Wear performance test of SiO_2& TiO_2 based on hybrid Composites

M.Shunmuga Priyan, M.Kartheesan, S.Patrick Gordon, M.Ramesh, A.J.Sahayacharles Lebin

Department of Mechanical Engineering, Loyola Institute of Technology & Science, Thovalai, Kanya Kumari District – 629302

Abstract

Wear performance test is carried out to predict the wear resistance of the composite material. Composite material is nothing but it is a material which is produced from two or more different reinforcement materials. Composite materials formed from matrix and reinforcement materials. Present work based on Aluminum alloy-based hybrid Composites. Aluminum based composites are used in many industries. Because it has properties like high ductility, high conductivity, light weight, strength to weight ratio etc. Present work is focused on the study of behavior of Aluminum alloy (Al6061) with different wt. % of TiO_2 and SiO_2 powder mixed by stir casting technique. Casting is prepared by stir casting method. Then the Wear performance of the Aluminum based hybrid composite material is tested by Pin on disc method. Wear performance is tested at different combinations and Plot the Graph for the wear performance at different combination.

Keywords: Composite Materials, Properties, Hybrid, Casting, Wear test

1. Introduction

Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. The matrix in these composites is a ductile metal. These composites can be used at higher service temperature than their base metal counterparts. These reinforcements in these materials may improve specific stuffiness specific strength, abrasion resistance, creep resistance and dimensional stability. The MMCs is light in weight and resist wear and thermal distortion, so it mainly used in automobile industry. Metal matrix composites are much more expensive those PMCs and, therefore, their use is somewhat restricted. the effect of reinforcement of Boron Carbide with the Al. By adopting stir casting technique fabricated the specimen by varying the wt% of Boron Carbide [1]. Investigated that better stir process and stir time. The high silicon content aluminium alloy –silicon carbide MMC material, with 10% SiC by using a variance stirring speeds and stirring times. The microstructure of the produced composite was examined by optical microscope and scanning electron microscope. The results with respected to that stirring speed and stirring time influenced the microstructure and the hardness of composite [2]. It reported that magnesium played an important role during the synthesis of aluminum alloy matrix composites with dis-persoids such as zircon ($ZrSiO_4$), zirconia (ZrO_2), Titania (TiO_2), silica (SiO_2), graphite, alurninium oxide (Al_20_3) and silicon carbide (SiC). Magnesium is one of the important alloying elements in aluminum [3]. Moreover, the hybrid composites i.e., aluminium alloy 6061 as a base material and reinforced material as sic (6%) and graphite (3%, 6% & 9%). They calculated mechanical properties of tensile, compressive and hardness tests. They have increased the percentage of reinforcement (graphite), then the hardness will be decreased and tensile, compressive strength will be increases with the influence of sic particles [4, 5]. The mechanical properties of hardness and brief investigation of microstructure must be conducted on checking electron magnifying lens (SEM) to verify the scattering of support within the network [6]. Al7075-silicon carbide composite and studied the sliding velocity and varying load on wear rate using a pin-disc test [7]. the characteristics of silicon carbide reinforced aluminium matrix composite in various proportions. The loss of mass for aluminium-silicon carbide was less in comparison to the pure form of aluminium [8, 9]. Studied AL6061 with SiC and graphite and found that the wear rate decreased with the addition of both SiC and graphite [10]. The mass loss increased with increase in applied load and this is because of the pull out of graphite and the presence of alumina ceramic phase in the metal matrix composite [11].

The wear behavior of Al7075 with silicon carbide, alumina and boron carbide as the reinforcement which is mainly determined the wear test was performed on pin disc for varying applied load and sliding distance. The composite with boron carbide showed superior wear resistance than others. This is because of the heat resistance and hardness of the particle [12]. The inclusion of silicon carbide increased the wear resistance and the addition of graphite increased it further more. Interfacial bonding was good in the composite as analyzed by XRD [13]. It is evident from the literature review that the wear resistance can be improved by the addition of both silicon carbide and graphite.

The composite is defended by the particles of silicon carbide that are prominent on the outer layer of material while the graphite helps in reducing the wear rate when the composite has to be dealt at higher load. Other reinforcements are not as effective as these two and neither there is any consistency in their results. The present investigation of the aluminium based hybrid composite wear properties prepare the alternative Aluminium based Hybrid composite material. In this aluminium based composite material SiO2 & TiO2 reinforcement material is using for preparation. To check the wear performance of the material using Pin on disc method.

2. **Material and Methods**

This section depicts the subtleties of preparing of the composites and the trial strategies followed for their mechanical portrayal.

Al6061	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Wt%	0.65	0.7	0.25	0.15	0.8	0.07	0.25	0.15	Other

Table1. Composition of Al6061

Density	2.7g/cm^3
Melting Temperature	585°C (1085°F)
Thermal Conductivity	151-202W/(m*K)
Linear thermal Expansion Coefficient	2.32*10^{-5}K^{-1}
Specific Heat	897 J/(kg*K)

Table 2.Properties of Al6061

Density	4.23g/cm^3
Melting Point Temperature	1843°C
Boiling Point Temperature	2972°C
Molar Mass	79.866g/mol

Table 3.Properties of TiO_2

Density	2.65g/cm^3
Melting Point Temperature	1710°C
Boiling Point Temperature	2230°C
Molar Mass	60.08g/mol

Table 4.Properties of SiO_2

Stir Casting Method

Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process, which affect the final microstructure and mechanical properties of the composites. In this study, micron-sized SiC particles were used as reinforcement to fabricate Al-3 wt% SiC composites at two casting temperatures 680 and 850 °C and stirring periods 2 to 6 min. Factors of reaction at matrix/ceramic interface, porosity, ceramic incorporation, and agglomeration of the particles were evaluated by Scanning Electron Microscope (SEM) and High-resolution transition electron microscope (HRTEM) studies. From micro structural characterizations, it is concluded that the shorter stirring period is required for ceramic incorporation to achieve metal/ceramic bonding at the interface. The higher stirring temperature 850 °C also leads to improved ceramic incorporation. In some cases, shrinkage porosity and intensive formation of Al6061 at the metal/ceramic interface are also observed. Finally, the mechanical properties of the composites were evaluated, and their relation with the corresponding microstructure and processing parameters of the composites was discussed.

Wear Performance Test

Grinding and wear (normally wear rates and wear obstruction) portrayal of materials is normally performed utilizing different sorts of tribometers, while nail to circle test being likely quite possibly the most normal. The pin-on-circle tribometer, appeared in Figure, comprises of a level, pin, or circle which is joined to a firm flexible arm that is weighted down onto a covered test with a correctly known weight. The example is turned at a chose speed. The flexible arm guarantees an almost fixed contact point and a steady situation in the grating track shaped by the pin on the test. The dynamic contact coefficient is resolved during the test by estimating the redirection of the flexible arm, or by direct estimation of the adjustment in force by a sensor situated at the turn point of the arm. Wear rates for the pin and the plate are determined from the volume or weight of material eliminated during the test. Figure shows the track and wears trash on a test plaque. With this machine one can handle test boundaries, for example, speed, contact pressure (consequently PV), and time. With the privilege ecological chamber one can likewise control and measure the impact of mugginess, temperature, and barometrical piece. The pin-on-circle estimation is generally done per ASTM G99-05 Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus.

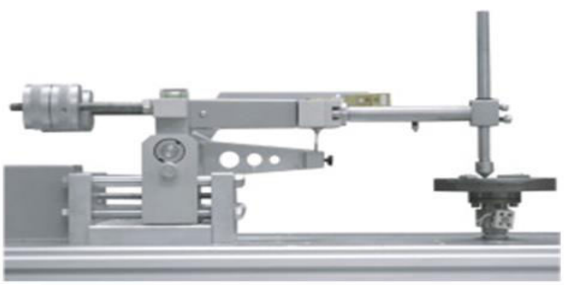


Fig. 1 Pin-On-Disc wear performance tester

Sample Composition

Creation of the testing half breed based composite material was completes by receiving the accompanying Stir Casting Process.

FACTORS/LEVELS	1	2	3
Wt% of TiO_2	0	1.5	3
Wt% of SiO_2	0	1.5	3

Table 5.Composition of TiO_2 and SiO_2

At first shifting sort heater is utilized to soften Aluminum 6061 composite at 850OC. All the while, fortifications (SiO2 and TiO2) are preheated in a Box type heater at1000OC temperature to eliminate dampness, pollutions and so forth Both Preheated SiO2 and TiO2 powder are blended in the liquid aluminum compound on shifting type heater. the vortex which drives the blending of the support (SiO2 and TiO2) material which are presented in the soften. After the nonstop mixing of combination, the grid and support blend are pouring in the shape. Accordingly, took into consideration settling season of around 30 min – 3 hours, at that point form was delivered. At that point the aluminum-based half and half composite material is created.

Fig.2 Stir Casting Process

3. Results and Discussion

Pin on Disc Test comparison results

Arranged composite material is fixed in the Pin on plate machine prior to fixing the material; compute the heaviness of the material. Composite material is pivoted at the chose speed. The versatile arm guarantees an almost fixed contact point and a steady situation in the grating track shaped by the pin on the example. The motor erosion coefficient is resolved during the test by estimating the avoidance of the versatile arm, or by direct estimation of the adjustment in force by a sensor situated at the rotate place of the arm. Wear rates for the pin and the plate are determined from the volume or weight of material eliminated during the test.

Before test (Wt)	After test (Wt)
5.57198	5.56841
5.52832	5.52235
5.49262	5.48596

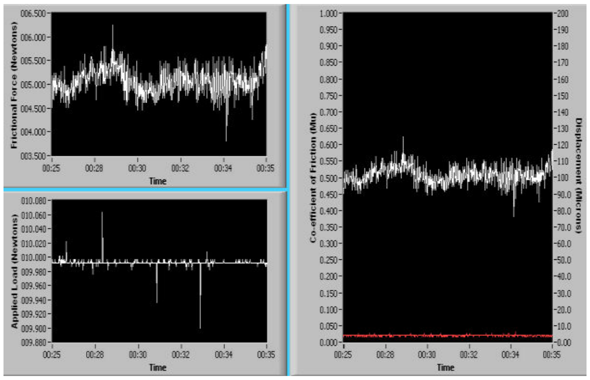
Pure aluminium (100%) at Load 1 Kg

Before test (Wt)	After test (Wt)
5.98882	**5.98689**
5.79812	**5.79418**
5.59853	**5.59477**

Aluminium with (SiO_2+TiO_2) 3% at Load 1 Kg

Before test (Wt)	After test (Wt)
5.32983	5.32726
5.81417	5.81049
5.91492	5.91402

Aluminium with (SiO_2+TiO_2) 6% at Load 1 Kg



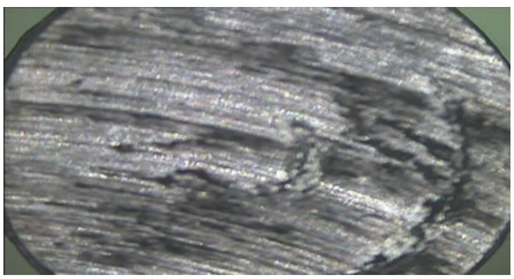


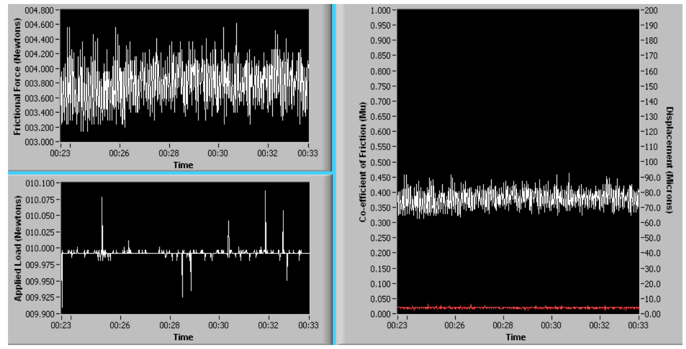
Fig. 3 Wear performance on pure aluminium at 1 Kg load

