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STUDY OF DRY SLIDING WEAR OF ALUMINUM FLYASH METAL MATRIX COMPOSITE

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Abstract In the present investigation Al – 4.5%Cu metal matrix composite was produced by adding the Fly ash using metal mold and squeeze cast. The results shows that there is an increase in hardness and wear resistance with increase in the Fly ash content for both metal mold and squeeze cast specimens. The microstructure analysis has been done using Scanning Electron Microscope to know the distribution of Fly ash in the Aluminum matrix.

Keywords: Aluminum Fly ash composite, Hardness, Wear

INTRODUCTION

Applications of composite materials are among the most important development in material engineering in recent years. Metal matrix composites (MMCs) have emerged as an important class of materials and are increasingly utilized in various engineering applications such as aerospace, marine, automobile etc. which require materials offering a combination of light weight with considerably accelerated mechanical and physical properties such as strength, stiffness and wear resistance etc. In the present investigation Al – 4.5% Cu alloy was taken as the matrix and Fly ash as filler material. This alloy can be heat treated to realize enhanced properties. The wear resistance of Al – 4.5% Cu alloy is strongly dependent on the alloy composition and applied load. The wear resistance of these alloys can be enhanced by the incorporation of filler material i.e., Fly ash in the soft Aluminum alloy matrix.

LITERATURE SURVEY

Aluminum alloys are the most commonly used materials in composite fabrication. The reinforcement phase is generally fibers or particulate. The volume fraction of reinforced particles is generally within the range of 10 to 30% by weight. Wear can be generally described as the removal of material from a surface in relative motion by mechanical and or by chemical process. D.J.Kim[5] has given the experimental data of dry wear for different disc on pin on disc machine. It is observed that wear varies according to different discs. Lim S.C.[6] gives dry wear for specimens made by rheo casting process. The wear rate has increased with increasing applied load. Zhu H.G.[10] reports dry wear behavior of MMC prepared by different techniques. It is reported that more uniform distribution of particles in matrix gives more strength. Pandey[8] gives microstructure and wear characteristics of Al-4.5%Cu 5%Pb alloy for castings prepared by sand and chill castings. The morphological features of wear track on specimens and debris indicated a mixed oxidation cum adhesive wear mechanism. Charles M[3] gives details regarding advantage of MMCs over conventional alloys. It is reported that MMCs can be designed to give improved strength, stiffness and wear resistance.

Lim S.C.[7] gives comparison of wear resistance unreinforced and graphite reinforced Al composites for casting made by an innovative partial liquid phase casting technique. The reinforced MMCs has a higher resistance to wear. Yellup J.M.[2] gives the comparison of various Al based MMCs regarding their wear behavior and other mechanical properties. It is shown that wear rate of MMCs in general depends on various factors. Asthana R.[1] gives the physical and mechanical properties of MMCs synthesized using various casting techniques. It is shown that both the structure and properties of cast composites are extremely sensitive to a myriad of process related variables. Rohatgi P.K.[9] describes the production of Al alloy (A356.2) Fly ash composite by stir mixing method. It is reported that the composite with Fly ash shows increase in hardness. Guo

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R.Q.[4] gives the chemical reaction of Fly ash with metal. This has been studied by metallographic examinations.

MATERIAL AND EXPERIMENTAL DETAILS

Materials

The Aluminum alloy matrix used in this work is Al – 4.5% Cu alloy. The melt stirring technique was used to fabricate the composite. The Aluminum alloy was initially placed inside a graphite crucible and heated to 750^0c to 800^0c in a pit furnace. The molten metal was stirred with a stirrer operated at 300 to 400 rpm. At this stage Fly ash was added to the stirred metal. After removing the slag the composite melt was poured in to the metallic mould of 50mm diameter and 200mm length. Castings were also prepared using squeeze technique under a pressure of $10Kgf/cm^2$. The Fly ash was added in 10, 15 and 20% by weight.

Hardness

The hardness of the castings were found using Brinell Hardness tester. The hardness values (BHN) are shown in the Table 1.

Table –1

	0% Fly ash	10% Fly ash	15% Fly ash	20% Fly ash
Metal Mould	52	58	62	64
Squeeze cast	56	61	64	67

Wear test

Specimen of diameter 5mm and length 20mm were machined from castings and used for wear test. Dry sliding test was carried out on pin on disc wear testing machine under ambient temperature conditions. The wear tests on all specimens were carried out at a normal load of 200grams and 500grams at a constant sliding speed of 950 rpm. The wear of the specimen was measured directly on the LVDT (Linear variable differential transformer) attached to the machine.

Heat Treatment

Both unreinforced and reinforced specimens made from both metal mold and squeeze cast was subjected to heat treatment. The specimens were heated up to 550^0c for 12 hours and then quenched in water, again reheated to 250^0c for 16 hours to get uniform distribution of $CuAl_2$ phase.

METALLOGRAPHIC OBSERVATIONS

The microstructure of the unreinforced and MMCs specimens was observed under scanning electron microscope (SEM) at different magnifications. This was done mainly to know the distribution of Fly ash in the Metal Matrix.

RESULTS AND DISCUSSIONS

Hardness of MMCs

Fig 1. Shows the dependence of hardness of MMCs with Fly ash content for metal mould and Fig 2. For Squeeze cast specimens. The hardness values are increasing with an increase in Fly ash content for both conditions. This seems to indicate that the addition of Fly ash increases the hardness of the matrix.

Wear behavior of MMCs

Fig 3. To Fig 6. Shows the wear of specimens made in metal mold before heat treatment with 0% to 20% Fly ash content. It is observed that with increase in normal load from 200 grams to 500 grams at a constant speed of 950 rpm the wear has increased in all the cases. But with the addition of Fly ash the wear has reduced with increase in Fly ash content. Fig 7. to Fig 10. Shows the wear of specimens made by metal mold after heat treatment with 0% to 20% Fly ash content. It is again observed that with increase in normal load from 200 grams to 500 grams at constant speed of 950 rpm the wear has increased in all the cases. But with the addition of Fly ash the wear has reduced with increase in Fly ash content. By comparing the values of as cast condition with heat-treated condition the wear has decreased marginally after heat treatment. This may be due to precipitation of $CuAl_2$ phase around the grain boundary giving an additional strength to the matrix in addition to Fly ash.

Fig 11. To Fig 14. Shows the wear of specimens made by squeeze cast before heat treatment with 0% to 20% Fly ash content. It is observed that with increase in normal load from 200 grams to 500 grams at constant speed of 950 rpm the wear has increased in all the cases. But with the addition of Fly ash, the wear has reduced with increase in Fly ash content. Fig 15. To Fig 18. shows the wear of specimens made by squeeze cast after heat treatment with 0% to 20% Fly ash content. It is again observed that with increase in normal load from 200 grams to 500 grams at constant speed of 950 rpm the wear has increased in all the cases. But with the addition of Fly ash the wear has reduced with increase in Fly ash content. By comparing the specimens made by metal mold and squeeze cast, it is observed that wear is less for specimens made by squeeze cast. This may be due to good compaction of the casting during squeezing.

Fig 19 and Fig 20 indicates the SEM micrographs of the unreinforced Al – 4.5% Cu alloy at 400X and 1000X magnification respectively. The grain boundary can be seen very clearly in these figures. Fig 21 and Fig 22 indicates the SEM micrographs of reinforced Al – 4.5% Cu alloy with 10% Fly ash at 500X and 2000X magnifications respectively. In both the figures the distribution of Fly ash can be seen very clearly. It is observed that due to presence of these Fly ash particles the matrix has been strengthened. Fig 23 and Fig 24 indicates the SEM micrographs of the reinforced Al –

4.5% Cu alloy with 15% Fly ash at 500X and 2000X magnification respectively. It can be observed very clearly that the % of Fly ash is more here. Due to this the strength of composite is also more as more uniform distribution of the Fly ash is visible.

