INFLUENCE OF REINFORCEMENT PARTICLES ON DRY SLIDING WEAR BEHAVIOUR OF ALUMINIUM 7034 METAL MATRIX COMPOSITES

Roshan Zameer Ahamed
Department of Mechanical Engineering,
S.T.J. Institute of Technology, Ranebennur,
Karnataka, India.

Lohit B. H.
Department of Mechanical Engineering,
S.T.J. Institute of Technology, Ranebennur,
Karnataka, India.

Received Nov. 10, 2015 Accepted Nov. 29, 2015

ABSTRACT

Aluminium metal matrix composites are widely used in aerospace and automobile industries because of its lighter weight and great mechanical properties like low density, better corrosion resistance, low coefficient of thermal expansion and good wear resistance compared to the convectional metals and alloys. Better mechanical properties and low cost makes them very useful for many applications from technological point of view. Present study is focused on fabrication of composites using stir casting technique Aluminium 7034 is the matrix material reinforced with 3% fly ash constant and varying Al2o3 3%, 6%and 9% and 3% facing sand combined with 3% Silicon carbide. These samples were tested for tension, bending and hardness. And dry sliding wear test used to predict the wear loss of the samples by varying parameters like load 1,1.5 and 2 kg, speed 600,700 and 800 rpm and time 1,2 and 3 min respectively. Specimen having composition 3%flyash and 9%Al2o3 Showed good increase in tensile, bending, hardness and good wear resistant. Samples were examined by using scanning electron microscope after wear test and analysed.

Key words : Learning, innovation performance, process-phase.

1. INTRODUCTION

A Composite material is nothing but material consists of two or more constituents. Constituents are combined in macroscopic level and they are not soluble in each other. Generally composite material is composed of fibres, particles or flakes embedded in a matrix. And matrix holds the reinforcement to form a desired shape and reinforcement improves the overall mechanical properties of the composite. The composite material shows better properties then the individual material. Composite materials are classified usually on the basis of chemical and physical nature of the matrix phase, e.g., polymer matrix, metal matrix and ceramic matrix.

2. METHODOLOGY

2.1 Aluminium based metal matrix composite preparation by stir casting technique

The stir casting set up is shown in fig, consists of a muffle furnace and stirrer assembly was used to prepare the composite. Stirrer assemble consists of a graphite stirrer which is connected to a variable speed vertical drilling machine with a range of 80-890 rpm by means of steel shaft. Stirrer is made by cutting and shaping of graphite block manually to the needed shape. It consists of three blades 120degree apart. Approximately 1kg of aluminium alloy in solid form is melted at 820 degree in the furnace. Preheating of reinforcement is done to remove the moisture from the surface of the particulates.

Fig 1 Stir casting set up

The stirrer was then lowered vertically into the crucible and the speed of the stirrer raised to 800rpm and the reinforcement particles were added to the molten alloy at a rate of 10 to 20g/min. After the addition stirring continued to 8-120min for the proper mixing and then the molten metal is poured into the mould.

2.2 Materials used

2.2.1 Matrix alloy

Aluminium alloy 7034 was used as matrix material in the synthesis of composite. Aluminium alloy was taken from the Rsp technology Bangalore in the form of hexagonal bars and these were cut into smaller pieces with the help of power hacksaw in order to place the alloy inside the crucible properly.

The chemical composition of matrix alloy is given in the table

Table 2 Chemical composition of Al 7034 alloy

Element	Si	Fe	Mn	Mg	Cu	Zn	Zr	Cr	Al
Wt%	0.10	0.12	0.25	2-3	0.80-1.2	11-12	0.08-0.30	0.20	82.6-86.1

2.2.2 Reinforcement materials

1) Fly ash
2) Al2O3
3) Sic
4) Facing sand

Table 3 Particle size range of reinforcements

Reinforcement	**Particle size range(μm)**
Fly ash	10
Aluminium oxide(Al2O3)	400-500
Silicon carbide(Sic)	10
Facing sand	10

2.3 TESTING OF COMPOSITES

2.3.1 Tensile and bending test

Tensile test is also known as tension test it is a fundamental materials test in which sample is subjected to uniaxial tension up to failure. Properties which are directly measured through tensile test are ultimate tensile strength, reduction in area and maximum elongation. The results got from the tests are used to select the material for various applications, quality control and to predict the reaction of material under other forces.

