INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Production And Tribological Characterization Of Stir-Cast Hybrid Composite Aluminium 6061 Reinforced With Sic And Ti Particulates

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Abstract:

The Aluminium 6061 alloys are mainly used in the application of automobile and aeronautical applications. An attempt has been made to increase the mechanical and tribological property of Al6061 alloy by adding SiC and Ti particulates as reinforcements. The ratio of particulates based on weight percentage such as (2.5%, 5%, 7.5%, and 10%) both SiC and Ti. The composite is developed by stir casting method. The particle size of SiC and Ti between 16 to 22µm. The optical microscopic test is conducted to examine the distribution of reinforcement particulates. Rockwell hardness test and XRD test also included calculating the hardness and constituents present in the composite samples. Friction and wear test is done by pin-on-disc method and the microscopic examination done by scanning electron microscope (SEM).The investigation results that Al6061 hybrid composite with good tribological properties and used in automobile components for reliable, long life and high performance.

Key words: *Hybridcomposite, Particulate Reinforcement, SEM, Wear, Stir-cast*

1.Introduction

The demand for good quality materials for automobile and aeronautical applications leads to production of best structural composite materials. From the different materials Aluminum based composites achieving better results. The Al 6061 metal matrix composites reinforced with Ti and SiC particulates are one of new range of materials. Basically the hard material is mixed with reinforcement to improve the mechanical and also tribological properties. That composites are very well suitable to automobile components such as engines, brake disc etc…From the literature survey based on aluminum composites, the reinforcement as SiC or Al_2O_3 to base alloy. These found to improve the wear resistance under sliding and abrasion condition. Mohammed.k.hasan [1] suggests decreasing the particle sizes to achieve the strength and reduce porosity. The yield strength increases with increase in percentage added of reinforcements. A.Chennakesava reddy[2] suggest the cheap reinforcements helps to achieve better yield stength.mode of failure of Al-SiC MMC are predominantly by the reinforcement matrix interface cracking.V.C.Uvaraja[3]from the comparison of Al0601 and Al7075 composites,Al6061 results better in bonding, hardness and tribological properties.S.M.Seyed reihani[4]suggests the squeeze casting method reduces the pores and achieving good bonding. The dislocation of density mainly due to thermal mismatch. G.B. Veeresh Kumar [5] suggests that the Al6061-SiC composites are better compared with Al7075-Al_2O_3 composites based on mechanical and tribological properties. R.Ensani [6] suggests the aging T6 heat treatment helps to obtain the maximum hardness with less time compared with T4 heat treatment and it cause poor ductility. Y.Sahin [7] adding of reinforcements increase the hardness of composite but the gradual decrease the performance of cutting tool. The abrasion and edge chipping causes more wear. D.Ramesh [8] the addition of frit particulates in Al6061composites leads to high tensile strength but poor in compressive strength. D.Ramesh [9]when compared to Al6061 matrix alloy in cast and heat-treated condition the Al6061 with frit particles are good in bonding and density of composites. Thomas.J.Mackin [10] suggests the yield and fatigue strength of the material and temperatures are the main cause of brake failure. Redesign the setup and increase the mechanical property of materials to perform the brake disc well. S.Rajasekaran [11] In T4 and T6 heat treatment for Al6061-15%vol SiC composites.T6 treatment leads to peak hardness with less time. V.C.Uvaraja [12] from the hybrid composites reinforcements such as SiC and B_4C ratios is 10% and 3% combination having good tribological properties. The volume fraction of reinforcement decreases the wear rate of composites. E.Hajjari [13] suggests that the high pressure applying of composite leads to separate of nickel coatings layers and destroy the fibers and decrease the strength. J.Onoro [14] suggests that TiB2 particulates reinforced with aluminum alloys increase the strength, ductility and reduce fracture property. Muhammed Haya Jokho [15] suggests that addition of Cu-Zn-Mg reinforced with Al_2O_3 results 10% of tensile strength and elongation.

