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Fabrication and Investigation of Mechnical Properties of Al-flyash-SiC Composites

Gurpreet Singh[1], Khushdeep Goyal[1,*], Deepak Kumar Goyal[2]

[1]Department of Mechanical Engineering, Punjabi University, India
[2]Department of Mechanical Engineering, Baba Banda Singh Bahadur Engineering College, India

Abstract The composite materials have received great attention due to their light weight, high performance, environment friendly and wear resistance properties and excellent tribololgical properties over the metals and their alloys. There is a good scope to develop new aluminum based composite material which will further improve these properties. Therefore in this research work, a new aluminum based composite material was successfully fabricated by reinforcing with fly ash and Silicon carbide and its mechanical properties like wear resistance, hardness and tensile strength were investigated.

Keywords Composites, Stir Casting, Fabrication, Fly Ash, Wear

1. Introduction

Composite materials are able to meet the global demand for light weight, high performance, environmental friendly and wear resistance materials [1]. The composite materials have received great attention due to their excellent tribololgical properties over the metals and their alloys [2-4]. In a metal matrix composite, one constituent is called matrix phase and other is called reinforcing phase. Reinforcing phase is embedded in the matrix to give the desired properties [5].

Fabrication of metal matrix composite has several limitations such as porosity, poor wettability and improper distribution of reinforcement particles. Achieving uniform distribution of reinforcement is very important for the composite [6]. The conventional stir casting is an important processing method for fabrication and is inexpensive and offers wide selection of materials and processing condition. It offers better matrix particle reinforcement due to stirring action of particles into melt [7].

The variables such as composition of matrix, reinforced particles distribution, weight percentage affect the mechanical properties of the composite but weight percentage of reinforcement has more effect on the mechanical properties like wear resistance, hardness, tensile strength etc. Fly ash is one of the residues generated in the coal [8]. Silicon carbide is a compound of silicon and carbon with a chemical formula SiC. Silicon carbide was originally produced by a high temp electrochemical reaction of sand and carbon. Any acids or alkalis or molten salts up to 800°C do not attack silicon carbide [10]. It is reported in the literature that the silicon carbide and fly ash particle size and its volume fraction also significantly affect the wear and friction properties of composites [9]. Senapati et al. [10] studied the extensive literature review on the usage of fly as a reinforcement agent for different matrix. Fly ash was used in molten metal and cast because it can reduce the overall weight and density due to low density of fly ash [11].

The aim of the present study is to investigate the wear rate, hardness, tensile strength (breaking load) of stir cast Al6061 with 5wt%, 10wt% of fly ash and 5wt%, 10wt% of silicon carbide. The wear test was performed on pin on disc type of wear testing machine. Micro wicker hardness tester and universal tensile tester were used for hardness measurement and tensile strength (breaking load) measurement respectively.

2. Experimentation

The aluminium(6061)-fly ash (5%, 10%), aluminium(6061)-SiC (5%, 10%) and aluminium(6061)-fly ash-SiC (5%-10%) composites were prepared by stir casting route. First of all, 400 gm of commercially aluminium(6061) was melted in the electric induction furnace at 760 deg. C in a graphite crucible and then (5, 10) wt% of fly ash were added to the Al melt for production of two different composites. The fly ash particles were preheated up to 300 deg. C in muffle furnace for two hours to remove the moisture. Then the melt was stirred using a mild steel stirrer. Fly-ash particles were added to the melt at the time of formation of vortex in the melt due to stirring. The melt temperature was maintained at 760-770 deg. C during the addition of the particles. Then the melt was casted in a clay graphite crucible.

After that another 400 gm of aluminium(6061) was melt in the furnace at 760 deg. C and (5, 10) wt% of SiC were added to the Al melt for the production of two different composites. The SiC were preheated up to 500 deg. C in muffle furnace to remove the moisture content. Then mild steel stirrer was used for stirring the melt. SiC particles were added in molten aluminium. Then the melt was casted in a clay graphite crucible.

After the fabrication of aluminium-fly ash and aluminium-SiC composites, the final composites are fabricated by melting the 400gm aluminium (6061) in the furnace and mix the SiC and fly ash. The mixture was preheated at 500 deg. C in muffle furnace to remove moisture. Mixture was added to the molten aluminium at 760 deg. C and mild steel stirrer was used for stirring. Then the melt was casted in a clay graphite crucible.

The wear characteristics and friction of Al-(5, 10) wt% fly ash,Al-(5, 10) wt% SiC and Al-(5, 10) wt% SiC-(5, 10) wt% fly ash composites were evaluated using Pin on Disc wear testing machine. For this, cylindrical specimens of 6 mm diameter and 25 mm length were prepared from the cast Al-fly ash, Al-SiC and Al-SiC-fly ash composites. Test was performed under 2 N load and 300 rpm for 10 minutes. The Optical microscopy was done for all the samples.

The hardness testing and tensile strength (breaking load) were carried out Al-(5, 10) wt% fly ash, Al-(5, 10) wt% SiC and Al-(5, 10) wt% SiC-(5, 10) wt% fly ash composites. The hardness of the samples was determined by Micro Vicker hardness testing machine. The tensile strength of the samples was determined by Universal tensile testing machine.

3. Result and Discussion

3.1. Results of Wear Behavior and Variation of Frictional Force

In the figures below, the wear behavior and variation of frictional force of Al+ (5%) Fly ash is shown:

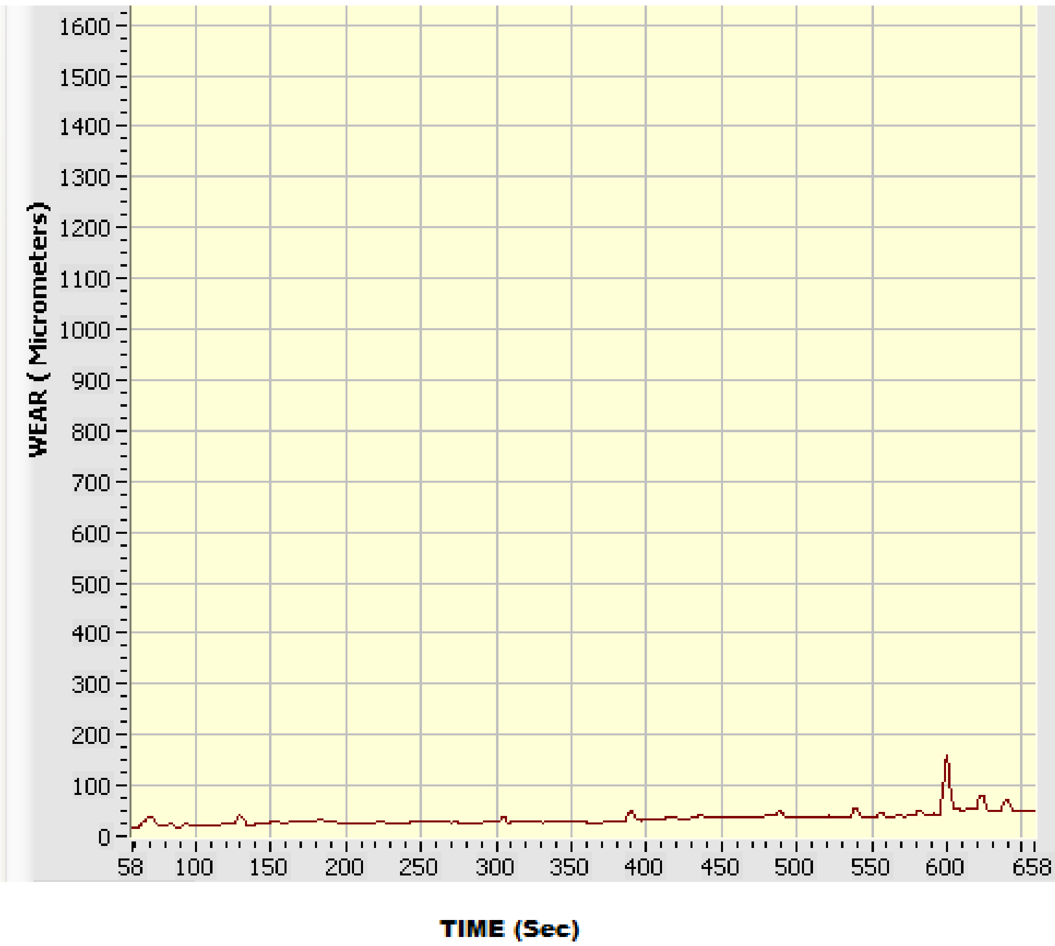

Figure 1(a). Wear behavior of for Al+ (5%) Fly ash composite at 300 rpm and at 20 N

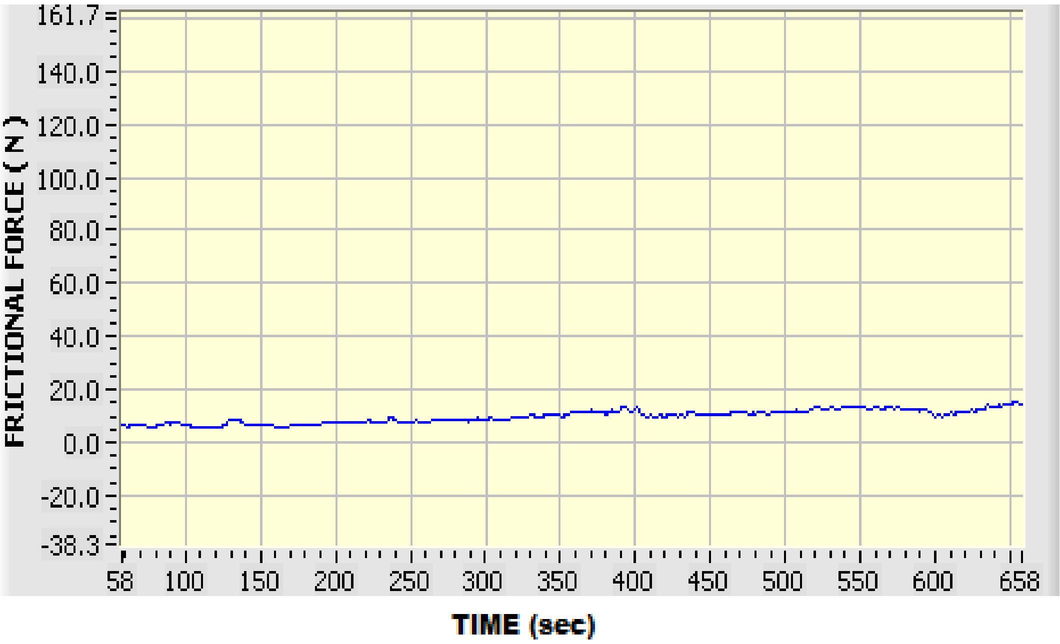

Figure 1 (b). Variation of Frictional force for Al+ (5%) fly ash at 300 rpm and at 20 N.

In figures below, the wear behavior and variation of frictional force of Al+ (10%) Fly ash is shown:

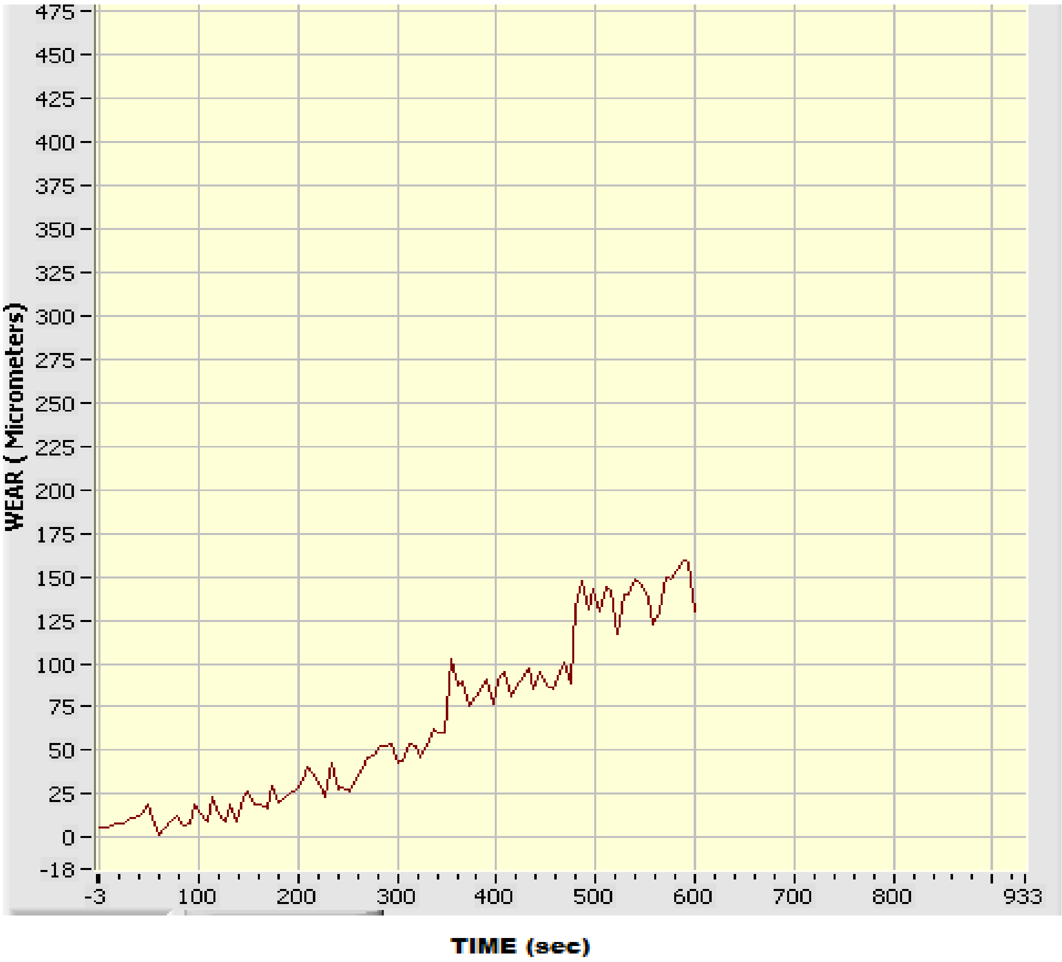

Figure 2 (a). Wear behavior of Al+(10%)Fly ash composite at 20N load at 300 rpm.

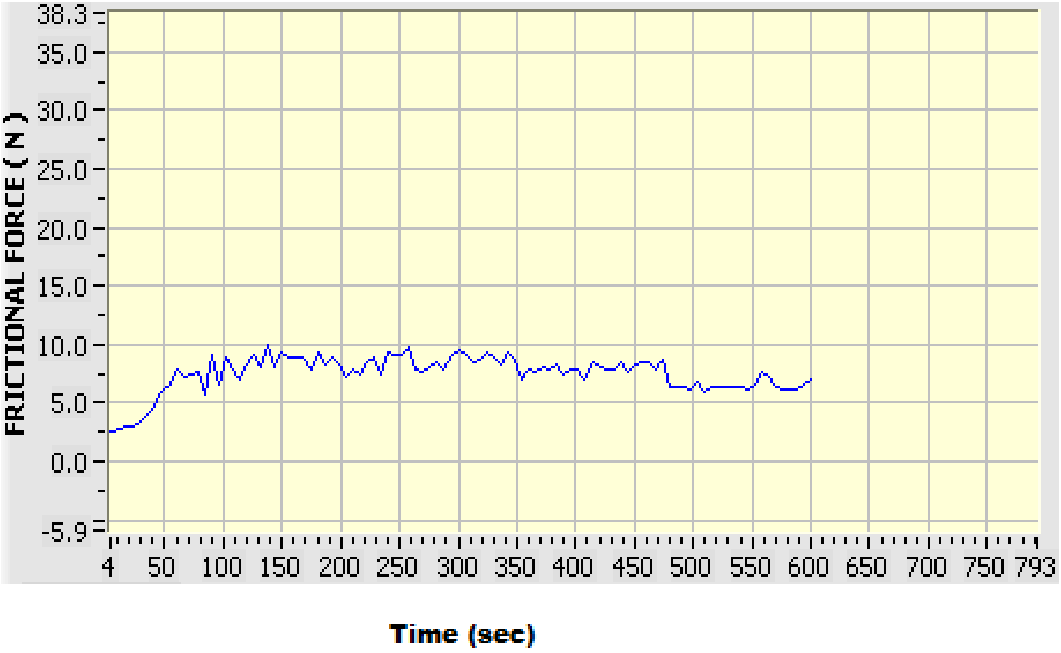

Figure 2 (b). Variation of Frictional force for Al+(10%)Fly ash composite at 20N load at 300 rpm

In figures below, the wear behavior and variation of frictional force of Al+ (5%) SiC is shown:

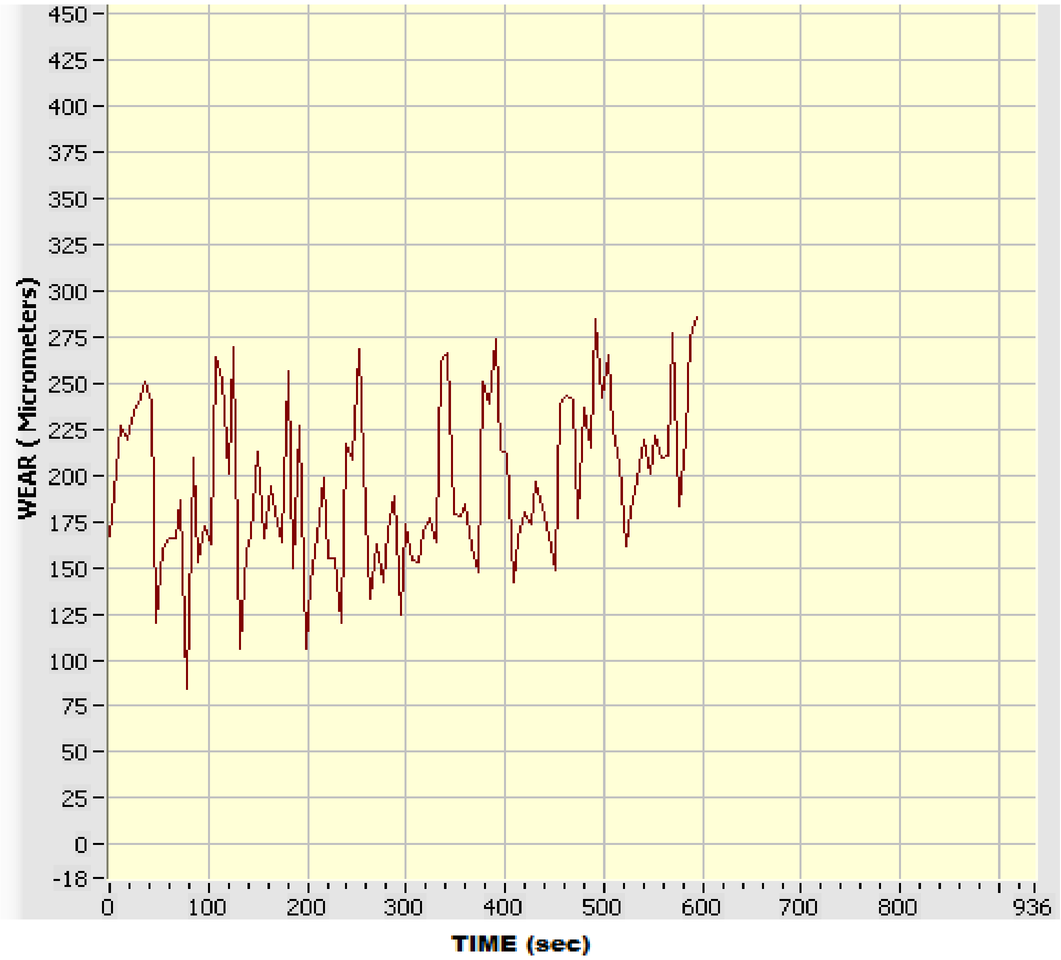

Figure 3(a). Wear behavior of for Al+ (5%) SiC composite at 300 rpm and at 20 N

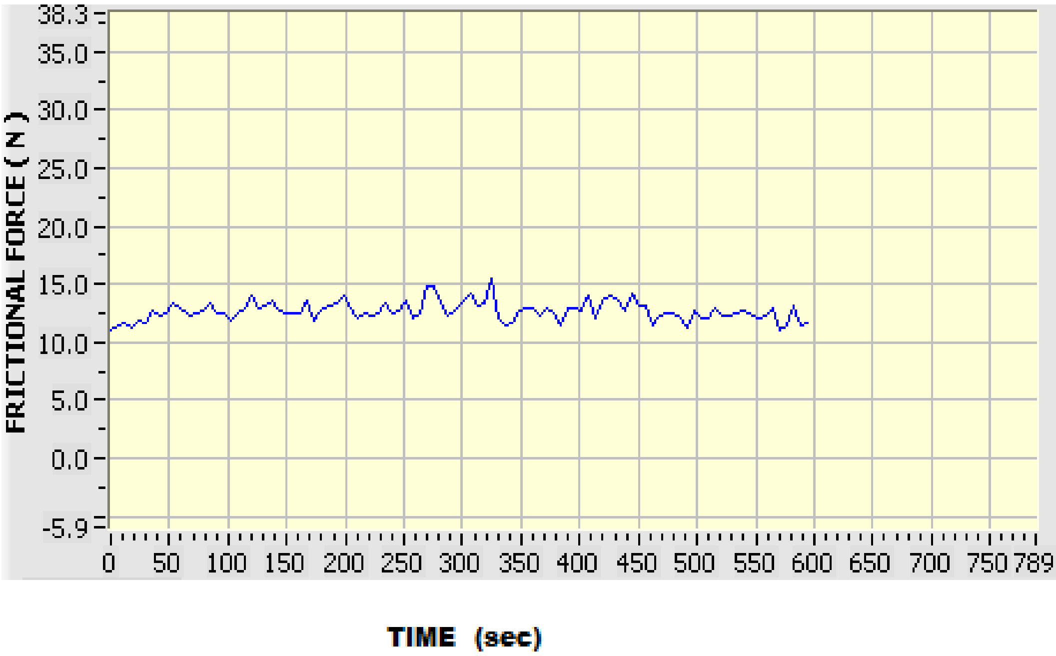

Figure 3 (b). Variation of Frictional force for Al+ (5%) SiC at 300 rpm and at 20 N.

In figures below, the wear behavior and variation of frictional force of Al+ (10%) SiC is shown:

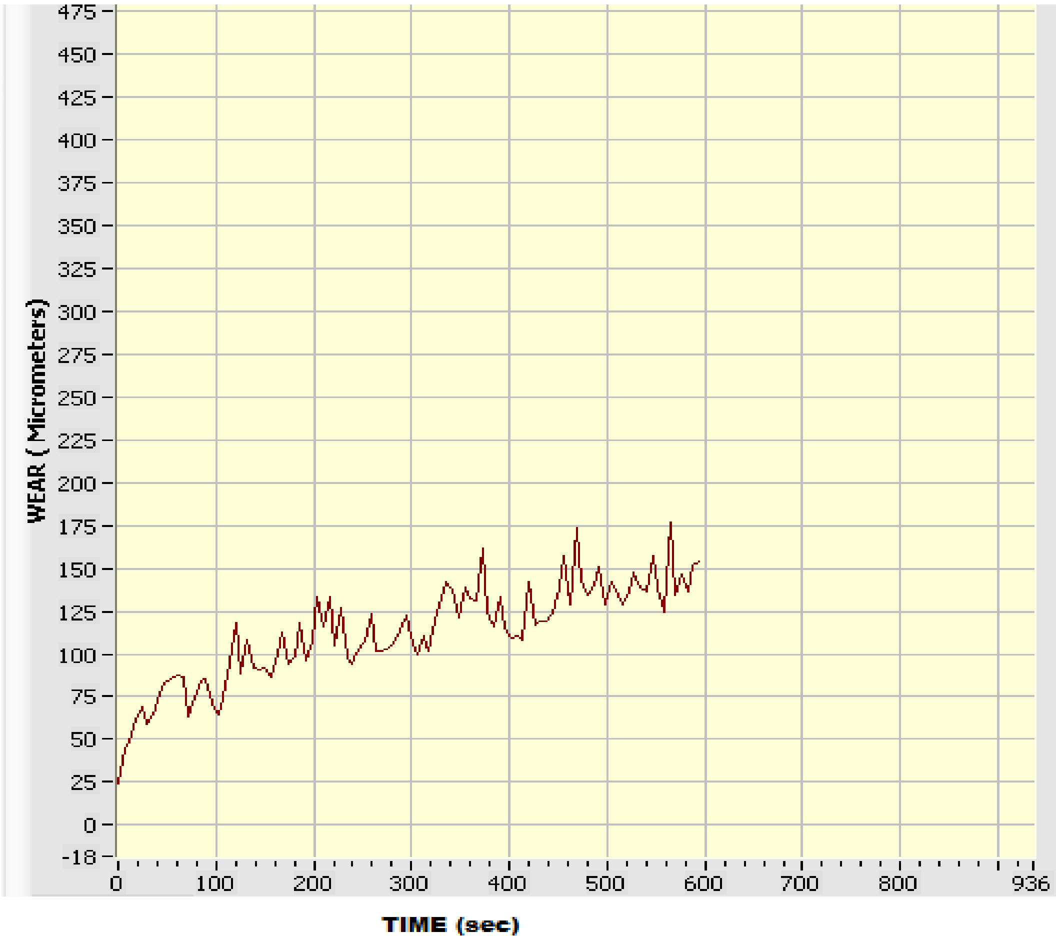

Figure 4(a). Wear behavior of for Al+ (10%) SiC composite at 300 rpm and at 20 N

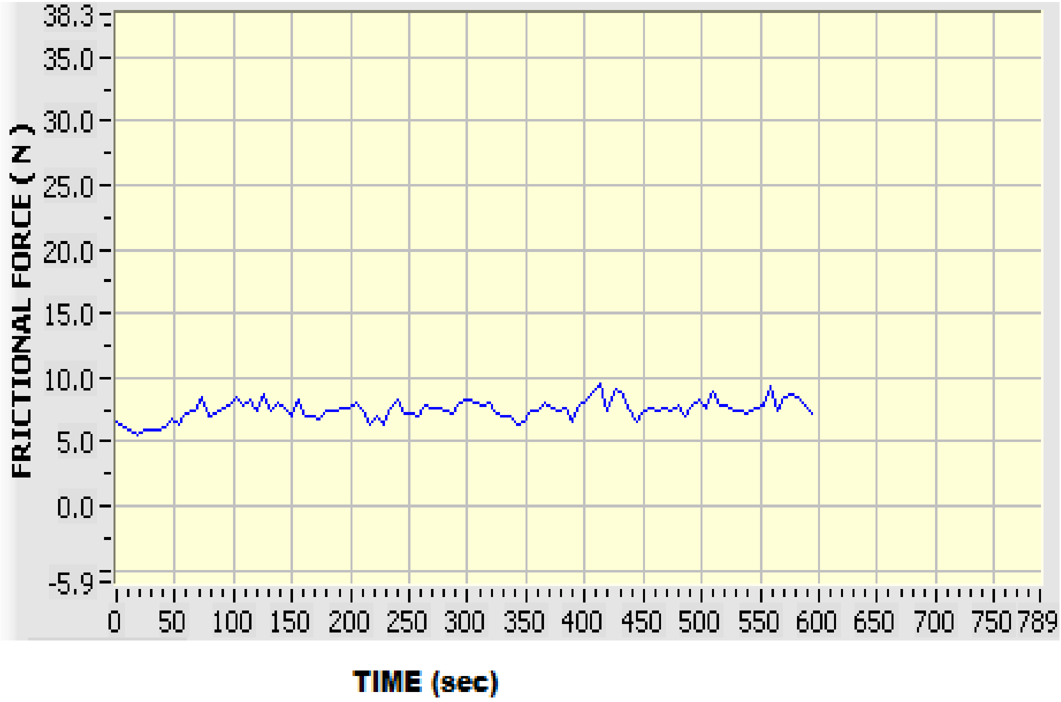

Figure 4 (b). Variation of Frictional force for Al+ (10%) SiC at 300 rpm and at 20 N.