The standard use to produce tensile test specimen in this work is ASTM E8.

Bending test**,** three point bending test is employed to evaluate the bending behaviour of the specimens. Property which is directly measured from this test is bending strength of the specimen. It is also an fundamental materials test.

The standard used to produce bending test specimen is ASTM E290.

Fig 3 Tensile and bending test specimens after testing

2.3.2 Hardness test (Brinell hardness test)

Hardness is the measure how solid resistant matter changes the permanent shape when the load is applied. Hardness is the one characterised by the strong intermolecular bonds. There are three types of hardness tests they are Brinell hardness test, Rockwell hardness test and Vickers hardness test. The standard use to produce hardness specimens is ASTM E10**.**

Fig 5 Hardness test specimens after testing

2.3.4 Dry sliding wear test

A pin on disc test apparatus is used to examine the dry sliding wear features of Aluminium metal matrix composites as per standard ASTM G99-95.Wear specimen 10m dia and 30m length were cut ,machined and then polished. Wear tests were conducted with varying load 1kg, 1.5kg and 2kg by keeping speed and time constant. And speed varied from 600,700and 800 rpm by keeping load and time constant. Time is varied from 2,3and 4min by keeping load and speed constant. Tests were conducted at room temperature. Initial weight of specimens were noted using electronic weighing machine with an accuracy 0.0001g.During the test pin was pressed against the rotating steel disc by applying the load. All the specimens were rotated at the track dia of 115mm with a tangential force. Friction detecting arm is connected to the strain gauge held and loaded the specimen vertically in to the rotating steel disc. After running for a fixed distance the specimens were removed, cleaned with acetone and then weighed to determine the weight loss occurred due to wear. Difference in the weight measured before and after testing gives the wear of the specimen. Wear of the composite specimens studied as a function of sliding distance, sliding velocity, applied load and volume percentage of reinforcements.

Fig 7 Wear test specimens after testing

2.3.5 Scanning electron microscope (SEM)

It is a type of electron microscope which images the surface of the sample by scanning with high energy beam of electrons. These electrons interact with atoms that make up in the sample and it produces the signals which contain information about sample surface topology. The composition and the other properties be electrically conductive in nature at least at the surface and must be electrically grounded to prevent accumulation of electrostatic charges at the surface. The micro structural studies were conducted on reinforced samples. This is done through scanning electron microscope. The samples were polished before the examination. The characterisations are done in etching conditions. Etching was done using Kepler reagent.SEM micrographs of samples were obtained by scanning electron microscope. The images were taken at the magnifications 500x, 1000x, 2000x, 3000x, 4000x and 5000x respectively.