BEFORE HEAT TREATMENT

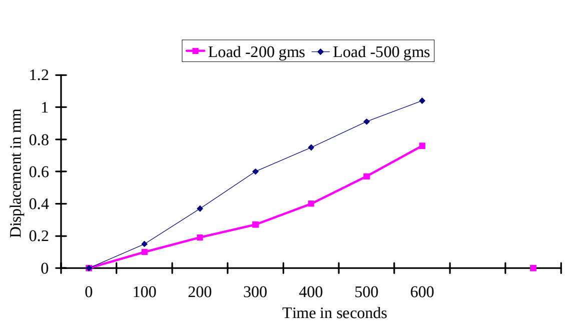

Fig. 3 wear metal mold before heat treatment

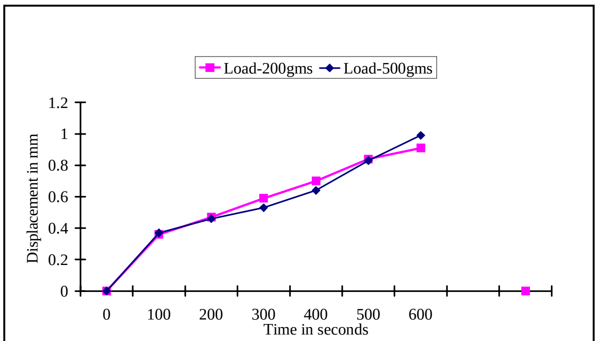

Fig 4 Wear metal mold 10% Flyash before heat treatment

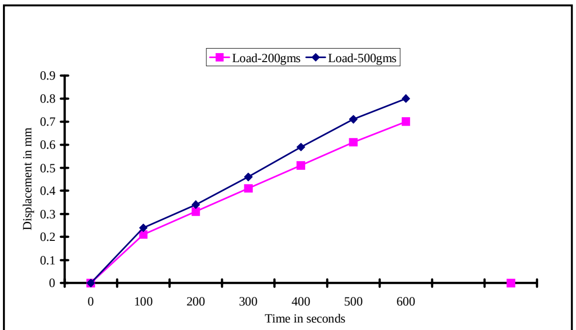

Fig 5 Wear 15% Flyash metal mold before heat treatment

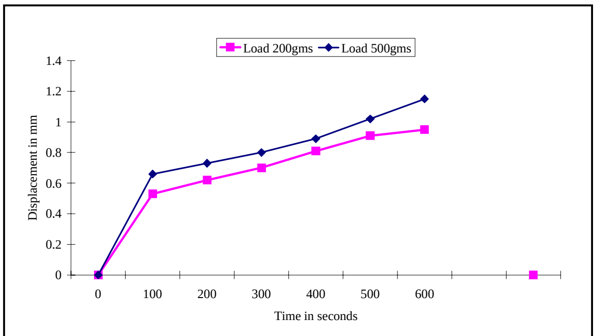

Fig 6 Wear 20% Fly ash metal mold before heat treatment

AFTER HEAT TREATMENT

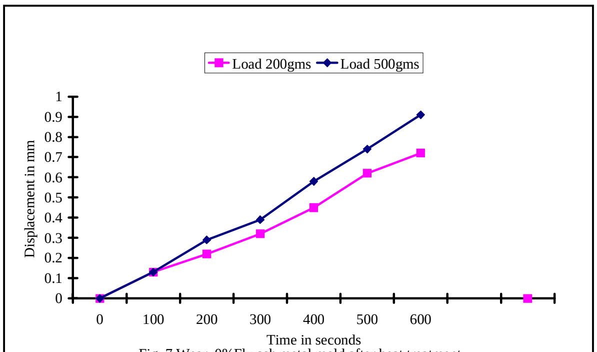

Fig. 7 Wear 0%Fly ash metal mold after heat treatment

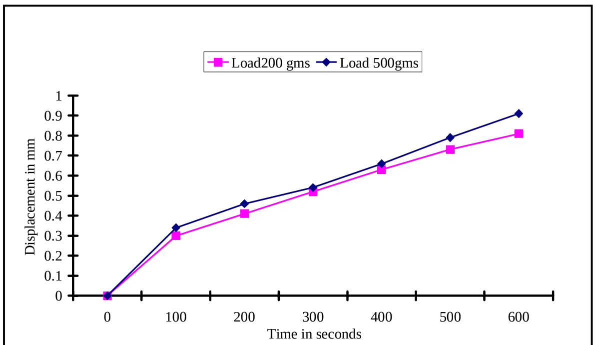

Fig 8. Wear 10%Fly ash metal mold After heat treatment

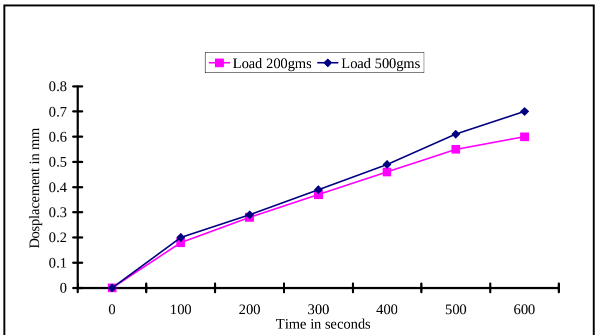

Fig 9. Wear 15% Fly ash metal mold after heat treatment

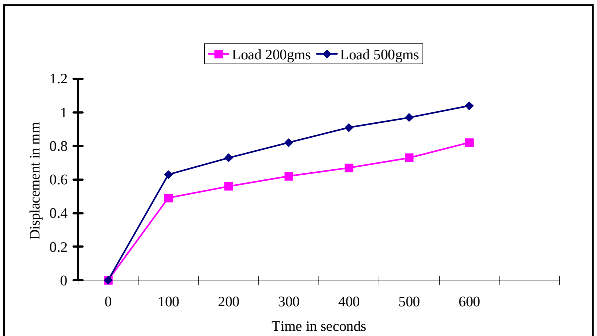

