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RESEARCH ARTICLE

EVALUATION OF WEAR PROPERTIES OF FLY ASH PARTICULATE AND S-GLASS FIBER REINFORCED Al 4046 HYBRID MMC

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ABSTRACT

In recent years, Metal Matrix Composites (MMC's) reinforced with Fly Ash particulates have attracted considerable interest due to their inherent good mechanical properties such as tensile strength, compression strength, hardness, wear resistance etc. This research work is concerned about the production of Fly Ash particulate, S-Glass fiber reinforced hybrid Aluminium 4046 Metal Matrix Composites (MMC's) and further to investigate on wear properties of the processed composites. In this work, experimental study begins with mixing of Aluminium billets, Fly Ash particulates and S-Glass fibers using a stir casting technique at different weight fraction addition of Fly Ash (2wt%, 4wt%, 6wt%) and S-Glass (3wt%, 5wt%, 7wt%). The test specimens are prepared as per standard to conduct wear test. It has been observed that addition of Fly Ash particulate significantly improves wear properties as compared with that of unreinforced matrix.

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INTRODUCTION

After more than a quarter of a century of active research, composites based on metals are now beginning to make a significant contribution to industrial and engineering practice. This is partly a consequence of developments in processing methods.In its most basic form a composite material is one which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. 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 ofresearch. 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 demandof 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.

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MATERIALS AND METHODS

Material selection

Aluminium 4046 with Fly ash particulate and S-glass fiber as reinforcements are used to study the wear properties of the hybrid metal matrix composite. Aluminium 4046 alloy, with excellent casting properties and reasonable strength was used as the basic alloy. This is a popular aluminium alloy with good strength and is suitable for the mass production of lightweight metal castings.Aluminium alloy 4046 with silicon as the primary alloying element is selected has a base material for present investigation. Fly Ash and S-Glass fibers are selected as a reinforcement material. The present study is mainly concentrated on effect of reinforcement on composites.Aluminium 4046 have very good flow characteristics which can be extensively used in forging of aircraft pistons.

Preparation of theComposites

The Aluminium 4046 alloy was used as the base alloy. The Fly Ash particulate and S-Glass fibers 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 2wt%, 4wt%, 6wt% and 3wt%, 5wt%, 7wt% of S-Glass fiber. 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°C-750°C. The melt was degasified using hexa- chloro ethane pellets (0.2%) before the introduction of Fly Ash particulates and S-Glass fibers are preheated to 500°C. Preheated Fly Ash particulates and S-Glass fibers are added into the vortex while the melt temperature is maintained at 720°C 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.

Fig. 1.Stir Casting

Testing of Wear Properties

The wear test was conducted using a pin-on-disccomputerized wear testing machine as show in accordancewith ASTM standards G99-05. The surface finish of thespecimens (Ra) 2µm was rubbed against a hardened steeldisc, which has a better surface finish of (Ra) 0.2µm. Thetest uses the specimens of diameter of 8mm and length35mm machined from the cast specimens. The wear testswere conducted using loads of 2 kg in steps of 300rpm, 500rpm & 700rpm .The testperiod was taken to be 5 minutes and the track radiusselected was 50mm. The apparatus consists of a steel disc of120 mm which forms the counter face on which the testspecimens or the pins slide over. Keeping other conditions same, Aluminiumalloy with varying percentage of fly ash particulates and S-glassfibers in a cast conditions were assessed for wear resistance. The wear results of as cast hybrid composites withdifferent compositions of reinforcements at varying sliding speeds are shown in the graphs.

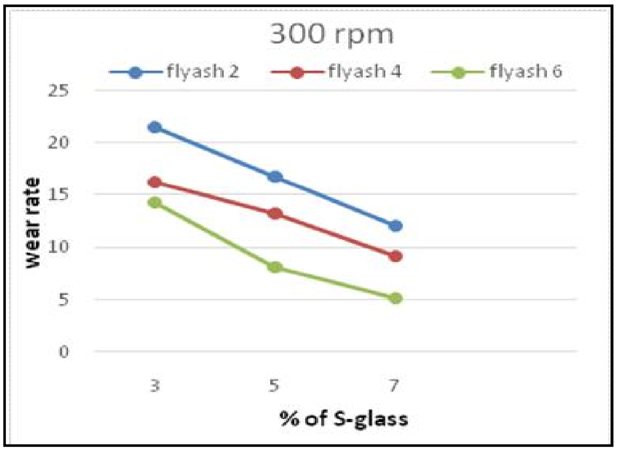
Experimentation

In this method we calculate the wear rate by first measuring the initial length of the specimen(L1). Then the specimen is held on the Pin on disc testing machine at track diameter of 50mm. the disc is rotated for 5 minutes for the required speed.After this final length of the specimen(L2) is measured. These initial and final length areused to calculate initial and final volume of the specimen. Thedifference 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 andsliding distance are substituted to get the wear rate.