3. RESULTS AND DISCUSSIONS

3.1 Tensile test results

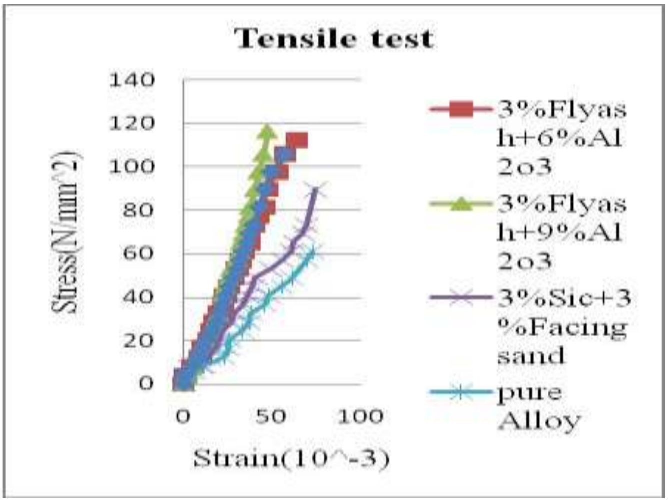

Fig 8 Comparison of Tensile strength of different composition

The above Fig 4.6 shows stress v/s strain relation for pure alloy and composites tested in this work. From these curves it can be seen that Al7034+3%Flyash+9%Al2O3 it has more tensile strength compared to pure alloy and other composites Al7034+3%Sic+3Facing sand,Al7034+3%Fly ash+3%Al2O3 and Al7034+3%Fly ash+6%Al2O3 tested in this work.

3.2 Hardness test (BHN)

Table 4 Hardness test results of different compositions

Sl. no	Composition	BHN
1	Pure alloy	84.86
2	3%Sic+3%Facingsand	113.643
3	3%Flyash+3%Al2O3	129.227
4	3%Flyash+6%Al2O3	159.154
5	3%Flyash+9%Al2O3	171.412

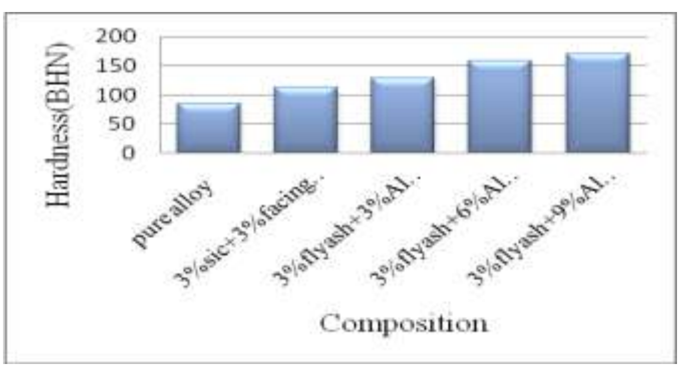

Fig 9 Hardness v/s composition

The above Fig 4.7 shows hardness v/s composition relation for pure alloy and composites tested in this work. From these graph it can be seen that Al7034+3%Flyash+9%Al2O3 it has more hardness compared to pure alloy and other composites Al7034+3%Sic+3Facing sand,Al7034+3%Fly ash+3%Al2O3 and Al7034+3%Fly ash+6%Al2O3 tested in this work.

3.3 Bending test results

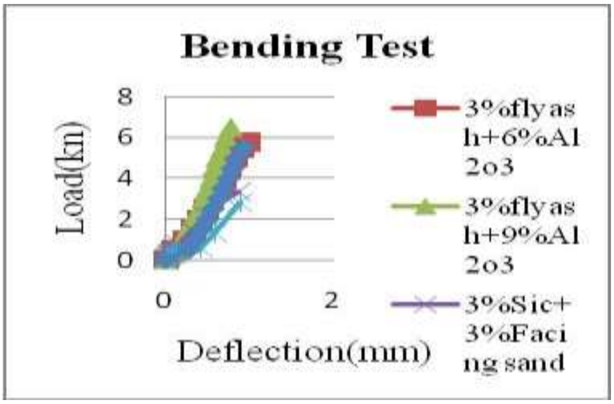

Fig 10 Comparison of bending strength of different composition

The above Fig 4.13 shows load v/s deflection relation for pure alloy and composites tested in this work. From these curves it can be seen that Al7034+3%Flyash+9%Al2O3 it has more bending strength compared to pure alloy and other composites Al7034+3%Sic+3Facing sand,Al7034+3%Fly ash+3%Al2O3 and Al7034+3%Fly ash+6%Al2O3 tested in this work.