Fig 10 wear 20% Fly ash metal mold after heat treatment

BEFORE HEAT TREATMENT

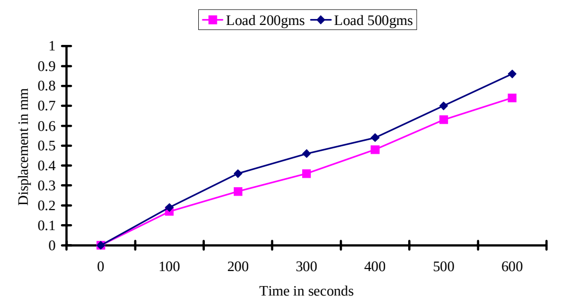

Fig 11 sqeeeze 0% Fly ash before heat treatment

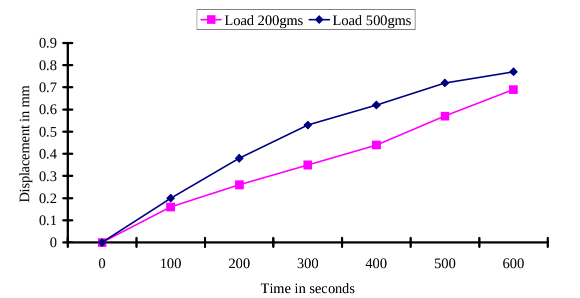

Fig 12 Wear sqeeeze 10% Fly ash before heat treatment

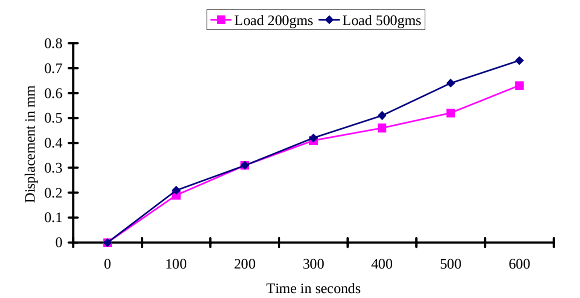

Fig 13 Wear 15% Fly ash sqeeze before heat treatment

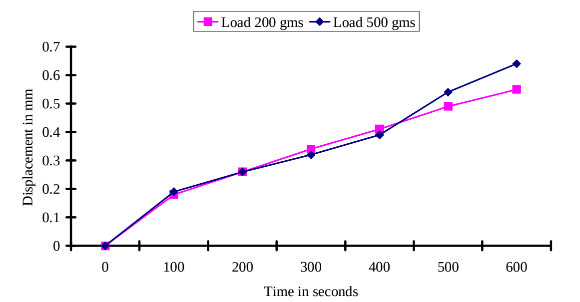

Fig 14. Wear 20% Fly ash sqeeze before heat treatment

AFTER HEAT TREATMENT

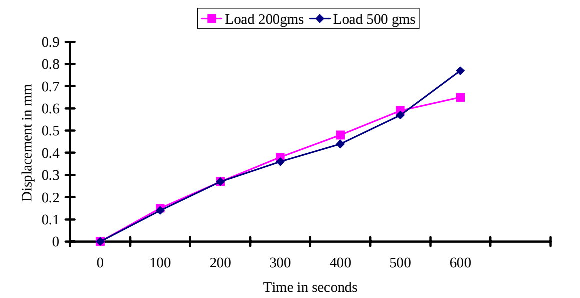

Fig. 15 wear 0% Fly ash sqeeeze after heat tratment

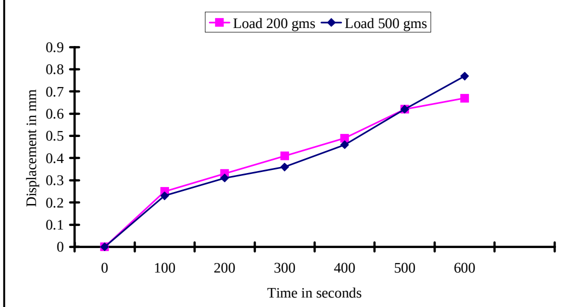

Fig 16 Wear 10% Fly ash sqeeeze after heat treatment

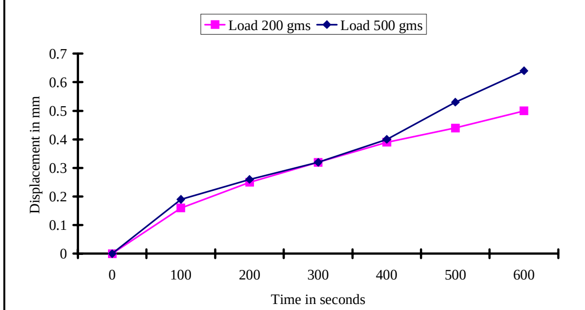

Fig 17. wear 15% Fly ash sqeeze after heat treatment