2. Experimental Procedure And Materials

2.1 Material And Sample Details

Al6061 alloy reinforced with Ti and Sic particulates the dry sliding wear tests were conducted. Table 1 shows the composition of weight percentage matrix materials and table 2 shows the Rockwell hardness and density of the material. The Rockwell hardness measurements were applying a load of 100kgf and examined from 5 different values of experiments. The measurement is based on ASTM standards (C1270-88).samples are in circular rod (10mm diameter and 30mm height).

Material	Si	Fe	Cu	Mn	Ni	Pb	Zn	Ti	Sn	Mg	Cr	Al
Percentage	0.43	0.7	0.24	0.139	0.05	0.24	0.25	0.15	0.001	0.802	0.25	balance

Table 1: Nominal composition weight percent of Al6061 matrix material

Matrix Material	Rockwell hardness (HRC)	Density (g/m3)
6061 – Al	72.25	2.70

Table 2: Matrix material hardness and density

Particulate	Size Range (µm)	Shape
SiC	30-70	Angular – irregular
Ti	10-15	Angular - irregular

Table 3: Particulates morphology details

2.2. Processing Methodology

Metal matrix composites are basically produced either by Liquid Metallurgy Route or Powder Metallurgy. In LMR the reinforcement's phases are mechanically dispersed in the matrix phase. Stir casting method is mostly used because components at a normal cost. The stir casting technique increases the microstructure and reduces porosity.

In this present work, stir casting method was used to develop 6061 Aluminum alloy with varying weight percentages of SiC and Ti (2.5%, 5%, 7.5 and 10%) reinforcements. The experimental sets up were as shown in plate1 and plate 2. The stir casting furnace is placed on the bottom floor and the temperature of the furnace is measured and controlled in order to achieve quality composite. Two thermo couple and one PID controller were used for this Purpose. This stirrer was connected to 1HP DC Motor through flexible link and was used to stir the molten metal in semi solid state. The melt was maintained at a temperature between 750 to 800^{o}C for one hour. Vortex was created by using a mechanical stirrer. The particulate, preheated at 500ºC were added to the melt with constant Stirring for about 5 min at 500 to 650 rpm for all samples.

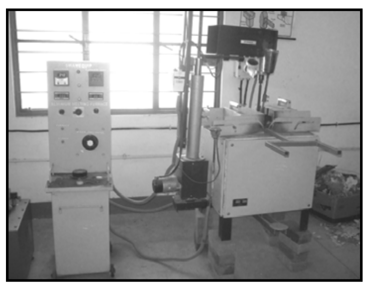


Plate 3: Stir cast unit with control system

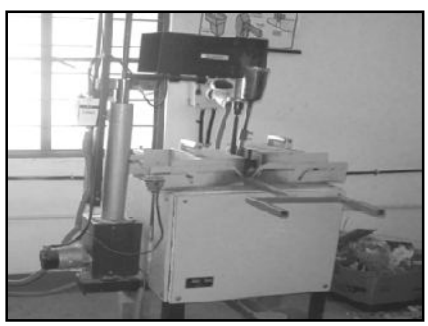


Plate 4: Stir cast unit with mechanical stir setup

2.3.Pin-On-Disc Wear Test

The test is done by various load conditions such as 10N, 20N and 40N (1kgf, 2kgf and 4kgf).the pin were rubbed against a hardened steel and different velocities such as 1.571m/s, 3.142m/s and 4.712m/s. Dry sliding wear tests conducted using pin -on- disc type. The slider disc having 0.95 to 1.20% carbon (EN31) hardened steel disc with hardness of 62 HRC having diameter 165mm. The pin test sample dimensions were 10 mm diameter and 30 mm height. The surface of samples must be flat and polished in testing. The wear rates measured in weight units and converted to volumetric wear rates. After that the micro structural examination is performed by SEM.

2.4. Hardness Test

The property in which that resists marks or indentation is known as hardness. The Rockwell hardness tester at least six indentations are taken at room temperature. The hardness graph shows the sample less than 2.5 wt% SiC and Ti is act as the same unreinforced aluminum. But the sample with5 wt% SiC and Ti showed slightly high hardness and low toughness as compare to 7.5wt%SiC and Ti. Higher the percentage of reinforcements in the matrix lesser is the toughness. This is due to obstacles to the motion of dislocation.

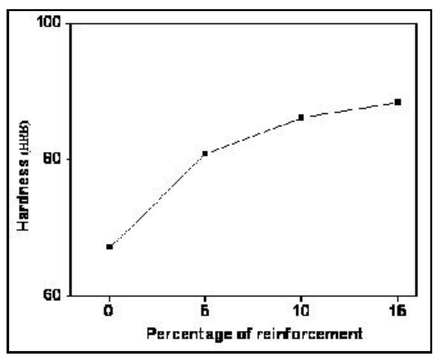


Figure 1: Hardness of unreinforced alloy and composites at different volume fraction

3. Results And Discussion

3.1.Microscopic Examination

The Optical Microscopy shows the microstructures of Al6061 alloy andAl6061composite with different volume fraction of SiC and Ti. Plates 5, 6, 7 ,8& 9 show the optical microscopic images at 100X magnification for both unreinforced and reinforced samples.

Plate 5: Optical Microscope image of unreinforced Al (6061) alloy at 100X magnification

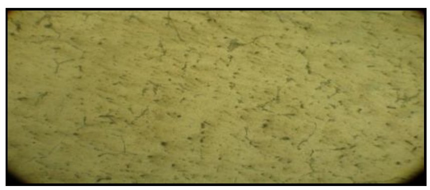


Plate 6: Optical Microscope image of 2.5% SiC and Ti particulate reinforced Al (6061) composite at 100Xmagnification

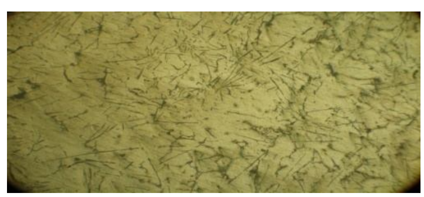


Plate 7: Optical Microscope image of 5% SiC and Ti particulate reinforced Al (6061) composite at 100X magnification.

Plate 8: Optical Microscope image of 7.5% SiC and Ti particulate reinforced Al (6061) composite at 100X magnification.

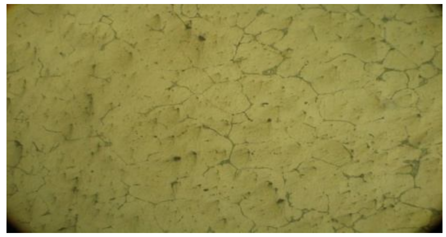


Plate 9: Optical Microscope image of 10% SiC and Ti particulate reinforced Al (6061) composite at 100X magnification.

3.2.X-Ray Diffraction Analysis

XRD was used to identify the phase constituents present in the composites. The investigation of the structure of a substance by methods that make use of the spatial distribution and intensities of X-radiation scattered by the object. The methods of X-ray diffraction analysis are used to study, for example, metals, alloys, minerals, inorganic and organic compounds, polymers, amorphous materials, liquids, gases, and the molecules of proteins and nucleic acids. X-ray diffraction analysis has been used most successfully to establish the atomic structure of crystalline substances because crystals have a rigid periodicity of structure and constitute naturally produced diffraction gratings for X rays.

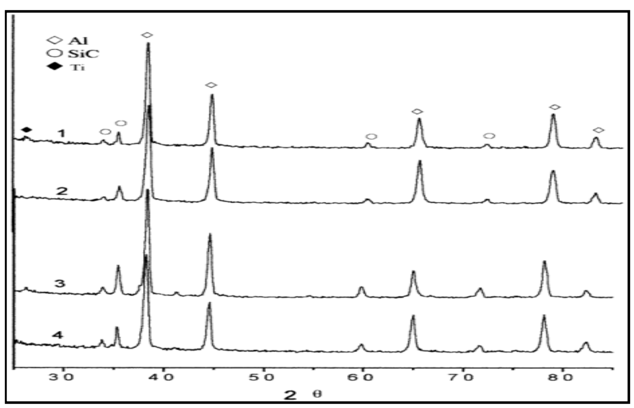


Figure 2: X-ray diffraction sample patterns (1)Al6061+2.5% of SiC and Ti (2) Al6061+5% of SiC and Ti (3) Al6061+7.5% of SiC and Ti (4)Al6061+10% of SiC and Ti.