3.4 Dry sliding wear test results

3.4.1 Varying load

Table 5 Wear test results by varying load

Sl.no	Load (N)	Pure alloy	Al alloy+3%Fly ash +3%Al2O3	Al Alloy+3%Fly ash+6%Al2O3	Al Alloy+3%Fly ash+9%Al2O3	Al Alloy+3%Sic+3 % Facing sand
		Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)
1	9.81	0.017	0.013	0.007	0.005	0.012
2	14.71	0.021	0.018	0.009	0.007	0.016
3	19.62	0.032	0.02	0.025	0.009	0.029

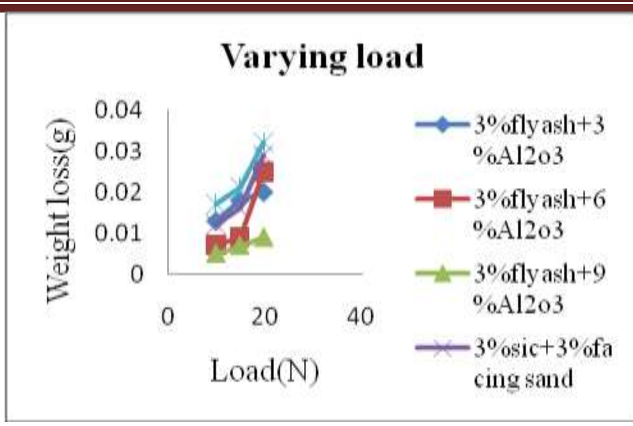

Fig 11 Comparison of Load v/s weight loss curves for varying load

The above curves shows the relation between load v/s weight loss .It is seen that the most dominating factor controlling wear behaviour is applied load .At varying load, constant speed and time wear of aluminium composites increases with increase in load. Wear rate of composite specimens decreased with increase in weight percentage .From the above graph it is seen that Al7034+3%flyash+9%Al2o3 shows less wear rate compared to other composition composites. Wear rates were less at low temperature and gradually increased with the increase in load .The critical wear manifested mainly due to the large surface damage and large amount of aluminium transfer to the face accompanied through the generation of debris particles is mainly in the shape of plates with shiny appearance.

3.4.2 Varying speed

Table 6 Wear test results by varying Speed

Sl.no	Speed (RPM)	Pure alloy	Al alloy +3%Fly ash +3%Al2O3	Al Alloy+3%Fy ash+6%Al2O3	Al Alloy+3%Fy ash+9%Al2O3	Al Alloy+3%Sic+3% Facing sand
		Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)
1	600	0.015	0.008	0.006	0.002	0.012
2	700	0.017	0.013	0.007	0.0035	0.016
3	800	0.025	0.017	0.0092	0.0041	0.021

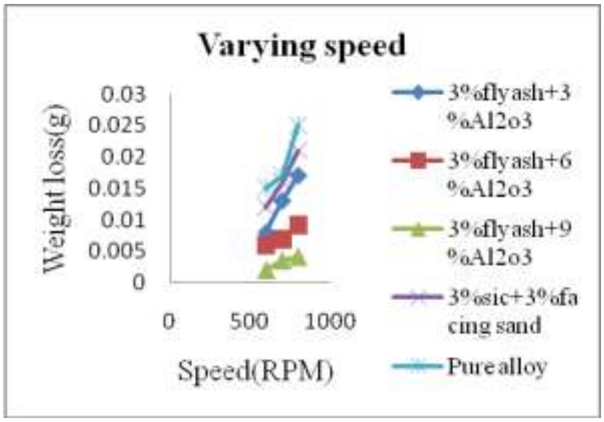

Fig 12 Comparison of Load v/s weight loss curves for varying speed

The above curve shows the relation between varying speed v/s weight loss .It is seen that Al7034+3%Flyash+9%Al2o3 shows less weight loss compared to other compositions. As the speed increases the reinforcement particles undergo less fracture and it helps in retaining amount of reinforcement particles. These accumulated reinforcement particles influences the wear resistance with the increase in speed .Reinforcement particles are squeezed onto the surface by subsurface deformation and subsequent transferring results in formation of the lubricating film.