Table 6 Wear performance of Al at 1 Kg of weight

S.No.	Material	Load kg	Time Sec	Initial wt in gm	Final wt in gm	Speed rpm	Volume mm^3	Wear rate mm^2/kg	Wear coefficient
1.	Al	1	480	5.571	5.56	673	1.332	$1.420*10^{-6}$	4.5676

Table 7 Wear performance of Aluminium with (SiO_2+TiO_2) 3% at Load 1 Kg

S.No.	Material (Wt.3%)	Load kg	Time Sec	Initial wt in gm	Final wt in gm	Speed rpm	Volume mm^3	Wear rate mm^2/kg	Wear coefficient
1.	Al+ SiO_2+TiO_2	1	480	5.5989	5.598	673	0.2015	$2.165*10^{-7}$	0.696



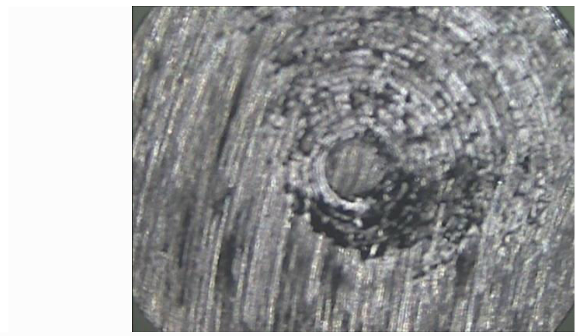
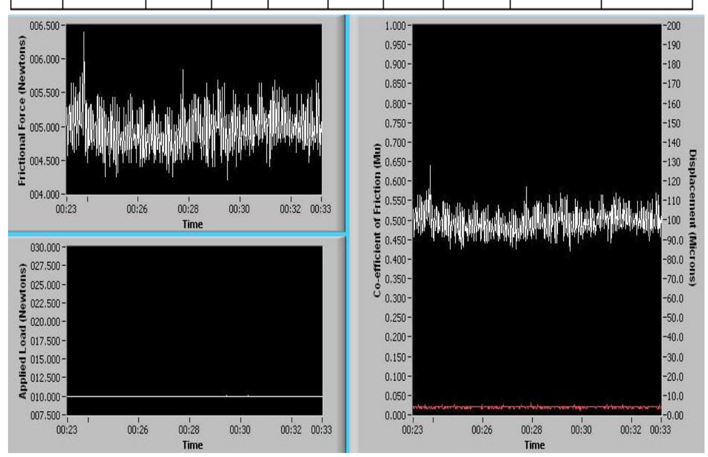


Fig. 4 Wear performance on Al + (SiO_2+TiO_2) 3% at 1 Kg load

Table 8 Wear performance of Aluminium with (SiO_2+TiO_2) 6% at Load 1 Kg

S.No.	Material (Wt.6%)	Load kg	Time Sec	Initial wt in gm	Final wt in gm	Speed rpm	Volume mm^3	Wear rate mm^2/kg	Wear coefficient
1.	Al+ (SiO_2+TiO_2	1	480	5.3298	5.3272	673	0.2682	$2.88*10^{-7}$	0.9265



