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Evaluation of Wear Properties of Flyash and C-Glass Reinforced Al4046 Hybrid MMC

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***Abstract*— Metal Matrix Composites (MMCs) are engineered materials designed by a combination of a particulate or fibre reinforced in a metal or alloy matrix. This research work is concerned about the production of Fly ash, C-glass reinforced hybrid Aluminium 4046 metal matrix composites and further to investigate on the wear properties of the processed composites. Aluminium4046-Flyash-C-glass metal matrix composites have been processed for this study. In this work, the experimental study began with mixing of Aluminium powder, Fly ash particulates and C-glass fibers using a Stir casting technique at different weight fraction addition of Fly ash(2%,4%,6%) and C-glass(1%,3%,5%,7%).After production, the machining of the hybrid metal matrix composites is carried out as per ASTM standards. The wear rate is calculated using Pin on disc test machine. This experiment result show that best wear resistant combination is at 6% of Fly ash and 7% of C-glass is used.**

Keywords*— *Metal Matrix Composites, Aluminium 4046, Fly ash, C-glass, Stir Casting, Pin on disc test.

I INTRODUCTION

Material scientists in this area have been fulfilling the demand of the engineering sector since decades in synthesizing materials to attain the demanded propertiesto enhance efficiency and cost savings in the manufacturing sector. In fulfilling this demand, a certain trend has been followed, the materials presently been used is tried for improvement through known methods of alloy additions,heat treatment, grain modification, and the like. Once the limit is reached through these methods, either due to economic constraint, difficulty in mass production, or further improvement is ruled out, a different line of thought emerges in further improving the properties or decreasing cost and increasing efficiency. At times, a completely new system takes over, like was done around three decades back when metal matrix composites (MMCs) were thought of. Since a few years, the economically feasible routes, and alloy system that can give meaningful improvement have been narrowed down. Among MMCs, Al-alloy-based composites were always on the forefront of research. Parallel areas of research had then emerged but after about decades of research in various disciplines to further enhance the properties to satisfy the ever increasing demand of the engineering sector, composites took a lead compared to the other processes when the cost and ease of fabrication were compared. The other methods changed track and choose for themselves different areas of application and Aluminium based metal matrix composites remained as the most potential candidate to be researched on for making engineering components viable.

II METHODOLOGIES

A. Material selecetion

Aluminium 4046 with Fly ash and C-glass as reinforcements are used to study the wear properties of the hybrid composite. Aluminium 4046 alloy, with excellent casting properties and reasonable strength was used as the basic alloy. This is a popular aluminum alloy with good strength and is suitable for the mass production of lightweight metal castings, The Fly ash is used as primary reinforcement due to properties of wear resistance , it posses when mixed with aluminium., C-Glass fibre of 2-3 mm length are also used in this as a fiber reinforcing material.

Alumimium 4046 have very good flow characteristics which can be extensively used in forging of aircraft pistons. They can also be used in weld filler alloy used in gas metal arc welding. In both of these applications friction plays a very important role. So, we have used

B. Preparation of the Composites

The Aluminium-4046 alloy was used as the base alloy. The Fly ash particulate and C-glass fibers with 2-3 mm in diameter and 2-3 mm length were used as the reinforcements. The vortex method (stir casting) was used to fabricate the hybrid composites. The composites with different compositions of reinforcements at different weight fraction addition like Fly ash with 2% 4% 6% and 1% 3% 5% 7% of C-glass The crucible in which the charge is melted is preheated to remove the moisture content from the crucible which otherwise leads to the cracking of the crucibles. The

Stir casting technique is showed in Fig.1 .Aluminium 4046 is cut into small bits, weighed according to the requirement and added into the preheated crucible. Once the crucible has been charged the furnace was switched on and the temperature was set to 720^0C-750^0C. The melt was degasified using hexa-chloro ethane pellets (0.2%) before the introduction of Fly Ash particulates and C-Glass fibers are preheated to 500^0C. Preheated Fly ash particulates and C-Glass fibers are added into the vortex while the melt temperature is maintained at 720^0C and stirred at 500 rpm till the reinforcements are thoroughly mixed using a mechanical stirrer coated with alumina and the melt was degasified with N_2 gas. The melt was poured into preheated and coated split mould die made of low carbon steel and allowed to cool naturally. After solidifying the required cast obtained was sent for proof machining on a centre lathe to remove the scaling from the surface.

Fig. 1.Stir Casting

C. Testing of Wear Properties

The wear test was conducted using a pin-on-disc computerized wear testing machine as show in accordance with ASTM standards G99-05. The surface finish of the specimens (R_a) 2µm was rubbed against a hardened steel disc, which has a better surface finish of (R_a) 0.2µm. The test uses the specimens of diameter of 10mm and length 20mm machined from the cast specimens. The wear tests were conducted using loads of 2,4 kg in steps of 2kg at 400rpm and 600rpm. 4kg at 400rpm and 600rpm .The test period was taken to be 10 minutes and the track radius selected was 50mm. The apparatus consists of a steel disc of 120 mm which forms the counter face on which the test specimens or the pins slide over. The wear test was also conducted for the cast specimens of the same conditions and standards. Keeping other conditions same, Aluminium alloy with varying percentage of fly ash particulates and C-glass fibers in a cast conditions were assessed for wear resistance. The wear results of as cast hybrid composites with different compositions of reinforcements at varying sliding speed and different loads are shown in the graphs.

III EQUATIONS

In this method we calculate the wear rate by first measuring the initial length of the specimen(L1)before. Than the specimen is held on the Pin on disc testing machine at track diameter of 50mm. the disc is rotated for 10 minutes for the required speed in this case 400RPM.After this final length of the specimen(L2) is measured. These initial and final length are used to calculate initial and final volume of the specimen. The difference between the volume gives the volume of wear. Sliding distance is calculated by noting track diameter ,speed of the disc ,sliding time. The values of volume of wear and sliding distance are substituted to get the wear rate.