RESULTS AND DISCUSSION

Graphs

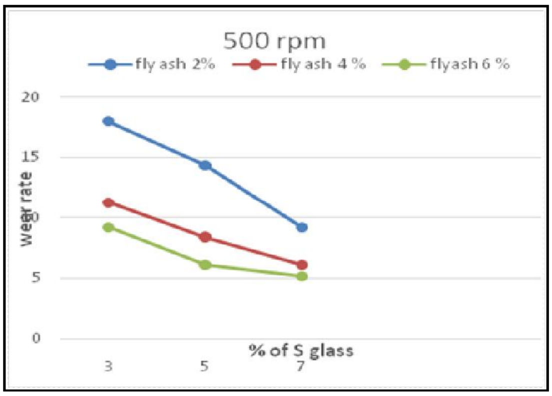
1)Wear rate of Al 4046, Fly ash and S-glass MMC at 2Kg 300rpm



	Flyash 2%	Flyash4%	Flyash6%
S-Glass 3%	21.44	16.24	14.336
S-Glass 5%	16.77	13.24	8.192
S-Glass 7%	12.11	9.2	5.12

The above graph shows the wear rate of Al4046 fly ash particulate and S-glass fiber reinforced hybrid metal matrix composite, under different S-glass composition (3wt%, 5wt% and 7wt%) with the fly ash ratio kept at the level of 2wt%, 4wt% and 6wt% at speed of 300rpm and load of 2kg. The highest wear rate was exhibited at 2% of Fly ash andleast wear rate was at 6% of Fly ash. From graph it is clear that with increase in Fly ash content the wear rate decreases.

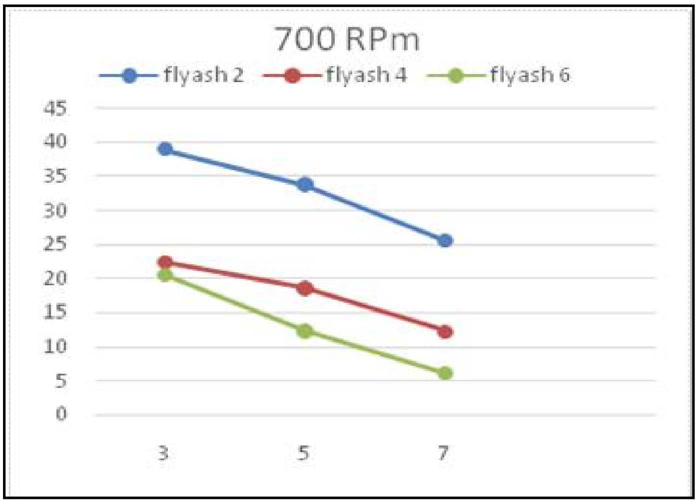
2)Wear rate of Al 4046, Fly ash and S-glass MMC at 2Kg 500rpm



	Flyash2%	Flyash4%	Flyash6%
S-Glass 3%	17.92	11.264	9.216
S-Glass 5%	14.336	8.421	6.14
S-Glass 7%	9.24	6.14	5.22

The above graph depicts the wear rate of Al4046 fly ash particulate and S-glass fiber reinforced hybrid metal matrix composite, under different S glass composition (3wt%, 5wt% and 7wt%) with the fly ash ratio kept at the level of 2wt%, 4wt% and 6wt% at speed of 500rpm and load of 2kg. The highest wear rate was exhibited at 2wt% of Fly ash andleast wear rate was at 6wt% of Fly ash.Incorporation of fly ash content significantly reduces wear.

3)Wear rate of Al 4046, Fly ash and S-glass MMC at 2Kg 700rpm



	Flyash2%	Flyash4%	Flyash6%
S-Glass 3%	38.912	22.42	20.48
S-Glass 5%	33.792	18.66	12.33
S-Glass 7%	25.6	12.33	6.22

The above graph shows wear rate of Al4046 fly ash particulate and S-glass fiber reinforced hybrid composite, under different S-glass composition (3wt%, 5wt% and 7wt%) with the fly ash composition kept at the level of 2wt%, 4wt% and 6wt% at speed of 700rpm and load of 2kg. The Wear rate decreases as the percentage of Fly ash and S-glass increases. The addition of Fly ash and S-glass fibresreinforcement 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.

Conclusion

From the research work entitled "Evaluation of wear properties of fly ash particulate and s-glass fiber reinforced Al 4046 HYBRID MMC", the following conclusions were drawn:

- Using liquid stir casting technique Fly ash particulate and S-Glass fiber can be successfully introduced in the Al-4046 alloy matrix to fabricate Hybrid MMC's.
- From the tabulations and graphs, it is inferred that wear rate decreases with increase in the weight percentage of reinforcements. This is due to the influence of the stiffer reinforcement on base metal.
- From the comparison graphs, it can be concluded that Fly ash remains as more wear resistant than S-Glass. This might be due to the fact that the longer S-glass fibers wear easily, when compared to the Fly ash particulates.
- It is clear that the best wear resistant combination is at 6wt% of Fly ash particulate and 7wt% of S-Glass fiber as consideration.
- From the over all observation, it can be concluded that S-glass and Fly ash remains a good wear resistant reinforcements.

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