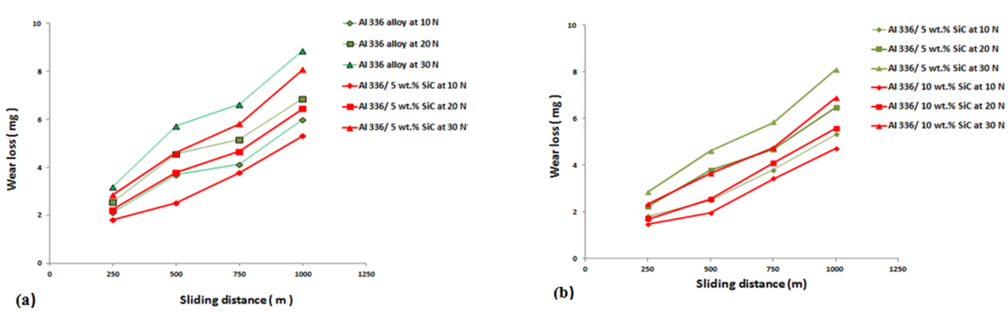


Figure.2. Comparison of Wear loss versus sliding distance relationship at different applied loads (10N, 20N, 30N) between (a) Al 336 alloy & Al 336/ 5 wt. % SiCp composites and (b) Al 336/ 5 wt. % SiCp & Al 336/ 10 wt. % SiCp composites sliding with constant sliding velocity 2m/s

In the first stage of wear test the effect of applied load and sliding distance on wear loss was analyzed. The variation of wear loss with sliding distance has been studied at 3 different loads (10N, 20N & 30N). The sliding velocity was taken as 2m/s, and is kept constant here in this test. Wear test was performed on Al 336/ (0-10) wt. % SiCp composites at 250 m, 500 m, 750 m & 1000 m sliding distance. The results obtained are graphically shown in figure 2. While analyzing the results it is clear that wear loss increases with increase in applied load (in all the 3 case of Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites). This is becauses, as the load is increased the intensity of contact between the sliding surfaces increases. Due to this more and more asperity to asperity contact establishes and their by the wear loss increases. Also we can analyze from figure 2 that wear loss of Al 336 alloy, Al 336/ 5 wt. % SiC and Al 336/ 10 wt. % SiC composites are increasing with increase in sliding distance. This increase in sliding distance causes more asperity to asperity contact time and results in increased real area of contact, which in turn results in increase in wear loss.

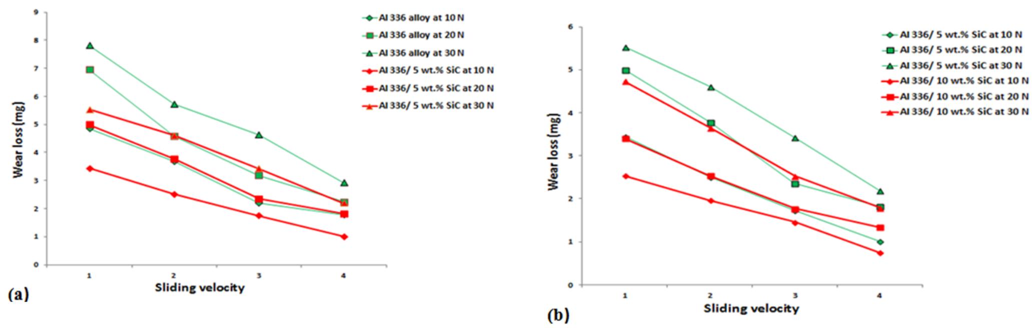


Fig.3. Comparison of Wear loss versus sliding velocity relationship at different applied loads (10N, 20N, 30N) between (a) Al 336 alloy & Al 336- 5 wt. % SiCp composite and (b) Al 336- 5 wt. % SiCp and Al 336- 10 wt. % SiCp composites sliding through constant sliding distance of 500m

Also we can analyze from figure 2 (a) that, the wear loss of Al 336/ 5 wt. % SiC composite is lesser compared to Al 336 alloy. Similorly from fig 2 (b) we can analyze that the wear loss of Al 336/ 10 wt. % SiC composite is lesser compared to Al 336/ 5 wt. % SiC composite. That is Al 336/ 10 wt. % SiC composites possess better wear resistance compared to Al 336/ 5 wt. % SiC composite and Al 336 alloy. Also Al 336/ 5 wt. % SiC composite possess better wear resistance compared to Al 336 alloy.

In the second stage of wear test the variation of wear loss with sliding velocity has been studied at 3 different load (10N, 20N & 30N). The sliding distance was taken as 500 m, and is kept constant during this test. Wear test was performed on Al 336/ (0-10) wt. % SiCp composites for 1m/s, 2m/s, 3m/s and 4m/s sliding velocities. The results obtained are graphically shown in fig 3.While analyzing the results it is clear that wear loss of Al 336 alloy, Al 336/ 5 wt. % SiC composite and Al 336/ 5 wt. % SiC composites decreases with increase in sliding velocity. This decrease in wear loss is due to less time for asperity to asperity contact.

Also by analyzing figure 2 and figure 3, we can conclude that Al 336/ 10 wt % SiC composite have higher wear resistance compared to Al 336/ 5 wt% SiC composite and Al 336 alloy. Similorly Al 336/ 5 wt. % SiC composite have higher wear resistance compared to Al 336 alloy.

IV. Conclusion

- Al 336/ (0-10) wt. % SiCp composites were successfully prepared using Stir casting method.
- Microstructure features of Al 336 alloy showed α- aluminium and eutectic silicon. Apart from α-aluminium and eutectic silicon, SiC particles were found to be uniformly distributed in Al 336/ 5 wt. % SiCp and Al 336/ 10 wt. % SiCp composites.
- Al 336/ (0-10) wt. % SiCp composites showed maximum value of Ultimate tensile strength for Al 336/ 10 wt. % SiCp composites (241 MPa) compared to Al 336/ 5 wt. % SiCp (192 MPa) and Al 336 alloy (130 MPa) respectively.
- Al 336/ (0-10) wt. % SiCp composites showed maximum value of hardness for Al 336/ 10 wt. % SiCp composites (76 BHN) compared to Al 336/ 5 wt. % SiCp (64 BHN) and Al 336 alloy (50 BHN) respectively.

- As the applied load is increased from 10N to 30N the wear loss of Al 336/ (0-10) wt. % SiCp composites were found to increase and is attributed to increased metallic intimacy. Further it was also observed that the wear resistance of Al 336/ 10 wt. % SiCp composite was found to be better compared to Al 336/ 5 wt. % SiCp composite and Al 336 alloy respectively.
- As the sliding velocity is increased from 1 m/s to 4 m/s the wear loss of Al 336/ (0-10) wt. % SiCp composites were found to be decreasing and are attributed to less time of contact between the aspirities of the mating surfaces. Further it was also observed that the wear resistance of Al 336/ 10 wt. % SiCp composite was found to be better compared to Al 336/ 5 wt. % SiCp composite and Al 336 alloy respectively.
- Wear loss of Al 336/ (0-10) % composites are found to be decreasing with increase in sliding velocity. This decrease in wear loss is due to less time for asperity to asperity contact.

ACKNOWLEDGEMENTS

The authors are grateful for the funds received from Centre for Engineering Research and Development (CERD), Government of Kerala for this work; and for the support received from the staff of College of Engineering Trivandrum, University of Kerala.

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