3.3 Wear Characteristics

3.3.1.<u>Effect Of Sliding Distance On Coefficient Of Friction</u>

Figure 3(A), 3(B) & 3(C) shows the relationship between co-efficient of friction and sliding distance under various load condition. In all the samples, the co-efficient of friction decreases with increase in sliding distance under various load conditions. The friction co-efficient is higher at the test due to the maximum friction force between the disc and the pin surface. Friction co-efficient of test specimen was obtained from the frictional force during sliding condition. The variation of co-efficient of friction against sliding distance was studied for three different applied loads like 10N, 20N, & 40N for unreinforced alloy and three different composite specimens with varying volume percentage particle reinforcement (2,5, 7.5 & 10% of SiC and Ti). From this test its shows the co-efficient of friction of composite is low with high 10%SiC and Ti for all loads, but considering the different loads condition then under high load 40N. figure 3(D) the composite shows opposite results that is high coefficient of friction.

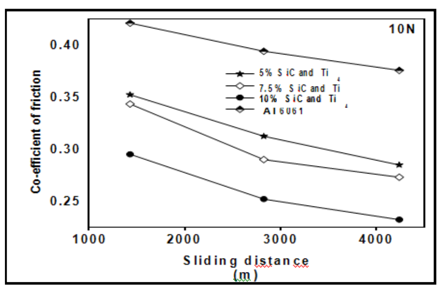


Figure 3(A):Co-efficient of friction of unreinforced alloy and composites at applied load of 10N with a function of sliding distance

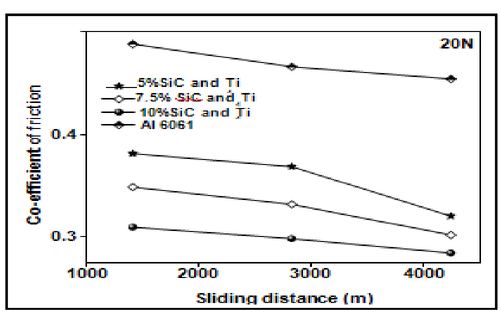


Figure 3(B): Co-efficient of friction of unreinforced alloy and composites at applied load of 20N with a function of sliding distance

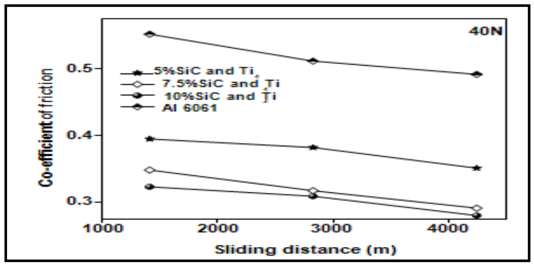


Figure 3(C): Co-efficient of friction of unreinforced alloy and composites at applied load of 40N with a function of sliding distance

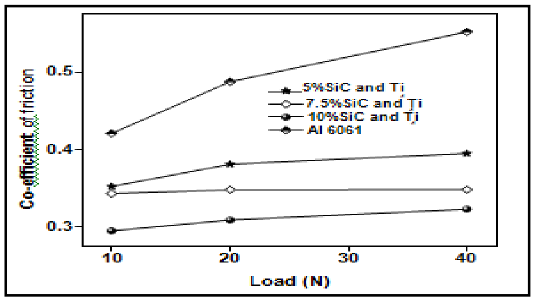


Figure 3(D): Co-efficient of friction of unreinforced alloy and composites at different loads

Figure 4(A), 4(B) & 4(C) shows that the reciprocal relationship between wear rate and sliding distance. The wear rate decreases the value with the increase in sliding distance, in all the samples. Test specimen's wear rate was taken from the ratio between volume loss and sliding distance. The variation of wear rate against sliding distance was calculated for three different applied loads 10N, 20N, & 40N for unreinforced alloy and three different composite specimens with varying volume percentage particle reinforcement (5, 7.5 & 10% of SiC and Ti).

