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Microstructure and Wear Behaviour of Aluminium Metal Matrix Composites Reinforced with Mg-Sic-TiO_2-flyash

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Abstract

Al6061 was particulate with various reinforcement composite metal matrix materials adding different matrices using stir casting method. Reinforcement of hybrid composites used to various kinds of applications such as good wear resistance, electrical semiconductor and development of mechanical properties. The characteristics of various combinations of Aluminium reinforcement material were investigated. Wear behavior has investigated by using pin-on-disc mechanism. Using Scanning Electron Microscope (SEM) examined in this investigation. Using optical microscopic to identifying the various worn surfaces such as Ploughing, debris and oxide layer. Pin-on-wear mechanism were carried out the reinforcement of Aluminium with different prepared composites of wear parameters such as sliding distance 300mm, sliding speed 2.5m/s and applying load 5N, 10N, 15N. This analysis result focused on minimum wear, coefficient of friction, frictional load and temperature effect. Experimental result shows the amount of adding composite particles to increasing the wear resistance and decreasing wear losses. From the effect of wear as curve fitting technique was applied for the polynomial and power law equation. These equations of R^2 value higher than power law equations and much agreed with the experimental observation.

Keywords: Pin-On-Disc, SEM, Coefficient of friction, Optical microscope.

INTRODUCTION

In recent years the development of Aluminium based Metal Matrix Composites (MMC) have emerged important role in automobile, electrical and aerospace industries [1, 2]. Most of the industries material manufacturing processing high thermal, electrical conductivity, corrosion resistance, and tribological behaviour of mechanical properties [5]. The ready Metal Matrix Composites using stir casting method for fabrication of composite materials by mechanical stirring action to reinforced with a ceramic matrix homogeneously under the solidification of particles [3, 4]. The particles reinforcement particulate the Al-MMC having low wear rate compared with the unreinforced metal matrix composites [6]. The developing of tribological properties for matrix reinforcement phase by adding a ceramic particle for the purpose of reduced wear. Recent literature surveys reviewed by the good wear resistance for adding different types of ceramic particles [7, 8]. Funatani and Kurosawa reported 41% energy losses due to wear [9]. Aluminium is cheapest one compared with other metal matrix composites such as copper, titanium, and magnesium [7]. In recent developed countries learn about stir casting method of aluminium metal matrix composites, it concerned dominant use of industrial applications [10-11].

Wear properties and friction is an important for industrial applications .The Al-Sic-Mg reinforcement has good wear resistance and outstanding mechanical properties [12]. These composites preparation generally prepared by the powder metallurgy route were followed [13]. Silicon Carbide reinforcement in aluminium based composite material the effect of volume fraction and particle size have discussed in Chawla et al 1998[14]. Sic reinforcement has less volume compared to other composite particulate materials. The behaviour of aluminium reinforced with Silicon Carbide has investigated by the powder metallurgy route [15-16]. It has high thermal expansion for electronic applications [17].

This investigation of study carried out the dry sliding wear behaviour of hybrid composite materials. And effects of sliding distance(S), applying load (L) and wear resistance investigate the various wear parameters. By adding reinforcement material Sic, Mg, Tio2, for increasing wear resistance of the aluminium particulate composite materials. Influence of affecting wear as a various parameters discussed in this study. By adding Sic and Mg, TiO2 is an important clear to prove decreasing coefficient of friction as increasing wear resistance. In present work to investigate the various reinforcement of composite materials responses for different load 5N, 10N, 15 N. Curve fitting technique used to established the polynomial and power law equations.

MATERIALS AND METHOD

Materials

Aluminium has to choose base material and the chemical composition of Al-Mg-Sic presented in the table 1. This composite mixture made by the powder metallurgy route were investigated as three matrix phase as Al-Mg-Fly ash, Al-Sic-Tio2 and Al-Tio2. Using stir casting method production of composite materials reinforcement as a percentage ratio of 5%, 10% and 15%. Manufacturing of composite production as conventional stir casting method chosen and availability of free cost, because of less economical for industrial measures. The experimental procedure described in this investigation [18]. In this fabrication process of composite mixture, stirring action carried out by the crucible graphite coal furnace of a molten metal. After solidification process the matrix reinforcement become a homogeneous phase. The melting material of coal used as a fuel. The blower furnace heated with a base material of aluminium 6061 at 7000 C for 15 min. Pre-heated powder was slowly added to the base material after that above melting temperature. As a constant rotation speed 500 rpm, carried out by the stirring action at 10 min as mixture form a mould cavity at room temperature. Other two combinations of matrix reinforcement of specimen prepared by the above procedure.

Table 1. Chemical composition of Al 6061

Element	Mg	Fe	Si	Cu	Mn	V	Ti	Al
Wt%	1.08	0.17	0.63	0.32	0.52	0.01	0.02	Remainder

Table 2. Chemical composition of Flyash

Element	Fe_2O_3	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	Na_2O_3	TiO_2
Wt%	8.1	1.14	24.98	55.85	0.15	1.16	0.85	2.54	0.2	1.75

Al 6061 chosen a base material and chemical composition shows that table 1 and 2. It has a density of 2.70 g/cm3. This material using wide range of industrial commercial applications Such as aircraft fittings, camera lens mounts couplings, etc.

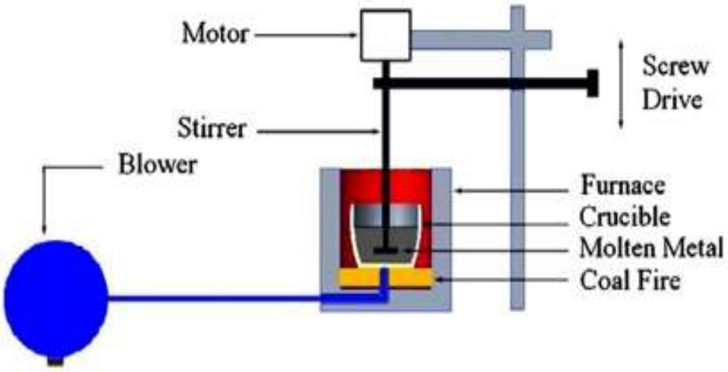

Figure 1. Stir Casting Method of MMC

Fly ash include Silicon di Oxide (SiO2), aluminium Oxide (Al2O3), Calcium Oxide (CaO) depending upon the amount of fuel burning in combustion products. Hard sintering process of Silicon carbide presented in this investigation. It will used variety of applications such as car brakes, clutches, and bullet proofs and used electronic applications. Silicon carbide for the chemical composition shows that table 2. Thermal conductivity of the silicon carbide material 120 W/m2 K. The particles of reinforcement has high temperature up to 1600o C it has no strength loss. Generally thermal decomposition of polymeric matrix prepared by the low temperature. The shapes of SiC are crystalline structure and vary a shape for depending upon the chemical composition. It has low coefficient thermal expansion 4.0X10-6 K. SiC of molten salt not enhanced with any acids up to 8000C and no strength losses up to 1600oC [Nagarajan et al. (1999). And used high performance applications such as structural and wear applications.Tio2 is also used as an electronic application of semiconductor device. And also using synthetic rutile for a solution to making a product of iron.

EXPERIMENTAL PROCEDURE

Wear test

Reinforcement of composite materials as various particles behaviour predicted by Pin-on-Disc wears mechanism. The wear test specimen was prepared by the shape of 6mm length and 200 mm dia. The circular platform was chosen by evaluated wear for composite materials. The disc material EN31 steel was used. And using wear parameter of constant load range 5N, 10N, 15N, at a constant speed 3m/s and sliding distance 300 mm. The disc was rotated under the mechanical action and the pin was perpendicular to the weighing machine. Every test was conducted using chemical solvent (ethanol, (95 ml water, 2.5 ml HNO3, 1.5 ml HCl, 1.0 mlHF), is used to remove the traces of wear regions. The surface roughness of the disc was lower than 0.9 µm.

Computerized check used to predict the wear loss data, coefficient of friction and frictional load. The measuring wear after and before test of accuracy 0.0001g. Generally Al-Mg-Sic had highest wear resistance and highest friction coefficient. Observation from the test for strengthening to increase the wear resistance due to increasing reinforcement of composite mixture.

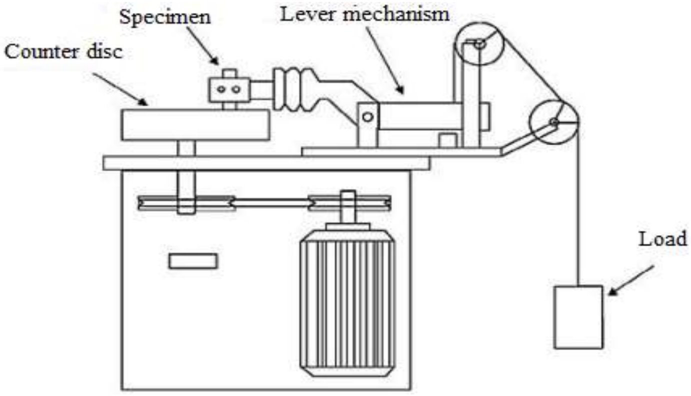

Figure 2. Pin on Disc wear mechanism

The microstructure is an important cause for every quality of composite materials. The wear specimen captured by using scanning electron microscope (SEM), surface morphology of a various specimen. After the wear analysis to using a simple work pieces examined by metallography. And various worn surfaces of matrix reinforcement observed in this investigation. The development of microstructure used to see the tribological characteristics of the composite materials. And optical micrographs were used to capture the various worn surfaces with suitable magnification factor. The microstructure of the hybrid composites examined using an optical microscope (Model: Olympus), and a scanning electron microscope (SEM). JSM-6610LV scanning electron microscope equipped with energy dispersive X-ray analyzer.

RESULT AND DISCUSSIONS

Effect of wear on various composites

Wear behaviour of various reinforcement of part mixture results obtained at a load of 5N, 10N and 15N for the wt % of 3, 6, and 9. From the observation for an experimental results are monitored by computerized system of graphical plot shows that figure. This result to make sure that effect low load having low wear and to increasing a load of high wear exists. The reinforcement of adding Mg-Sic-fly ash to decrease the wear, it is an important clear for to increasing wear resistance compared with the base material Al 6061 composite material. Similarly for other prepared composites such as Al6061+TiO2, Al6061+SiC+TiO2, Al6061+SiC+Mg+flyash. The wear behaviour increasing and decreasing as proved with the help of curve fitting technique applied. It based on the polynomial and power law equations of R2 value of regression nonlinear curve. The value of polynomial value high compared with the power law equations value. So better agreement with the wear characteristics. The polynomial and power law equation shows that table 4. This type of curve fitting technique used to cut the number of experiments.

The effect of load 5N, 10N, and 15N sliding distance 400mm at constant speed 5m/s for coefficient of friction shows that figure. Coefficient of friction is more at the before and after the oxide formation. For increasing oxide formation as a protective layer to increasing the load and to increasing wt% of reinforcement materials. The effect of composite mixture value of coefficient of friction is higher. The distance between the pin and discs are less contact, it causes low coefficient of friction. This is a good agreement with reinforcement of composite matrices. The graphical representation of coefficient of friction shows that figure.

Table 3: Curve fitting technique of various load (a) 5N (b) 10N (c) 15N

	Composite	Polynomial	R^2	Power law	R^2
	Al 6061+Tio_2	$y = -0.0006x^2 + 0.3878x + 77.879$	0.9748	$y = 43.227x^{0.2068}$	0.9629
	Al6061+SiC+TiO_2	$y = -0.0008x^2 + 0.5093x + 81.272$	0.9857	$y = 42.468x^{0.2368}$	0.977
	Al6061+SiC+Mg+flyash	$y = 3E-05x^2 + 0.2683x + 129.43$	0.9848	$y = 68.785x^{0.1879}$	0.9358
	Al 6061+Tio_2	$y = -0.0001x^2 + 0.2298x + 88.951$	0.991	$y = 46.627x^{0.1966}$	0.9523
	Al6061+SiC+TiO_2	$y = 0.0001x^2 + 0.2329x + 103.75$	0.9914	$y = 47.588x^{0.2278}$	0.9075
	Al6061+SiC+Mg+flyash	$y = 0.0005x^2 + 0.0968x + 125.03$	0.986	$y = 57.905x^{0.2061}$	0.8619
	Al 6061+Tio_2	$y = -0.0011x^2 + 0.7383x + 166.94$	0.984	$y = 91.802x^{0.2031}$	0.965
	Al6061+SiC+TiO_2	$y = -0.002x^2 + 1.3102x + 266.86$	0.9849	$y = 147.84x^{0.2074}$	0.9847
	Al6061+SiC+Mg+flyash	$y = -0.001x^2 + 0.9679x + 446.5$	0.9879	$y = 292.7x^{0.1353}$	0.9392