In figures below, the wear behavior and variation of frictional force of Al+ (5%) Fly ash+ (5%) SiC is shown:

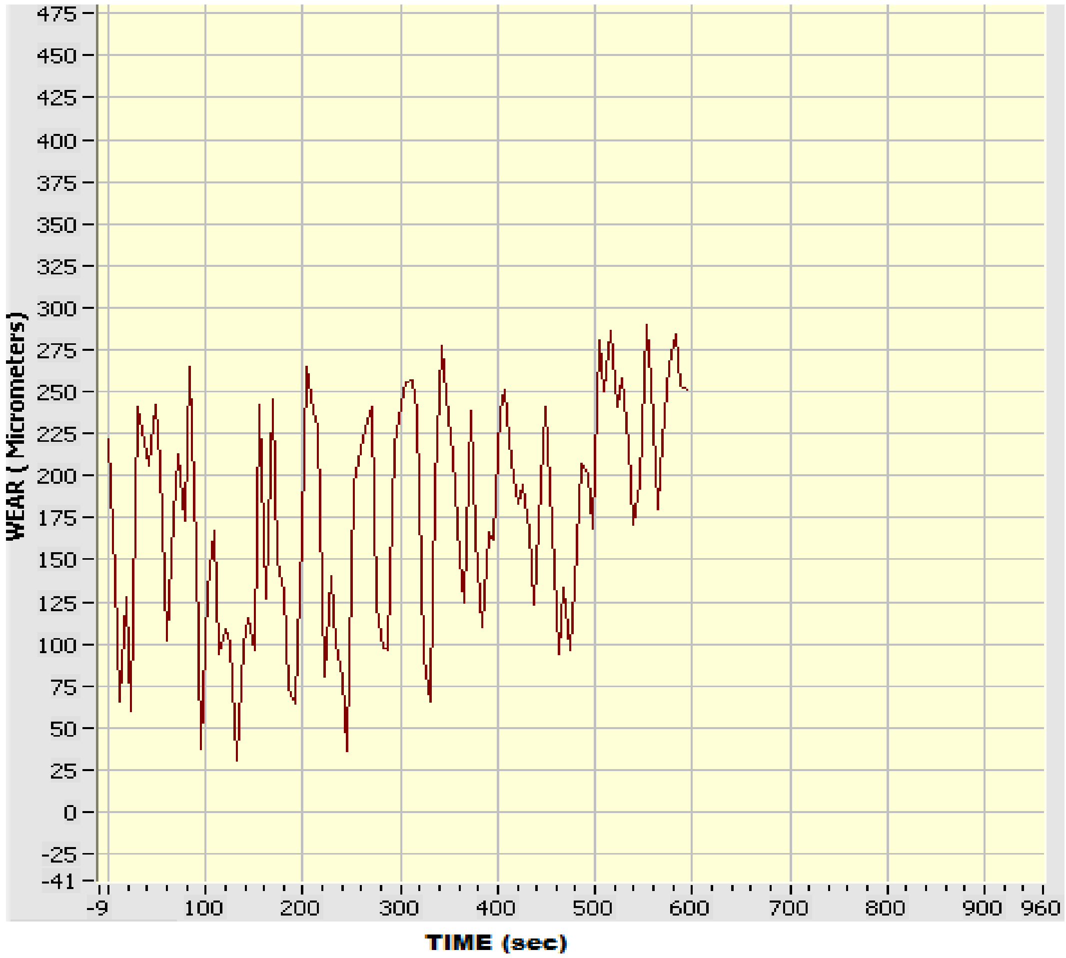

Figure 5(a). Wear behavior of for Al + (5%) Fly ash+ (5%) SiC composite at 300 rpm and at 20 N

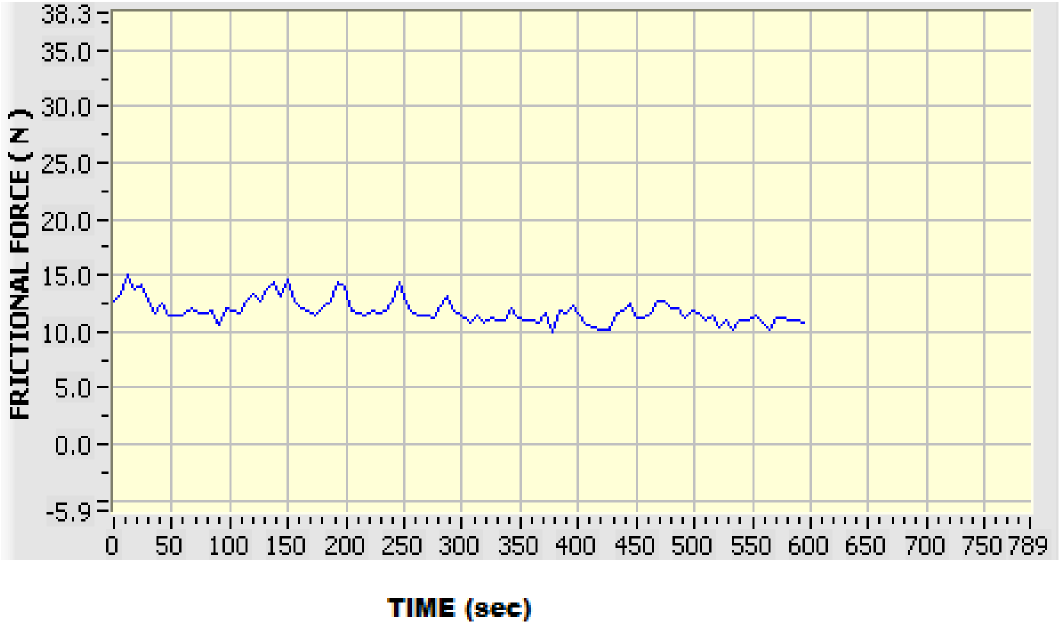

Figure 5 (b). Variation of Frictional force for Al + (5%) fly ash + (5%) SiC at 300 rpm and at 20 N.

In figures below, the wear behavior and variation of frictional force of Al+ (10%) Fly ash+ (10%) SiC is shown:

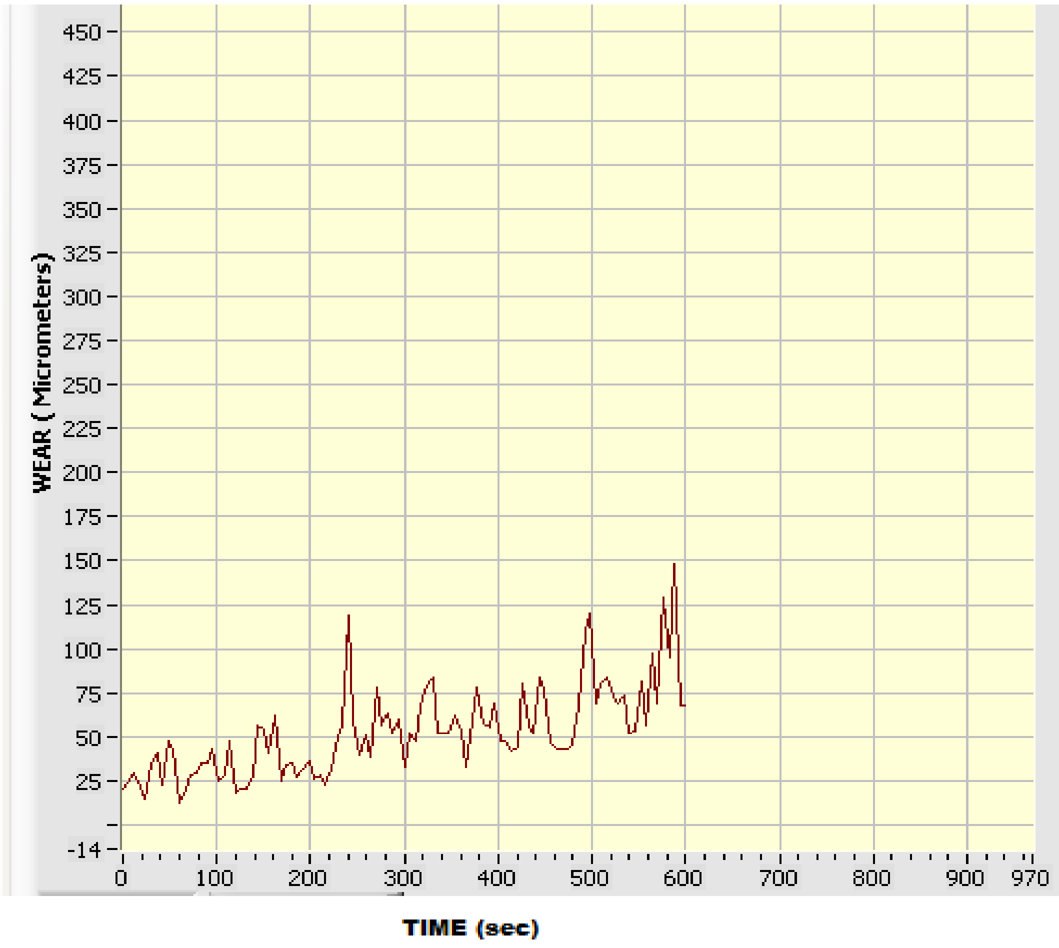

Figure 6(a). Wear behavior of for Al + (10%) Fly ash+ (10%) SiC composite at 300 rpm and at 20 N

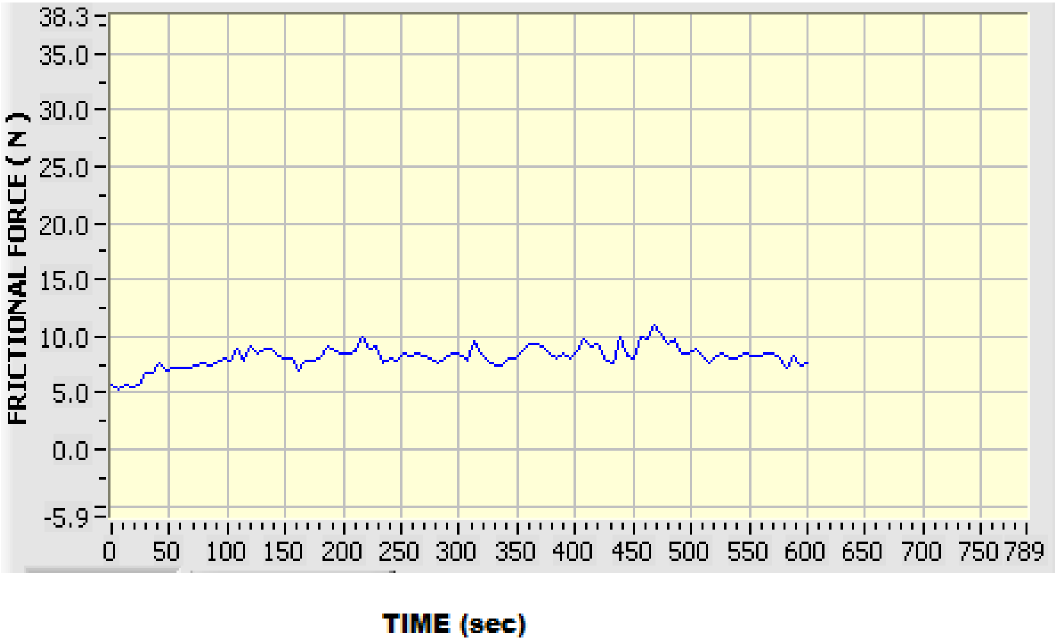

Figure 6 (b). Variation of Frictional force for Al + (10%) fly ash + (10%) SiC at 300 rpm and at 20 N.

The figures [1(a), 1(b), 2(a), 2(b)] shown above, clearly indicate that the wear rate had increased significantly and frictional force was decreased with the increase in the percentage of fly-ash at 300 rpm and 20 N load.

The figure [3(a), 3(b), 4(a), 4(b)] shown above, clearly indicate that the wear rate and frictional force had decreased with the increase in the percentage of SiC at 300 rpm and 20 N load.

The figure [5(a), 5(b), 6(a), 6(b)] shown above, clearly indicate that the wear rate and frictional force had decreased with the increase in the percentage of SiC and fly ash at 300 rpm and 20 N load.

It clearly shows that increase in percentage of reinforcement decreases the wear rate and variation of frictional forces. Al+fly ash+SiC composites had less wear rate as compared to single reinforced composites like Al+fly ash, Al+SiC.

3.2. Results of Weight Loss of Samples during Wear Testing

Table 1. Weight loss of Al+ Fly ash Composites

Sample Name	Initial Weight (gm)	Final Weight(gm)	Weight Loss(gm)
Al + 5% Fly ash	1.8501	1.8498	0.0003
Al + 10% Fly ash	1.4966	1.4955	0.0011

Table 2. Weight loss of Al+ SiC Composites

Sample Name	Initial Weight (gm)	Final Weight(gm)	Weight Loss(gm)
Al + 5% SiC	1.9625	1.9588	0.0037
Al + 10% SiC	2.2537	2.2403	0.0134

Table 3. Weight loss of Al+ SiC+ fly ash Composites

Sample Name	Initial Weight (gm)	Final Weight(gm)	Weight Loss(gm)
Al+5% SiC + 5% fly ash	2.9843	2.9792	0.0051
Al+10% SiC + 10% fly ash	2.9388	2.9366	0.0022

Tables 1, 2 and 3 clearly show that with the increase in wt% of reinforcement in Al+ fly ash and Al+ SiC composites, the weight loss was increased but in case of Al+SiC+fly ash composites there were decrease in the weight loss.

3.3. Results of Hardness Measurement

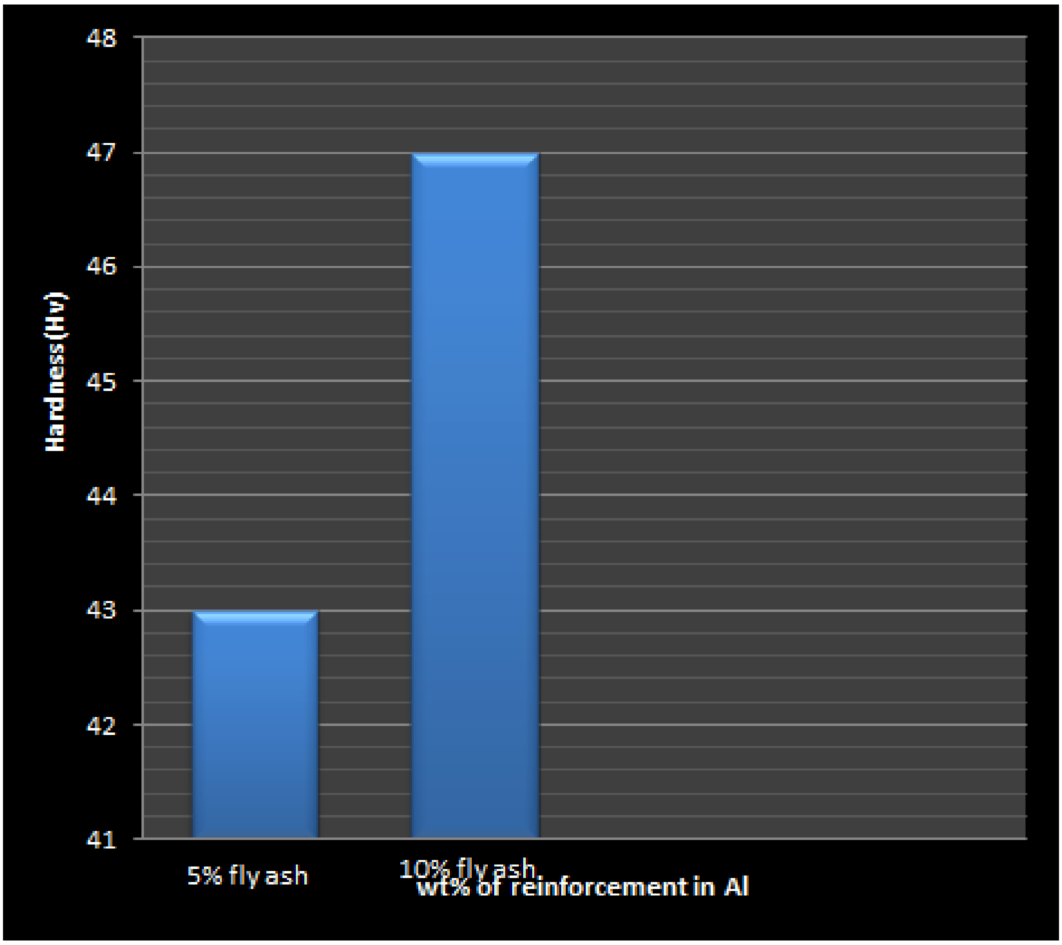

Figure 7. Hardness of Al+fly ash composites

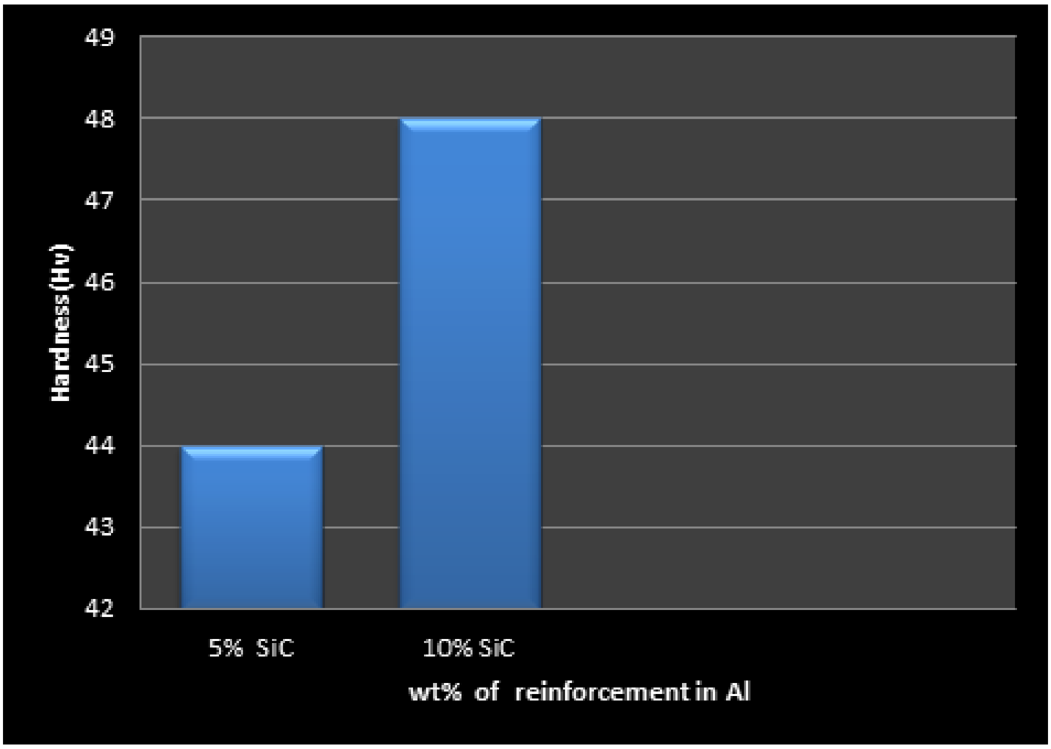

Figure 8. Hardness of Al+SiC composites

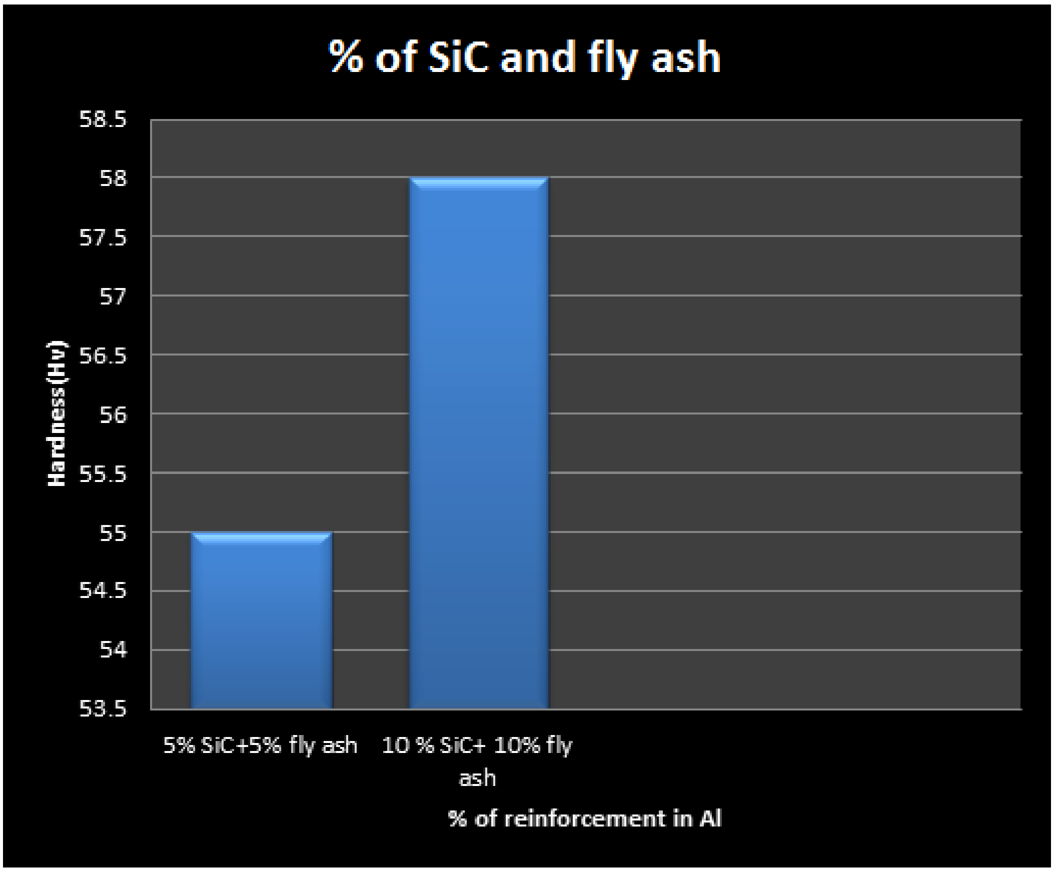

Figure 9. Hardness of Al+fly ash+SiC composites

Figures 7 and 9 clearly show that when fly ash content is increased the hardness is increased and figure 9 clearly shows that Al+SiC+fly ash composites have more hardness than Al+SiC and Al+fly ash composites.

