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Production of Aluminium-Fly Ash Composite using Stir Casting Methods and Their Charecteristics

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***Abstract*—Metal matrix composites (MMCs) have greatly improved properties including high specific strength; Specific modulus, damping capacity and good wear resistance compared to unmodified alloys. There is increasing interest in composites with low density and low-cost consolidated validation. Among the various simulators used, fly ash is the cheapest and low-density aggregator available in large quantities as a solid energy byproduct during coal horns in thermal power plants. Therefore, composites with fly ash in the form of consolidation are likely to pose a cost constraint for a wide-spread range in building and small engine production. It is therefore expected that the incorporation of fly ash particles into the active alloy will promote another use of this low-cost waste byproduct and, at the same time, has the potential to conserve energy intensive energy and thus From, Reduces costs online products. Now-a-days particulate reinforced alumina matrix composites are gaining importance due to low cost with benefits such as isotropic properties and the possibility of secondary processing to facilitate fabrication of secondary components. The present investigation has focused on the use of plentifully available industrial energy fly-ash to produce composites by the stir casting method in order to disperse it by accident.**

Key words: - composites, industrial waste, applied load and sliding velocity

I. INTRODUCTION

Traditional monolithic materials have limitations to achieve a good combination of strength, hardness, hardness, and density. To address these shortcomings and to meet the increasing demand for modern technology, composites are the most promising material of recent interest. