

Dry Sliding Wear Behaviour of Aluminium 6061-SiC-Graphite Particulates Reinforced Hybrid Composites

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Abstract. In this present work, systematic study has been conducted to investigate the wear phenomenon by adding micron size silicon carbide and graphite particles into Al6061 base. Al6061 compound was taken as the base lattice to which SiC and graphite particulates were utilized as fortifications. 6 wt. % of SiC and 6 wt. % of graphite were introduced to the base framework. The microstructural behaviour was analysed through scanning electron microscopy, which uncovered the uniform appropriation of SiC and graphite content in the Al matrix. Pin-on-disc equipment was utilized to assess the volumetric wear loss of arranged samples, in which EN32 steel disc was utilized as the counter face. The outcomes uncovered that the volumetric wear misfortune was expanded with increment in applied load, disc speed and sliding distance for every one of the specimens. The outcomes additionally showed that the volumetric wear loss of the Al6061-6% SiC-6% graphite composite was smaller than the Al6061 lattice. The worn out surfaces were portrayed by SEM analysis.

1. Introduction

Metal matrix composites (MMCs) have been made to meet solicitations of lighter materials especially suited for applications requiring high calibre to weight extent with high specific quality, dimensional constancy, helper resoluteness, and strength for different applications like auto, space, flying machine, obstruction, and in other building divisions [1-3]. Aluminum is the most extensively used matrix material for the arranging metal system composites. Aluminum blends are extensively requested into tossed composites and formed mixes. Major alloying parts in aluminum blends are copper, manganese, silicon, magnesium and zinc. Aluminum has been used as a system material as a result of its light weight, high calibre, heavenly wear resistance properties, high temperature, easy to set up the composite and openness in abundance [4, 5]. From speedy couple of year's aluminum cross section composites are extensively used as a piece of different, non-essential and down to earth applications. The critical points of interest of aluminum based composites in transportation region are low fuel use, less air borne surges and lower uproar.

Numerous artistic materials like particulates of SiC, TiC, graphite, boron carbide are generally utilized fortifications in aluminum compound [6-8]. Aluminum amalgam based particulate fortified composites have a more number of designing applications, strengthening aluminum combinations with various hard clay particles is for the most part because of wide accessibility. The most normally utilized aluminum composite networks are 2024, 2014, 2219, 5083, 5052, 6061, 6068, 7010 and 7075 compounds.



Particulate fortified aluminum composites are manufactured by strong or fluid state forms. These composites are more affordable as contrast with persistent fiber strengthened composites. Mechanical and tribological properties of particulate strengthened composites are in accordance with short fiber or consistent fiber fortified composites. The primary favorable circumstances of particulate fortified aluminum composites over different materials are their cost preference, formability, enhanced consumption and seizure resistance [9, 10]. Subsequently, these aluminum based composites are utilized as barrel squares, circle brakes, calipers, interfacing bars and structures for space applications. In the greater part of these administrations the segments are subjected to tribological stacking conditions [11].

A couple of researchers have explored the wear of Al based composites. Baradeswaran et al. [9] mulled over on mechanical and wear properties of Al7075-Al₂O₃-graphite composites. Exhibited hardness, unbending nature and weight nature of the composites are seen to be extended. The wear properties of composites containing graphite showed the overwhelming wear resistance properties. Suresh et al. [12] have point by point wear direct of Al-TiB₂ composites using reaction surface technique. Yuhai et al. [13] have researched the contact and wear lead of Al6061-B₄C composites. Composites were examined by considering the effect of sliding time, associated stack, sliding velocity and warmth treatment. Umanath et al. [14] drove explores dry sliding wear lead of Al6061-Al₂O₃-SiC cross breed metal system composites.

In this paper, an endeavour has been made to plan Al6061 matrix composites by including 6 wt. % of SiC and 6 wt. % of Graphite particulates into framework by utilizing a novel two phase support expansion strategy. The SiC and graphite substance is constrained to 6 wt. % to study the impact of particles on wear conduct of composites. Further, the arranged Al6061-SiC-graphite composites were contemplated for impact of load and disc speed on the wear behaviour by utilizing pin-on-disc equipment.

2. Experimental Details

2.1 Materials Used

Composites consisting 6 wt. % of SiC and 6 wt. % of soft graphite reinforcements were developed by fluid metallurgy course. For the generation of MMCs, an Al6061 composite was utilized as the network material while SiC and graphite particles with a normal size of 90-125µm were utilized as the fortifications.

The morphology of procured SiC and graphite particulates are shown in fig.1 which indicates that the combination of semi circular and sharp cornered morphology.

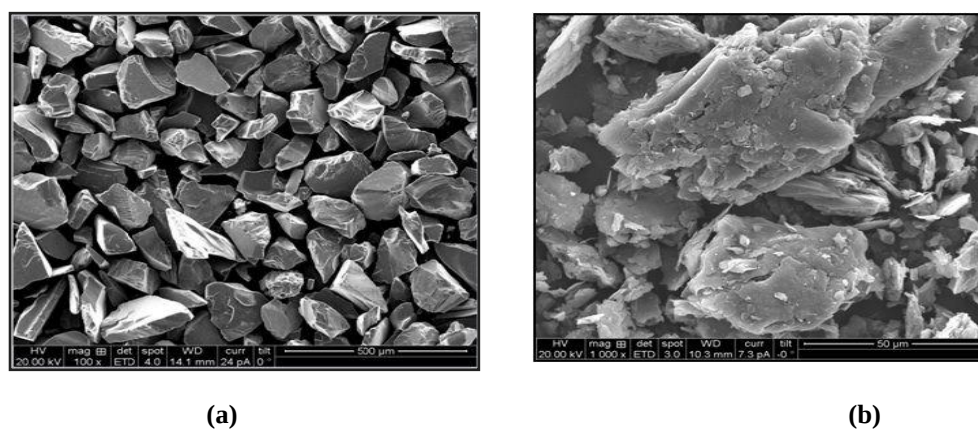


Figure 1. Shows SEM photographs of (a) SiC particulates (b) Graphite Particulates

2.2 Preparation of composites

The SiC and graphite fortified Al-6061 metal structure composites were made by using a vortex method. At first known quantity of Al6061 amalgam was set into pot made by SiC and heated to 740°C temperature in an electrical resistance furnace. Once the required amount of temperature is accomplished, degassing was finished using solid hexa-chloroethane (C_2Cl_6) to remove all the ingested gasses [15]. The separate was aggravated with the help of a zirconia secured mechanical stirrer to shape a fine vortex. A post speed of 300 rpm and blending time of 6-8 minutes were utilized. The reinforcement particles were preheated to 600 degree Celsius in a pre-warmer to fabricate the wettability. The pre-warmed particles embedded into liquid compound at a bolster rate of 1.1-1.3 g/sec. After stirring for 5 min., melt was poured to a die made by cast iron having estimations as required. Wear tests of size 25mm in length and 8mm in width was set up by using castings made.

2.3 Dry sliding wear test

Wear characteristics of Al-6061 and SiC and graphite composites were estimated by using pin-on-disc wear apparatus. Tube shaped stick examples of 8 mm breadth and 25 mm in length samples were placed vertically on a holder. The finishes of examples were cleaned with grating paper of coarseness size 600 and took after by review 1000. Amid the test the pin was squeezed alongside the EN32 steel plate with resistance of 60 HRC. The steel disc was cleaned with 320grit and after that by using 600grit SiC emery papers for couple of minutes took after by cleaning with acetone. Test conditions were made by load-speed settings in the intervals of 100rpm, 200rpm, 400rpm and 600 rpm under a 5kg typical load, and 1kg, 3kg and 5kg varying applied burdens at 400rpm speed. The underlying weight of the example was calculated in an electronic machine with ± 0.01 mg exactness. Information gathered and investigated for volumetric wear misfortune as weight reduction. Further, volumetric wear misfortune was figured. Fig. 2 showing the machined samples for wear test as per ASTM G99 standard.



Figure 2. Specimen used in wear test

3. Results and Discussion

3.1 Microstructural Studies

Fig. 3a-b shows microstructure of as cast Al6061 and Al6061-SiC-graphite composites. Silicon carbide and graphite reinforced aluminium composites have even circulation of particles and this can be seen in scanning electron microscopy photograph (fig. 3b). As it is examined in fig. 3b optical microphotograph of Al6061-SiC-graphite composites generally have equi-axed grains. Further these figures reveal the homogeneity of the cast composites. Further, in the case of Al6061-SiC-graphite composites, the bonding between Al and SiC can be between layers of silicon atoms or carbon atoms in SiC and aluminium, and this will further influence the properties [16].

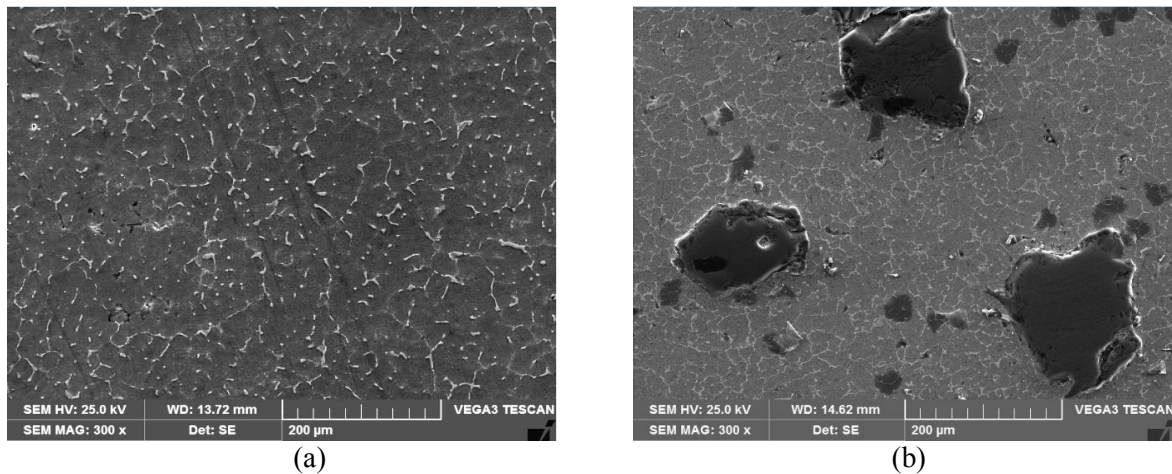


Figure 3. Showing the SEM microphotographs of (a) as cast Al6061 alloy (b) Al6061-6%SiC-6% Graphite composites

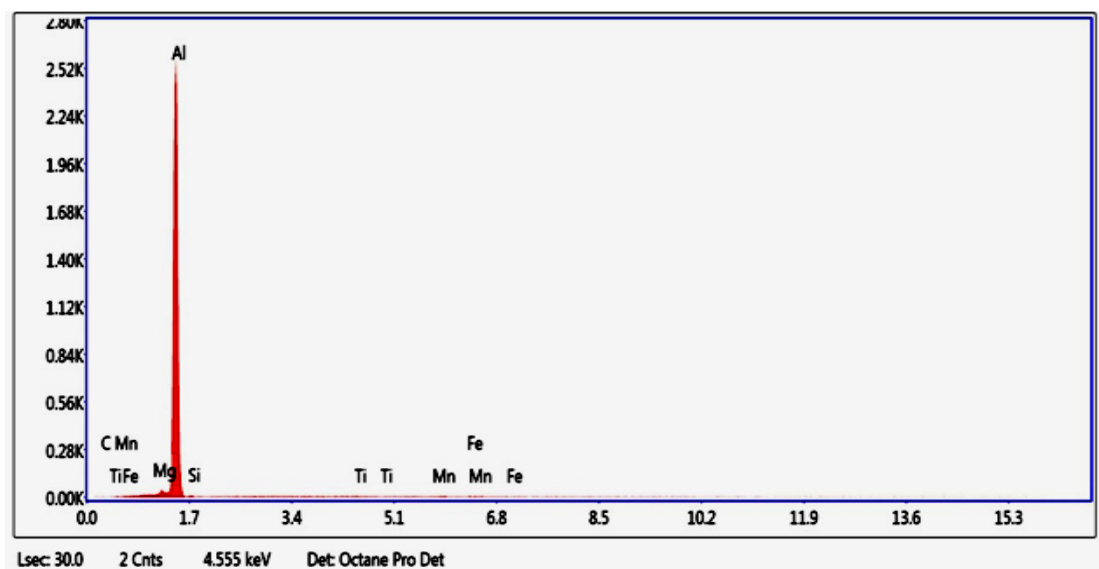


Figure 4. Showing the EDS analysis of Al6061-6%SiC-6% Graphite composites

Fig. 4 shows the EDS spectrum of Al6061-6% SiC and 6% graphite particulates embedded hybrid composites. From the spectrum, it is revealed that presence of SiC and graphite particulates in the form of Si and C elements.

3.2 Wear Properties

Fig. 5 shows the variation of volumetric loss with reverence to load and Al6061 metal based composites. The results are observed for the maximum sliding distance of 2000m. The results clearly indicate that the increase of load increases the volumetric wear loss. Also the maximum wear is observed for unreinforced alloy.

The variation of volumetric wear loss at constant 400rpm and varying loads of 1, 3 & 5kg is as shown in fig. 5. The load acting on the specimecn is played dominant role in the wear characteristics of base

as well as composites. From the results, it has been asserted that the addition of 6 wt. % of SiC and 6 wt. % of graphite particulates to the matrix has a marked effect on the volumetric wear loss.

The change in the wear resistance of the composites with the expansion of SiC support can be ascribed to the change in the solidity of the composites and enhanced hardness comes about the lessening in the wear failure of the composites. Sudarshan et al. [17] detailed that great interfacial holding is important for better wear conduct as load exchanges happens through interface and furthermore debonding of support particles brings about increment in wear rate at higher burdens. The expansion of 6 wt. % of graphite particulates into Al network assumes critical part in the wear conduct of composites. Graphite goes about as an ointment and structures oxide layer between the steel partner and stick.

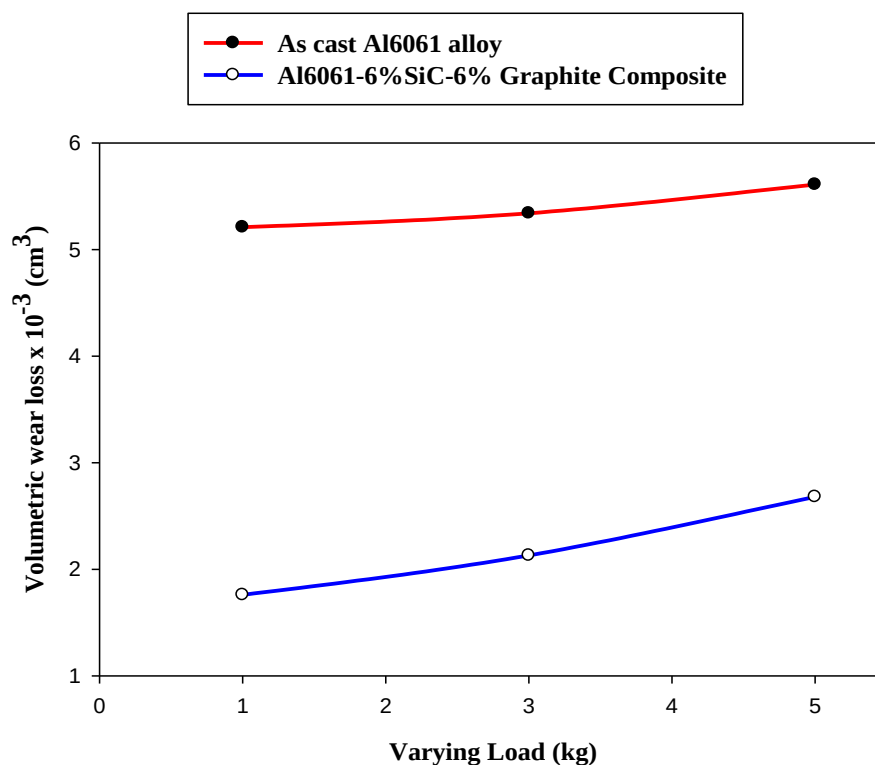


Figure 5. Volumetric wear loss of Al-6061 alloy and SiC-Graphite composites at constant sliding speed and varying loads

Fig. 6 demonstrates the variety of volumetric loss of Al grid compound and Al6061-6% SiC-6% graphite compound at consistent 5kg applied load and shifting sliding paces. With an expanding speed i.e. 100rpm, 200rpm, 400rpm, and 600rpm, there is an expansion in the volumetric wear misfortune for both network combination and its composites. For all the sliding rates concentrated, the wear loss of the materials was much inferior when contrasted and the network amalgam. Additionally expanded wear rate with expanded sliding velocity is because of warm softening of the composite. Then again the expanded temperature at increased sliding velocities can cause serious plastic disfigurement of the mating surfaces prompting structure high strain rate sub-surface distortion [18]. The expanded rate of sub-surface twisting builds the contact zone by crack, and discontinuity of ill tempers. Accordingly this prompts improved delamination adding to upgrade wear rate.

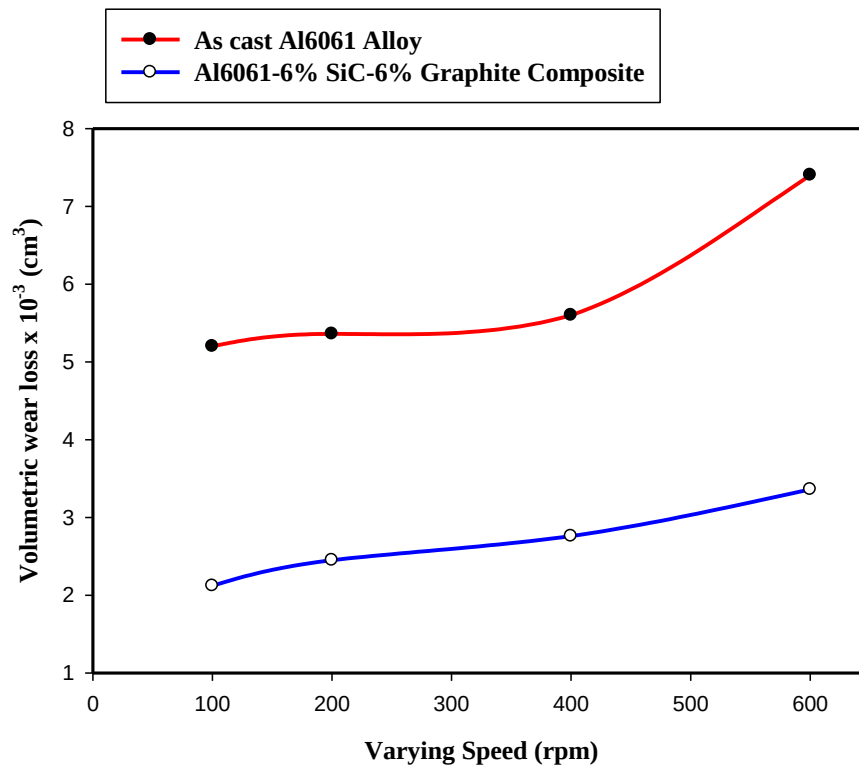
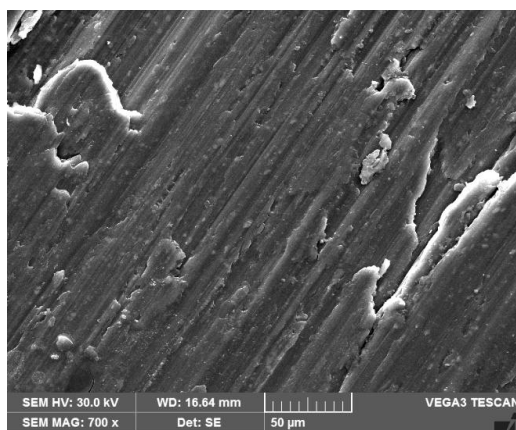
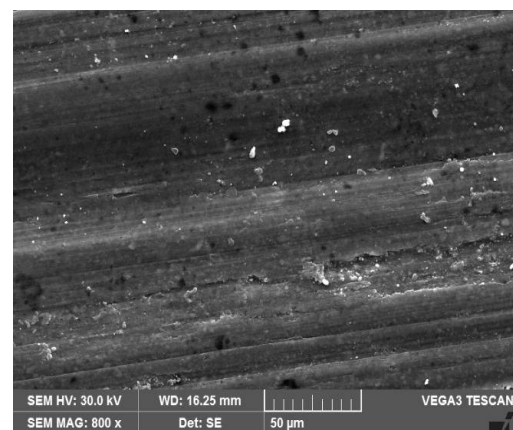