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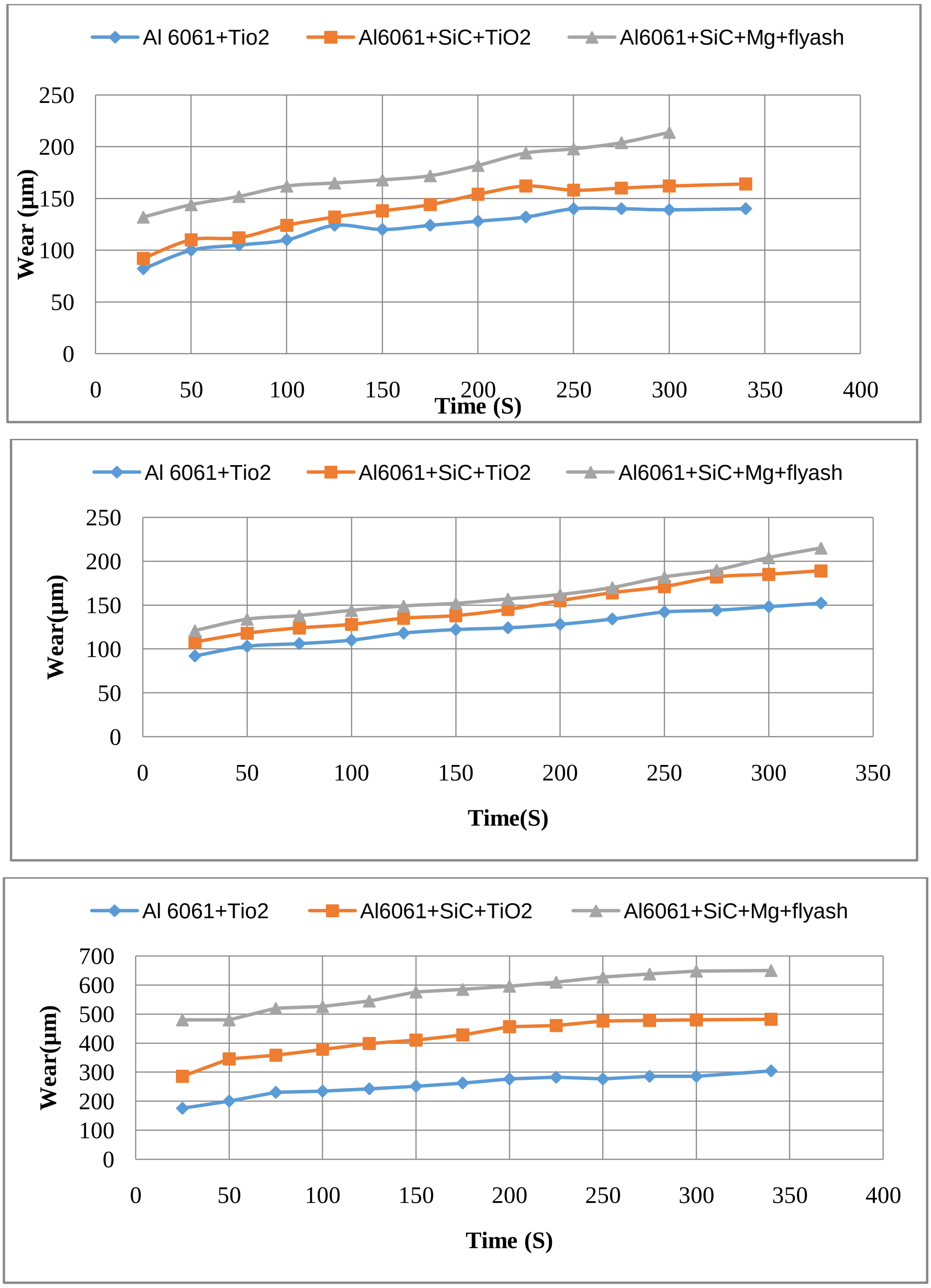

Figure 3: Wear of various composite mixture with different load (a) 5N (b) 10N (c) 15N

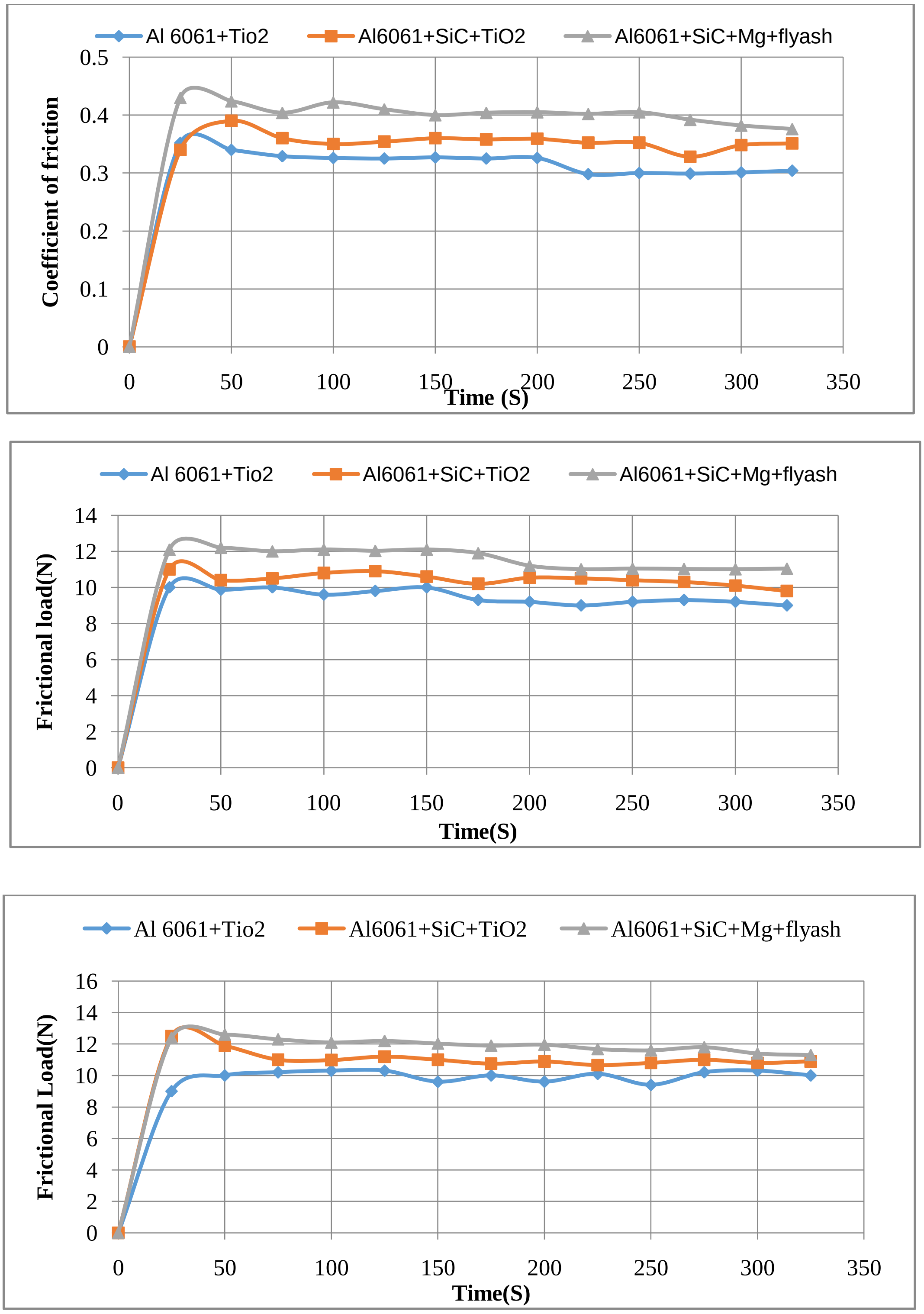

Figure 4: Frictional load as a various composite mixture with different load (a) 5N (b) 10N (c) 15N

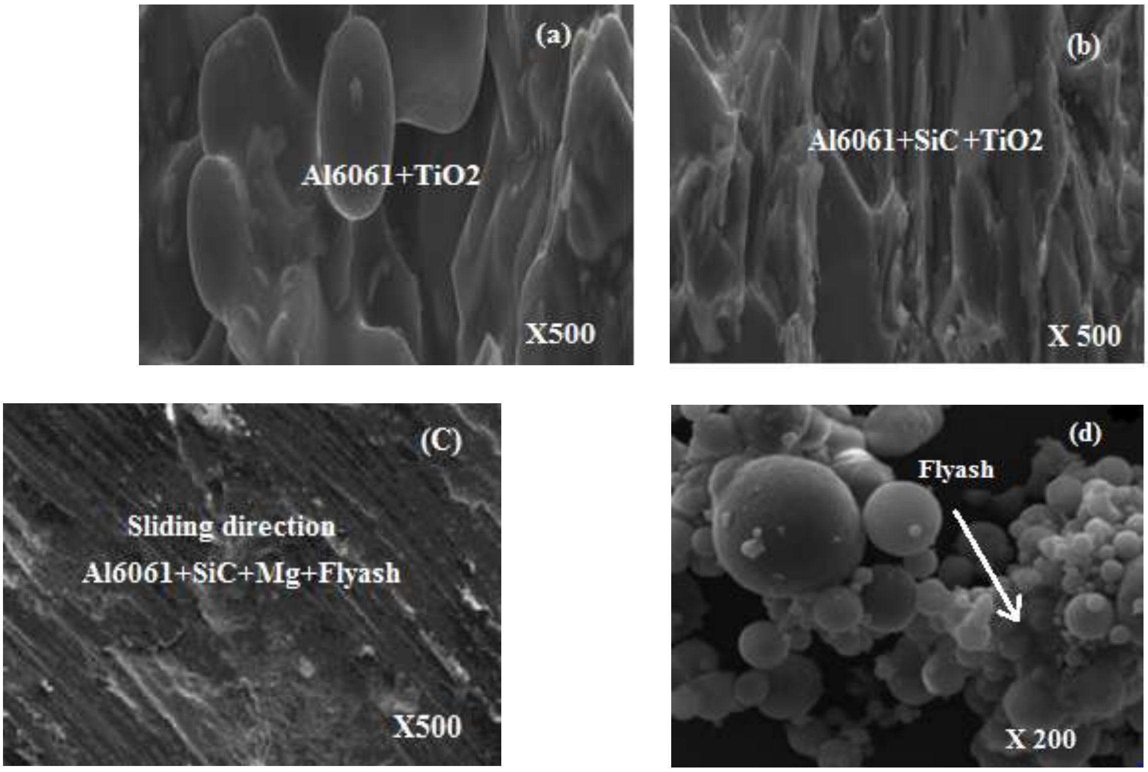

Figure 5: Microstructure of various composites (a) Al6061+TiO2 (b) Al6061+SiC+TiO2 (c) Al6061+SiC+Mg+Flyash (d) Flyash