V= Volume of wear m3=V1-V2 (1)
R= Radius of specimen
L1=Initial length of specimen
L2=Final length of specimen

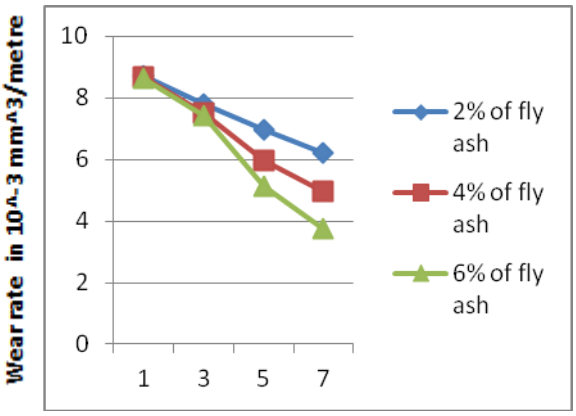
S=Sliding distance (meter)= π*D*N*T=2*π*R*N*T (2)
D= Diameter of wear track in meter
V1=πr^2 L1
V2=πr^2 L2
R=Radius of wear track in meter
N=Speed of the wheel in rpm
T=Sliding time in minutes

Wear rate (mm3/m)= V/S (3)
V= Volume of the wear in debri's in mm3
S= Sliding distance in meter

IV RESULTS AND DISCUSSIONS

Graph A

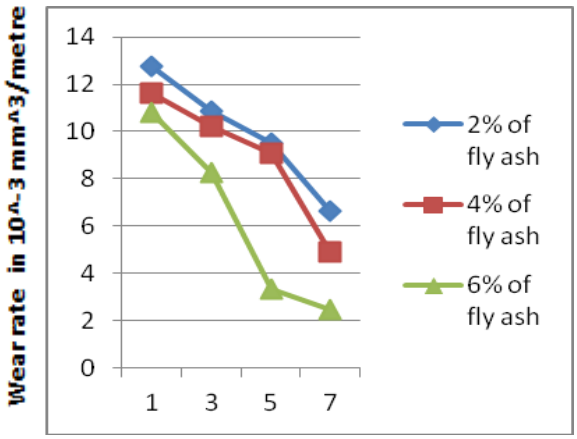
Wear rate of Al 4046, Fly ash and C-glass MMC at 2Kg 400rpm



Percentage of C-glass

Graph B

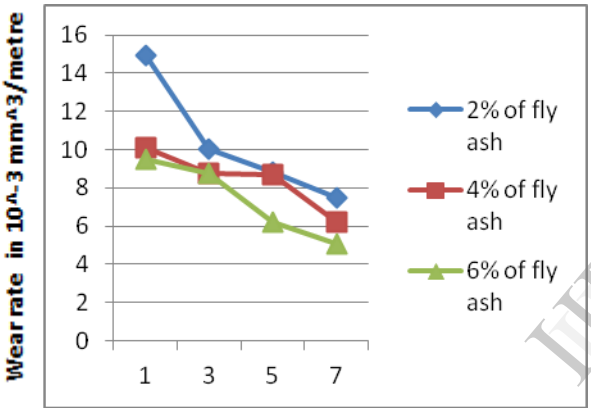
Wear rate of Al 4046, Flyash and C-glass MMC at 2Kg 600rpm



Percentage of C-glass

Graph C

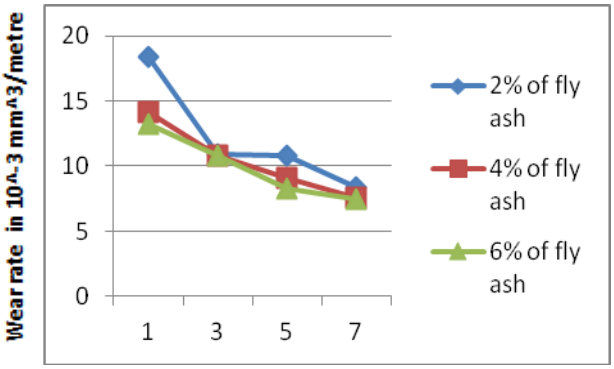
Wear rate of Al 4046, Fly ash and C-glass MMC at 4Kg 400rpm



Percentage of C-glass

Graph D

Wear rate of Al 4046, Fly ash and C-glass MMC at 4Kg 600rpm



Percentage of C-glass

The above Graphs A,B,C,D shows wear rate of Al4046 fly ash and C glass reinforced hybrid composite, under different C glass composition (1%, 3% 5% and 7%) with the fly ash composition kept at the level of 2%, 4% and 6%.. The Wear rate decreases as the percentage of Fly ash and C-glass increases. The addition of Fly ash and C-glass fibres reinforcement to Al 4046 matrix enhances the effective bonding between reinforcements and matrix by allowing the larger interfacial area of contact, and thereby increasing the wear resistance of the hybrid composite.

V CONCLUSIONS

Composite material of AL-4046 reinforced with C-glass fibre and Fly ash particulate was successfully casted.
Wear rate decreases with the increase in Fly ash and C-glass. With Flyash being the main Reinforcement with addition of C-glass fibres Wear rate has reduced marginally.
Addition of C-glass also to some extent decreased the wear rate but Fly ash plays a major role in reducing the wear rate.
With increase in Fly ash wear rate has decreased and is clear from the results that at 6% of Fly ash and 7% of C-glass fibres wear rate decreases gradually.
The best Wear resistant combination is at 6% of Fly ash and 7% of C-glass as consideration.

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