3.4.3 Varying time

Table 7 Wear test results by varying Time

Sl. no	Time (Min)	Pure alloy	Al alloy +3%Fly ash +3%Al2O3	Al Alloy+3%Fly ash+6%Al2O3	Al Alloy+3%Fly ash+9%Al2O3	Al Alloy+3%Sic+3% Facing sand
		Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)	Weight loss (g)
1	2	0.009	0.007	0.0031	0.0027	0.006
2	3	0.016	0.009	0.0055	0.0029	0.011
3	4	0.028	0.011	0.0056	0.0032	0.025

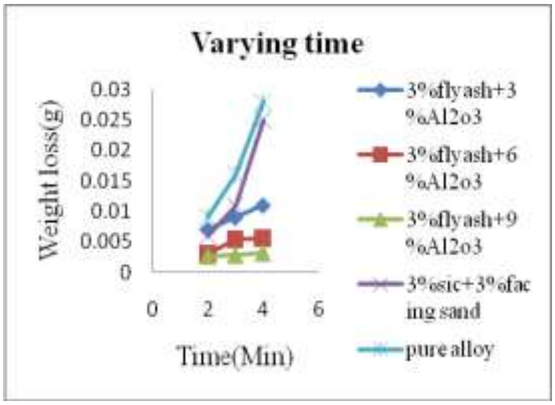

Fig 13 Comparison of Load v/s weight loss curves for varying time

The above curves shows the relation between varying time and weight loss from the graph it is seen that the wear rate of unreinforced pure alloy is more compared to reinforced composites.Al7034+3%flyash+9%Al2o3 shows less wear rate compared to other compositions. Wear rate of composites and pure alloy specimens increased with increase in sliding time.

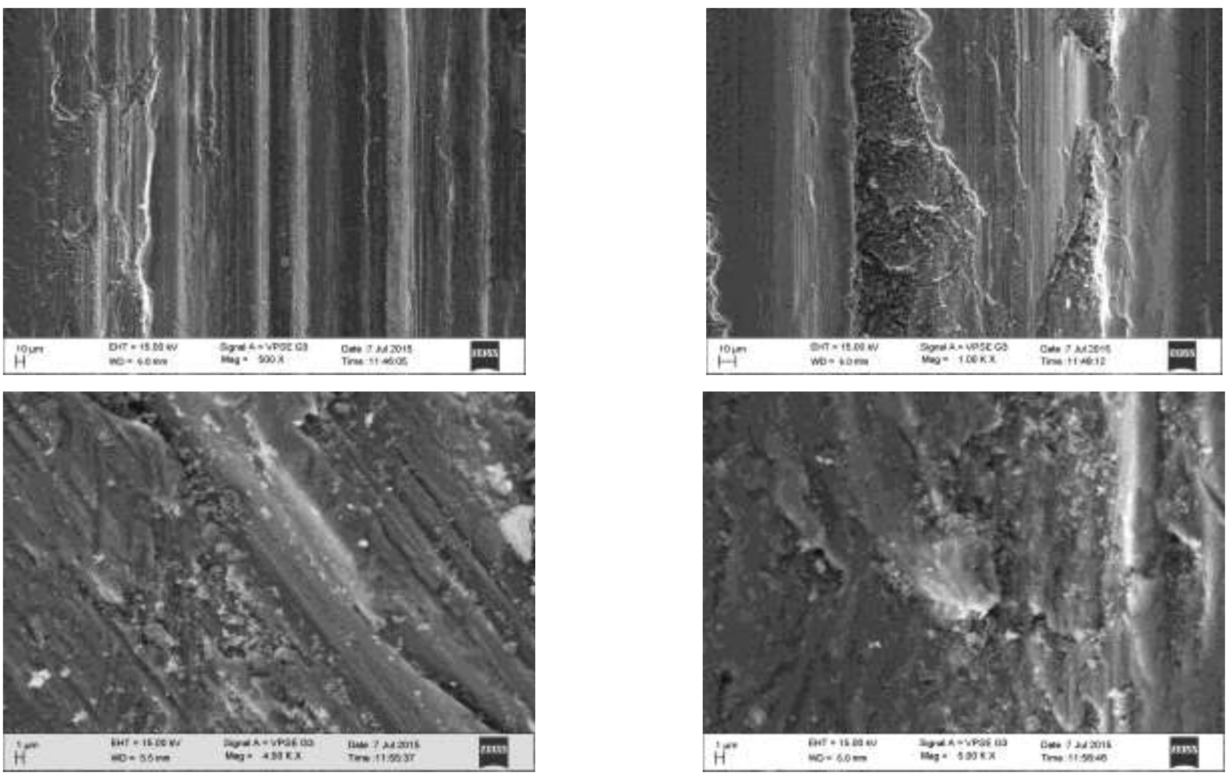

Fig 14 SEM micrographs of the worn surfaces of Al7034+3%fly ash+9%Al2o3 at varying load

The above SEM micrographs shown in Fig 4.1 are worn surfaces of composite Al7034 with 3% fly ash and 9%Al2o3.The above images are subjected to varying load 1,1.5 and 2kg at a constant speed and time. Material removals with some scratches were observed at low load and the grooves along sliding direction were found to be shallow, it indicates the minimum wear rate. And as the load increases from 1kg to 1.5 and 2kg more number of grooves with delaminating was observed .This indicates the transition from normal wear to sever wear resulting in more material removal rate .This is because of the plastic deformation between the disc and the specimen at high load. This implies the drastic increase of wear at high load 1.5 to 2kg.

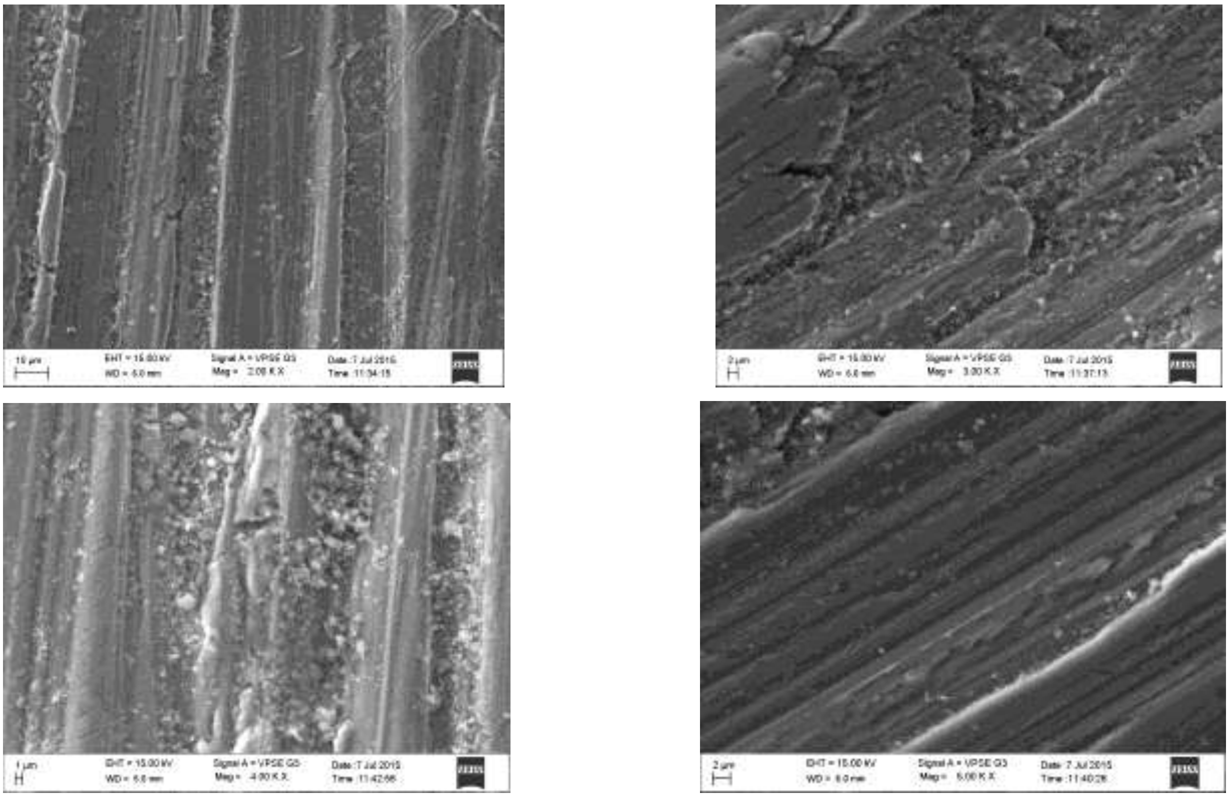

Fig 15 SEM micrographs of the worn surfaces of Al7034+3%fly ash+9%Al2o3 at varying speed

The above SEM micrographs shown in Fig 4.2 are worn surfaces of composite Al7034 with 3% fly ash and 9%Al2o3.The above images are subjected to varying speed600, 700 and 800rpm at a constant load and time. As the sliding speed increased from 600 to 800 rpm formation of MML (Mechanically mixed layer) took place and enhancement in the tribological properties were seen. At the high speeds the temperature at the over surface increases resulting in the oxidization of material and due to this material transfer occurs between the pin and disc leads to the formation of mml.Good tribological at high velocities are achieved due to this MML.

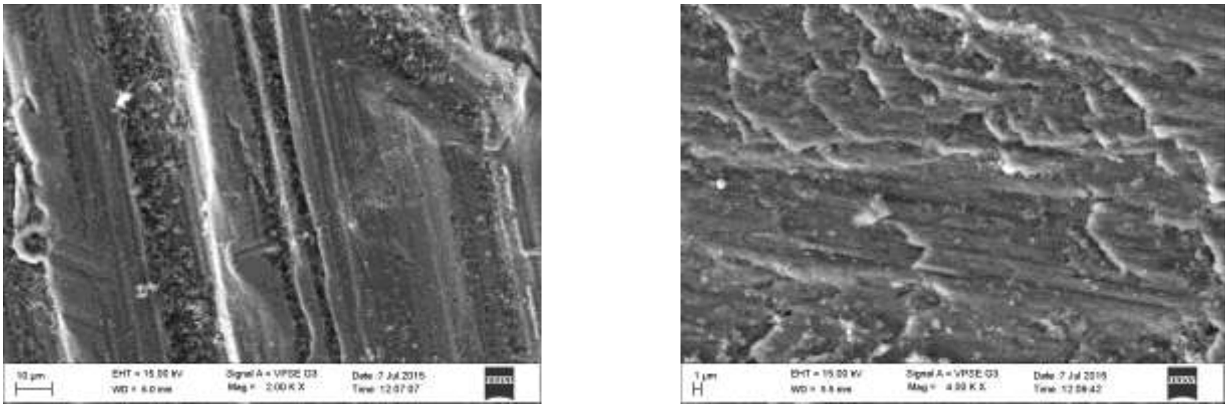

Fig 16 SEM micrographs of the worn surfaces of Al7034+3%fly ash+9%Al2o3 at varying time

The above SEM micrographs shown in Fig 4.3 are worn surfaces of composite Al7034 with 3% fly ash and 9%Al2o3.The above images are subjected to varying time 2,3 and 4 min at a constant load and speed. From the above figure it is seen that surfaces are not smooth. Due to the reinforcing particles grooves were formed .on the surface fractured appearance are observed. And the subsequent cracks which may be exist earlier get nucleated due to stresses and propagate due to wear.Delamination occurs due to the joining of subsurface cracks joining the wear surface.