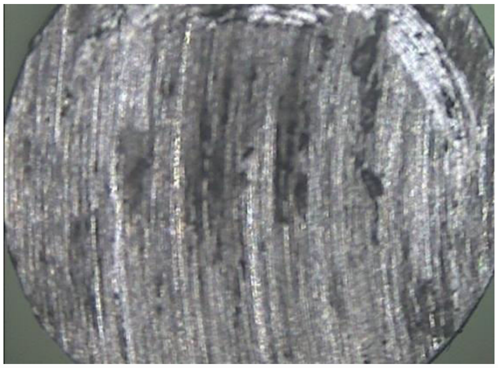


Fig. 5 Wear performance on Al + (SiO_2+TiO_2) 6% at 1 Kg load

4.Conclusion

Finally, this work described the wear performance of Al6061 and three casting is done with Al6061 by adding TiO_2 and SiO_2 with different wt%. By using pin on disk, wear rate is calculated by Al6061, TiO_2 and SiO_2 0%,3%,6%). The wear rate of the following casting is given below. The Pure aluminium 100% pure Al6061 is wear tested by using pin on disk machine. Before testing, the weight of the pure Al6061 is 5.57198, 5.52832, and 5.49862. After tested, the weight of the pure Al6061 is 5.56841, 5.52235, and 5.48596. Wear rate is calculated by using these weights. The wear rates are 0.4207x10-6mm²/kg, 0.22091*10-6mm²/kg, and 0.88349x10^{-6} mm²/kg.

References

[1]Bunsell A R, Renard J, "Fundamentals of Fibre reinforced composite materials", IoP Institute of Physics publishing, Bristol and Philadelphia, pp.37, 2015.

[2] K. Umanath, ST. Selvamani, and K. Palanikumar, "Friction and wear behavior of Al6061alloy hybrid composite," International Journal of Engineering Science and Technology, vol. 3, pp. 5441–5551, 2011.

[3] G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, and M. S. Bhagyashekar, "Studies on Al6061 based metal matrix composites," Journal of Minerals Materials Characterization Engineering, vol. 9, pp. 454–461, 2010.

[4] M. Kok and K. ¨ Ozdin "Wear resistance of aluminium alloy" Journal of Materials Processing Technology, vol. 183, no. 2-3, pp. 301–309, 2007.

[5] Roshan M, Mousavian RT, Ebrahimkhani H, Mosleh A. Fabrication of Al-based composites reinforced with Al_2O_3–TiB_2 ceramic composite particulates using vortex-casting method. J Min Metall Sect B. 2013; 49(3):299.

[6] Roshan M, Mousavian RT, Ebrahimkhani H, Mosleh A. Fabrication of Al-based composites reinforced with Al2O3–TiB2 ceramic composite particulates using vortex-casting method. J Min Metall Sect B. 2013;49(3):299.

[7] Valibeygloo N, Khosroshahi RA, Mousavian RT. Microstructural and mechanical properties of Al-4.5 wt% Cu reinforced with alumina nanoparticles by stir casting method. Int J Miner Metall Mater. 2013;20(10):978.

[8] Mohammadpour M, Khosroshahi RA, Mousavian RT, Brabazon D. Effect of interfacial-active elements addition on the incorporation of micron-sized SiC particles in molten pure aluminum. Ceram Int. 2014;40(6):8323.

[9].Mohammadpour M, Khosroshahi RA, Mousavian RT, Brabazon D. A novel method for incorporation of micron-sized SiC particles into molten pure aluminum utilizing a Co coating. Metall Mater Trans B. 2015;46(1):12.

[10].Boostani AF, Tahamtan S, Jiang ZY, Wei D, Yazdani S, Khosroshahi RA, Mousavian RT, Xu J, Zhang X, Gong D. Enhanced tensile properties of aluminium matrix composites reinforced with graphene encapsulated SiC nanoparticles. Compos A. 2015;68(2):155.

[11]. Naher S, Brabazon D, Looney L. Simulation of the stir casting process. J MaterProcess Technol. 2003; 143:567.

[12]. Rabinowicz.E., (1995), Friction and wear of materials, John Wiley & Sons, New York.

[13]. Gwidon W. Stachowiak and Andrew W. Batchelor (2001) Engineering Tribology Butterworth-Heinemann, Boston.

[14]. Bhushan.B., (1999), Principles and Applications of Tribology, John Wiley & Sons, New York.

[15]. B.C. Majumdar (1986), Introduction to Tribology of Bearings, A.H. Wheeler and & Company Ltd.

[16].I.M.Hutchings(1992) Friction, Wear and Lubrication Edward Arnold-London UK.