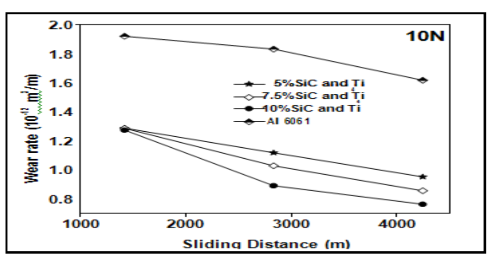


Figure 4(A): Wear rate of unreinforced alloy and composite at applied loads of 10N as a function of sliding distance

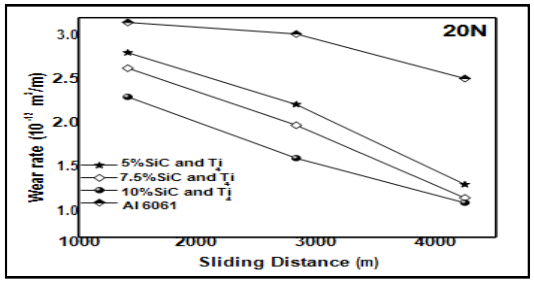


Figure 4(B): Wear rate of unreinforced alloy and composite at applied loads of 20N as a function of sliding distance

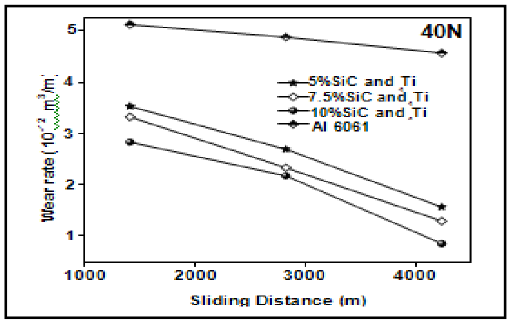


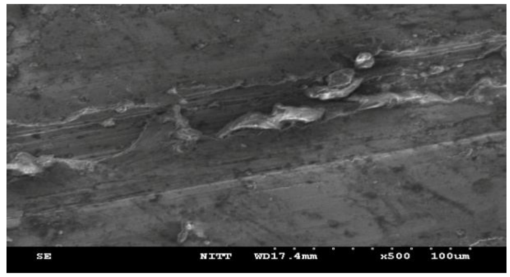
Figure 4(C): Wear rate of unreinforced alloy and composite at applied loads of 40N as a function of sliding distance

The following readings were made from figures 4(A,B and C),

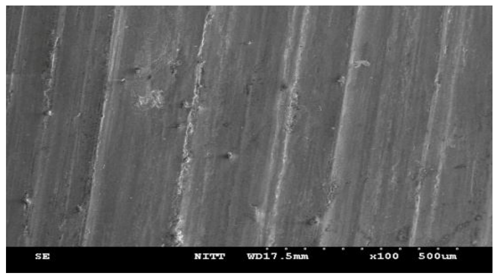
- At a constant sliding distance, the wear rate for the unreinforced alloy was found to be larger than the reinforced composite material in all the cases.
- The reinforced composite with higher concentration of SiC and Ti(10%) shows better decrease in wear rate.
- At the maximum load of 40N, wear rate is high at the range of 25 to 35 % as compared to other load condition.
- Thus the wear rate is low at low applied load and high sliding distance.

3.3.3.Effect Of Applied Load On Wear Rate

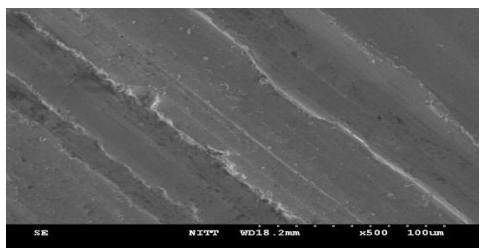
The effect of applied load of the Al6061 with 5 to 10% SiC and Ti composite wear against hardened steel. Wear rate depends on the amount of carbide phase in matrix. Plate 10 show the SEM worn surface micrographs of both unreinforced and reinforced sample.



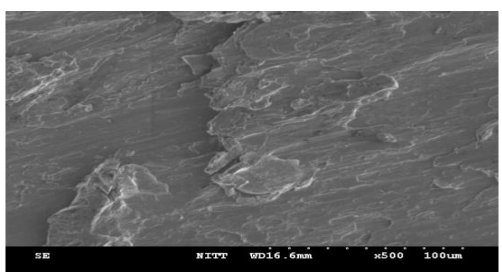
(A)



(B)



(C)



(D)

Plate 10: shows the SEM photographs of the worn surface of (A) the unreinforced Al alloy and composites with (B) 5%, (C) 7.5% and (d) 10% reinforcement of Sic and Ti under an applied load of 40N

3.3.4.<u>Effect Of Volume Fraction Of Reinforcement Particulate On Wear Rate</u>

Figures 5(A), 5(B) & 5(C) shows effect of varying volume fraction of reinforcement particulate on the wear rate. The wear rate of Al6061 alloy containing 5, 7.5, 10% SiC and Ti particles are compared. Increase in the volume fraction of the particle shows low wear rate.

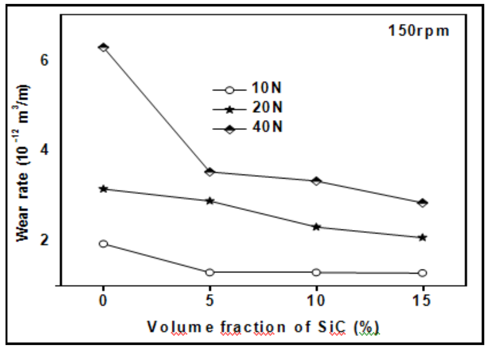


Figure 5(A): Wear rate of unreinforced alloy and composite at applied load of 10N as a function of volume fraction

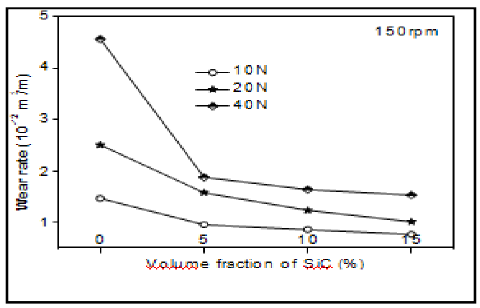


Figure 5(B): Wear rate of unreinforced alloy and composite at applied load of 20N as a function of volume fraction

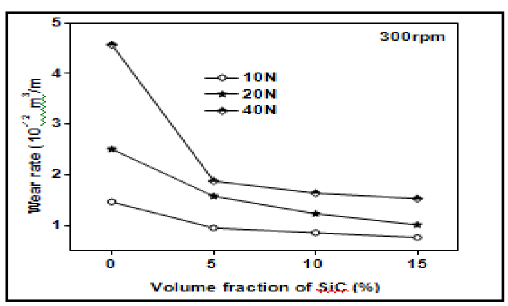


Figure 5(C): Wear rate of unreinforced alloy and composite at applied load of 40N as a function of volume fraction

4.conclusion

In this paper the aim is to study and investigate the tribological behavior of different percentage of silicon carbide with Titanium particulates in aluminum 6061 matrix hybrid composite. Hardness test, Pin- on-disk test, SEM analysis and XRD examination were performed and the following results were obtained:

- The fabricate Al6061 alloy and composites with 2.5, 5, 7.5 and 10wt,% SiC and Ti reinforcements were found using stir casting method.
- The uniform distribution of the particles was get in the Al6061/10 wt. % Ti and SiC cast at stirring speed of 600 rpm as compared to the other composites. From optical microscope is observed in the 6061 Al alloy matrix and 10 wt. % SiC and Ti reinforcements act as a good bonding.
- Hybrid composites showed high hardness as compared to unreinforced alloy due to hard phase silicon carbide and Titanium particulates bonded uniformly in aluminum 6061 based matrix.
- Hybrid composite sample with 10wt. % SiC and Ti composition have better tribological properties. The reinforcement of Al 6061 alloy with SiC and Ti particulates up to a volume fraction of 2.5 to 10 wt. % has marked effect on wear rate. The volume fraction of reinforcement decreases the wear rate of material.

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