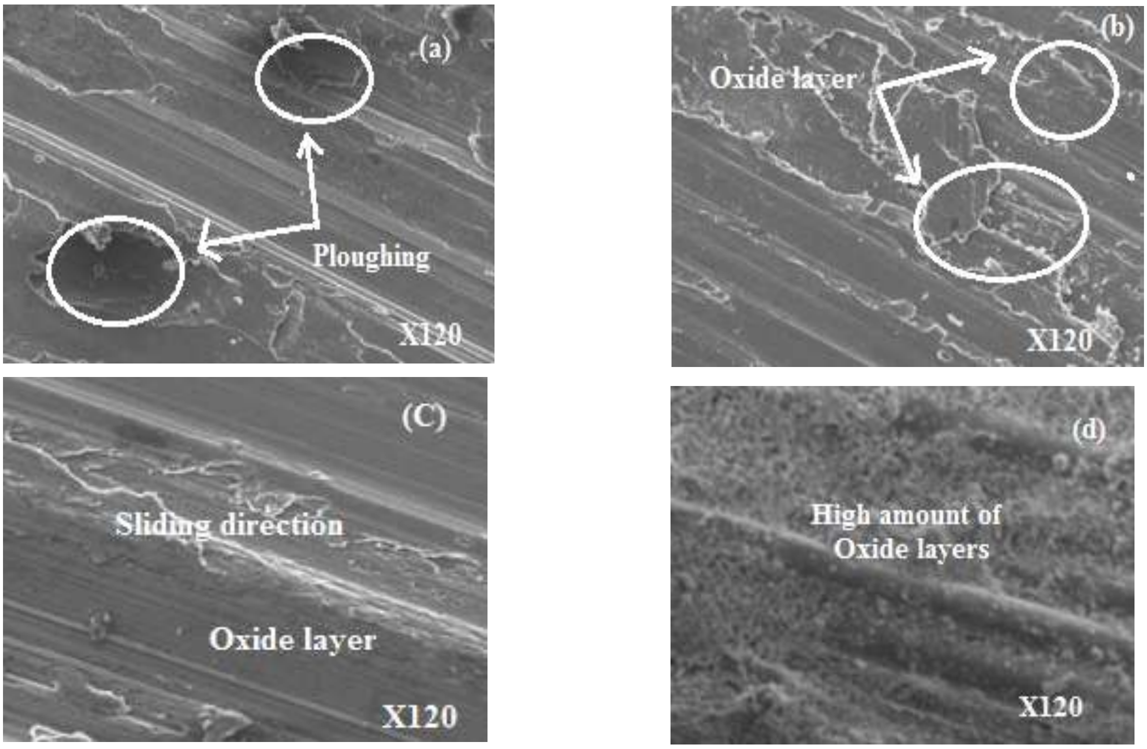

Figure 6: Microstructure of Al6061+SiC+Mg+flyash(a) Ploughing (b) Oxide layer (c) Debris (d) Oxide layer

By using SEM analysis for a sliding distance 300mm, sliding speed 2.1m/s and various limits of composite made in this investigation. Figure 6(a) shows the integrated reputation as a high magnification factor, the parallel grooves of ridges. For every load as 5N, 10N, and 15N of worn surfaces has compared with the Al 6061 materials. Due to reinforcement of composite smooth surface compared to the base materials. During the wear plough surface will detected and increasing load to form a rough surface from the figure 6(a). Deformation and delamination increases due to wear losses for the effect of increasing load shows that figures 6(b-c). However lot of debris formed depending upon the oxide formation shows that figure 6(a-c). The wear behaviour also related to the characteristics of worn surface and debris. The morphology of worn surface of a deep groove formed in the sliding direction as shown in figure 6(c) and the debris formed with the reinforcement. This type of reinforcement materials such as Sic, fly ash, Mg to forming debris, it will become an evident foe plastic deformation. Large amount of debris formed in then sample. The matrix reinforcement of debris to dominated the poor performance of the already samples.

Investigation of wear results reported a various worn surfaces by SEM microstructures in figure 6(c-d). This type of image shows the deposition of reinforcement materials.Deep grooves were formed by reinforcement of wt % of various composites. And lot of debris formed due to higher order coefficient of friction. In case of small grooves occurred due to lower amount of wear loses. Generally good agreement with the reinforcement bonding and high interfacing bonding energy observed from the investigation

CONCLUSION

Using stir casting of composite reinforcement has well-studied in this investigation. The uniform distribution of reinforcement particles has observed from the microstructure. The following observations were investigated from the experimental analysis of various reinforcement materials. To adding reinforcement of various matrixes to increasing wt. % of composites the wear loss decreases, effect of to increasing wear resistance. And also coefficient of friction increases with the addition of Sic. The curved fitting technique was used to develop the wear resistance and frictional load behavior. And using second order polynomial and power law equation compared with the R2 value much agreed with the experimental results with different loading conditions such as 5N, 10N, and 15N.

Reinforcement Sic has high wear resistance by adding this composite wear decrease the large amount of wear. The dry sliding wear parameter sliding distance, applied load, and wt. % of composite materials. It exhibits better wear properties. Worn surfaces of SEM micrographs of composite materials are much stronger and rougher than that of strengthened alloy.

Dry sliding performance also improved with the addition of Sic, Tio2, Mg, and Fly ash. Addition of reinforcement martial to increasing coefficient of friction at beginning and decreasing the end of the composites. However to increasing the wear resistance and decreasing the wear losses. And worn surface to formed a different types layers such as Oxide layer, ploughing, Debris to prove a high plastic deformation.

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