Results of hardness clearly indicate that reinforcement has high effect on hardness and Al+SiC+fly ash composites are harder than Al+fly ash and Al+SiC composites.

3.4. Results of Tensile Strength Measurement

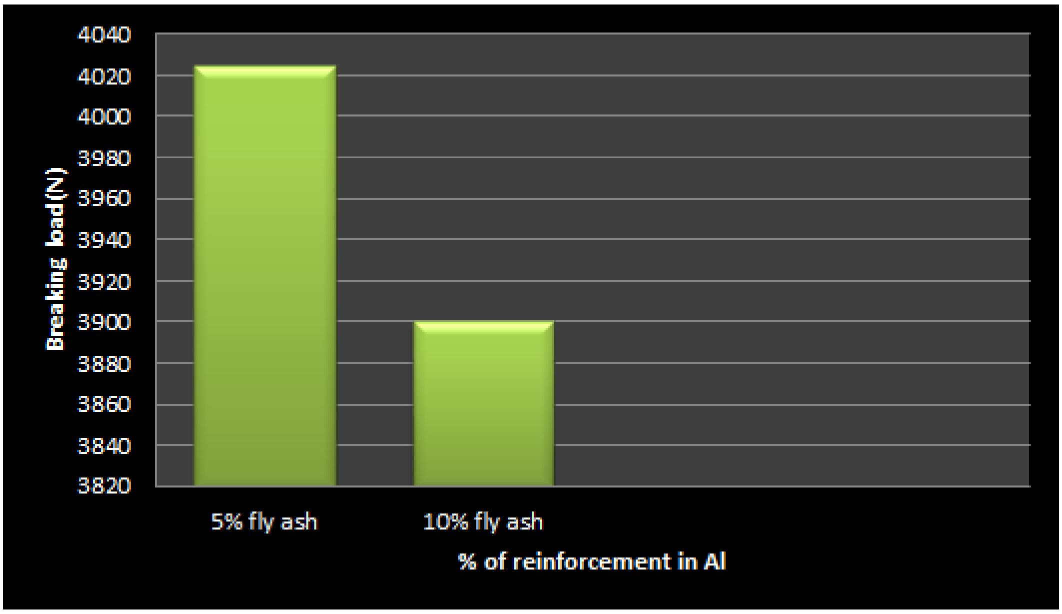

Figure 10. Breaking Load of Al+fly ash composites

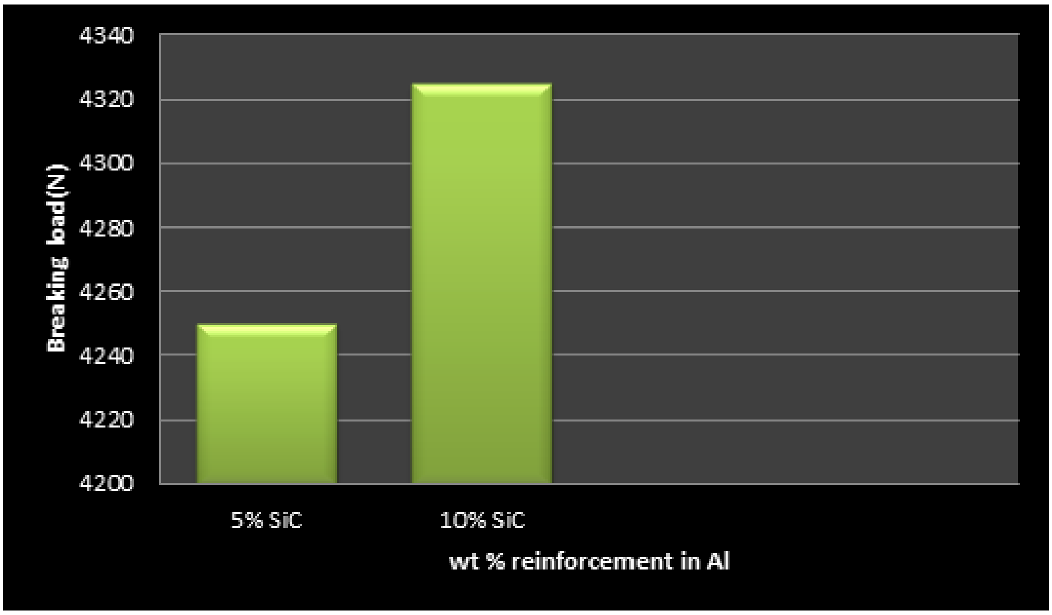

Figure 11. Breaking load of Al+SiC composites

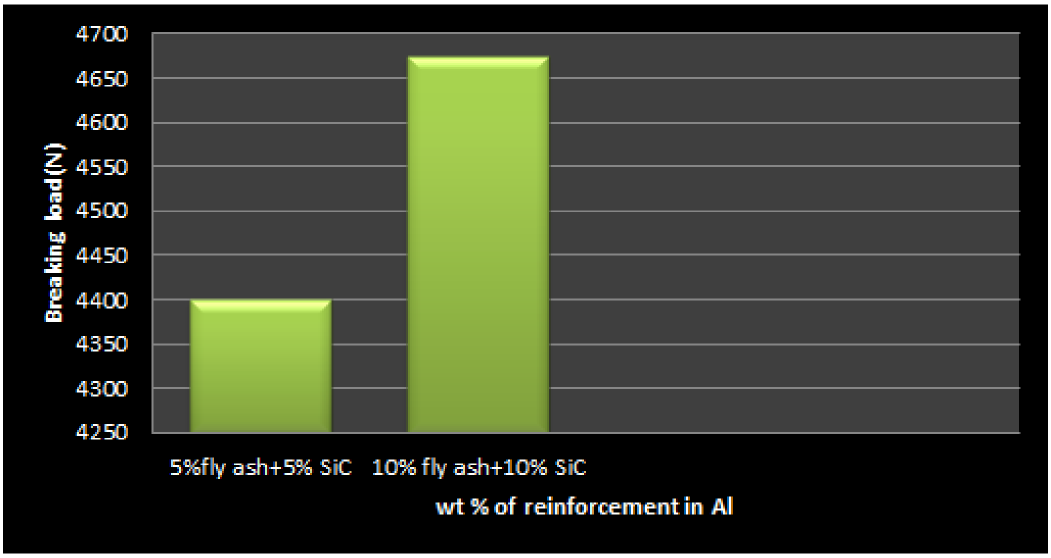

Figure 12. Breaking load of Al+ fly ash+SiC composites

Figures 10, 11 and 12 indicate that when wt% of fly ash is increased the breaking load is decreased that means its tensile strength is increased.

4. Conclusions

The conclusions drawn from the present investigation are as follows:

1. Fly ash was successfully used for the fabrication of composites.
2. Fly ash and Silicon carbide up to 10% by weight were successfully added to Al by stir casting route to produce composites.
3. There was reduction in the frictional forces with the addition of fly ash in Al melt but the wear rates increases little bit. But the increase in wt% of silicon carbide was able to decrease both frictional forces and wear rates.
4. The hardness of Al+fly ash, Al+SiC composites was increased with increase in wt% of fly ash and SiC But in case of Al+SiC+fly ash composites, the hardness was highly increased as compared to Al+fly ash and Al+SiC composites.
5. The Breaking load of Al+fly ash composites was found to be decreased with increase in wt% of fly ash. The breaking load of Al+SiC+fly ash composites was high as compared to Al+fly ash composites and Al+SiC composites.

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