4. CONCLUSIONS

1. The tensile strength has improved with the increase in fly ash and Al2o3 content. And the ductility has decreased with increase in fly ash and Al2o3 content.
2. The bending strength is also improved with the increase in Fly ash and Al2o3 content.
3. Hardness of pure aluminium alloy is also improved from 84BHN to 171BHN by the addition Fly ash and Al2o3.
4. Wear resistance of composites is greater than the pure aluminium 7034 alloy.
5. Degree of improvement of the wear resistance of metal matrix composites is mainly dependent on the kind of reinforcement, reinforcement size and volume fraction.
6. Increase in load, speed and time increases the magnitude of wear.
7. From this study it can be concluded that we can use fly ash for the preparation of composites and can be turned industrial waste into industrial wealth.
8. Composition Al7034+3%Fly ash+9%Al2o3 shows more increase in tensile strength, bending strength, hardness and Wear resistance.
9. SEM of Al7034 composites produced by stir casting technique shows the uniform distribution of reinforcement.
10. SEM of the worn surfaces of Al7034 composites shows the worn surfaces of composites Al7034+3%Fly ash+3%Al2O3,Al7034+3%Fly ash+6%Al2O3,Al7034+3%Fly

ash+9%Al2O3 and Al7034+3%Sic+3%Facing sand is much rougher then the unreinforced alloy.

Reference

1. K.Umanath, S.T.Selvamani, K.PalaniKumar, R.Sabarikreeshwaran"Dry Sliding Wear Behaviour of AA6061-T6 Reinforced Sic and Al2o3 Particulate Hybrid Composites" Procedia Engineering 97(2014)694-702.
2. Suresh R,M Prasanna Kumar "Investigation of Tribological Behaviour and its relation with Processing and Microstructures of Al6061 Metal Matrix Composites" IJRET ,Vol.1,Issue 2,July 2013,91-104.
3. S.Basavarajappa, G.Chandramohan, R.Subramanian, A.Chandrasekar"Dry sliding wear behaviour of Al2219/Sic metal matrix composites "Material Science-Poland,Vol.24,No.2/1,2006.
4. Raghavendra N, V S Ramamurthy "Effect of Particle Size and Weight Fraction of Alumina Reinforcement on Wear Behaviour of Aluminium Metal Matrix Composites"ISSN: 2319-8753, Vol.3, Issue 4, April 2014.
5. Deepak Singla, S.R.Mediratta"Evaluation of Mechanical Properties of Al7075-Fly Ash Composite Material"ISSN: 2319-8753, Vol 2, Issue 4,April 2013.
6. Vivekananthan M,Senthamarai K, "Experimental Evaluation of Aluminium-Fly Ash Composite Material to Increase the mechanical and Wear Behaviour by Stir Casting Method "CARE journal of Applied research Issn 2321-4090.
7. Viney Kumar,Rahul Dev Gupta,N K, Batra"Comparision of Mechanical Properties of sliding velocity on wear properties of Al 6061,Mg 4%,Fly ash and Al6061,Mg 4%Graphite,Fly as Hybrid Metal matrix composites"Procedia material science 6(2014)1365-1375.
8. M Kok"Production and mechanical properties of Al2o3 particle –reinforced 2024 aluminium alloy composites "Material Processing Technology 161(2005)381-387.
9. Anil Kumar H.C,H.Suresh Hebbar "Effect of Particle Size of Fly ash Mechanical and Tribological Properties of Aluminium alloy(Al6061)Composites and Their Correlations"IJMSE Volume 3, Issue 1 February 2013 PP.6-13.

Great thoughts speak only to the thoughtful mind, but great actions speak to all mankind.

~ Theodore Roosevelt