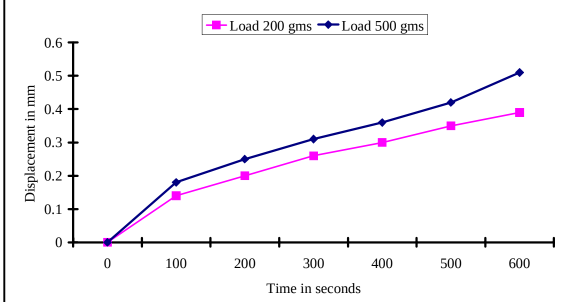

Fig 18 Wear 20%Fly ash sqeeze after heat treatment

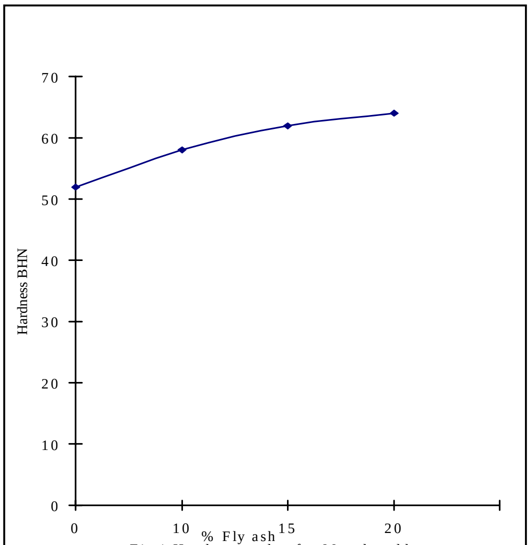

Fig.1.Hardness value for Metal mold

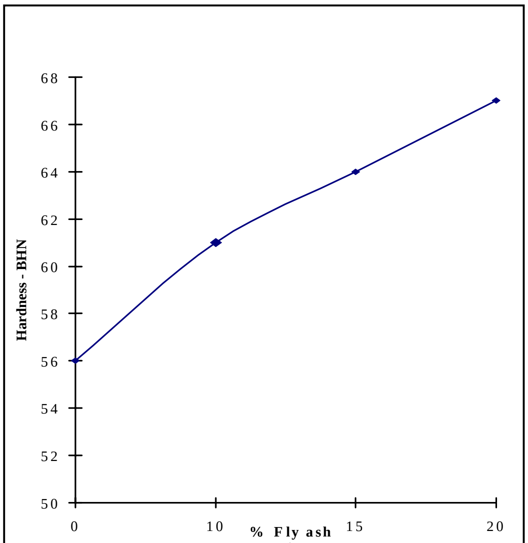

Fig 2. Hardness value for Sqeeze cast

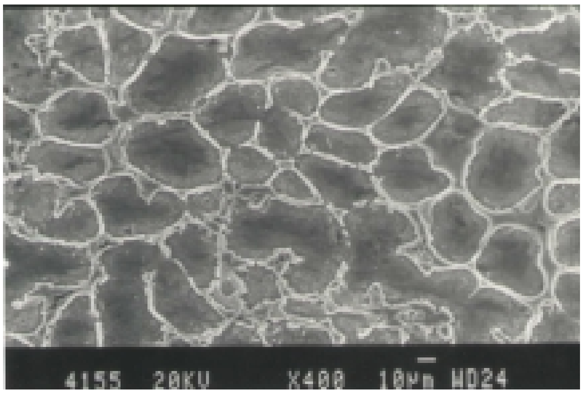

Fig 19 Al-4.5% Cu X400

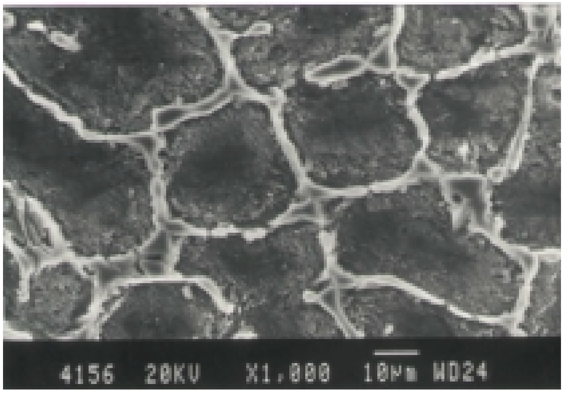

Fig 20 Al-4.5% Cu X1000

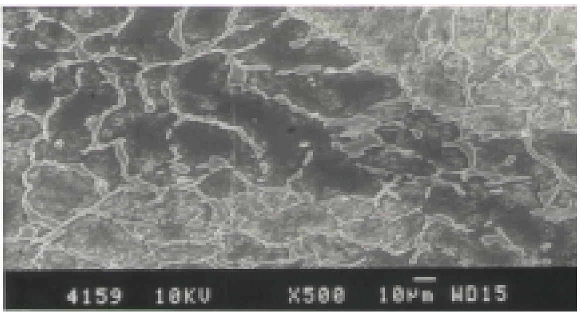

Fig 21 Al-4.5% Cu + 10% Fly ash X500

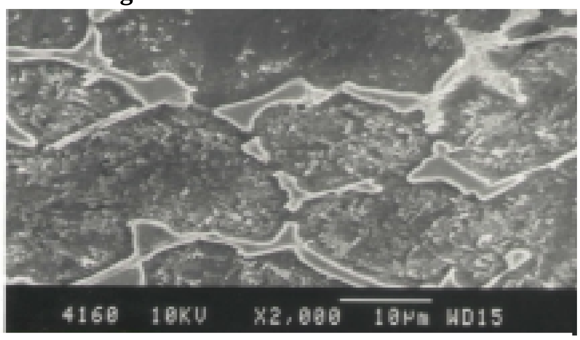

Fig 22 Al-4.5% Cu + 10% Fly ash *X2000*

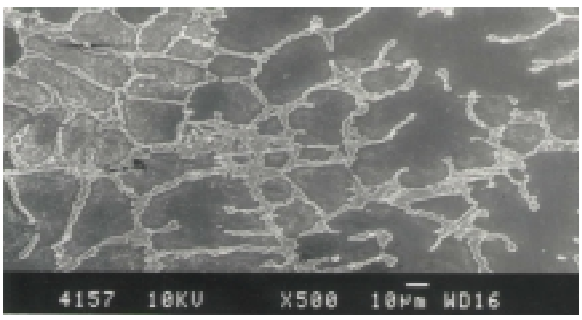

Fig 23 Al-4.5% Cu + 15% Fly ash X500

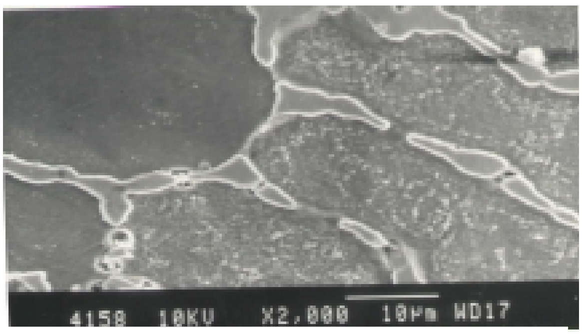

Fig 24 Al-4.5% Cu 15% + Fly ash *X2000*

CONCLUSIONS

1. The wear resistance of cast Al – 4.5% Cu alloy tested increases with increasing Fly ash percentage. The maximum effective wear resistance was shown by the 20% Fly ash composite.
2. The wear resistance of MMC made by squeeze casting was more compared with metal mold casting.
3. The increase in wear resistance was mainly due to the uniform distribution of Fly ash throughout the metal matrix.
4. Results of the hardness also show the increase in hardness with corresponding increase in % Fly ash.
5. The uniform distribution of Fly ash was seen in the SEM micrographs which was obtained by stirring method.
6. Thus the addition of Fly ash increases the wear resistance of Al – 4.5% Cu alloy and hence can be effectively used in number of engineering applications.

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