Figure 6. Volumetric wear of prepared Al6061 alloy and composites at constant load and varying speeds

3.3 Worn Surface Study



(a)



(b)

Figure 7. Shows the worn surfaces SEM photographs of (a) Al6061 alloy (b) Al6061-6%SiC-6%Graphite composites

The examinations of worn surface Fig. 7a demonstrated that the well used surfaces of base combination are substantially rougher than composites. Depressions and vast scored surfaces are found on worn surface of Al6061 combination. The sign of cavities and notches bolsters the way that delicate Al

compound distorted at higher heap of 5kg and at 400rpm speed and hauled out from the surface. The wear track perception demonstrates that bond and delamination are prevailing wear components saw at higher burdens. This is bolstered by the huge measured delamination chips and extreme bond bringing about mass expulsion of material at higher burdens.

Fig. 7b demonstrates the SEM micro-photographs of the well used surface of Al6061-6% SiC-6% graphite composite experimented at a load of 5kg and 400rpm speed. The cavities are little because of the hard way of SiC support and poor wear misfortunes. As the clay particles oppose the delamination procedure, composites are found to have more prominent wear resistance. Worn surface shows less breaks and furrows predominantly because of the nearness of graphite particulates. The spread graphite particles from the ragged surface of composites shape a thin wealthy tribolayer among sliding faces, which avoid coordinate metal contact.

4. Conclusions

The effort on synthesis and assessment of Al6061-6% SiC-6% graphite composite by dissolve mixing has prompted important output. Al6061 combination based composites were effectively manufactured by liquefy blending strategy. The SEM micro-photographs of composites genuinely uniform appropriation of support particles in the Al6061 combination metal framework. The volumetric wear loss is ruled by load consider and sliding rate. The expansion of loads and sliding paces prompts a critical increment in the volumetric wear misfortune. The Al6061-6% SiC-6% graphite composites have indicated bring down rate of volumetric wear misfortune when contrasted with that seen in as cast Al6061 compound lattice. SEM photographs of worn surface uncovered the nearness of soft sections in the Al6061-SiC-graphite composite contrasted with the base framework.

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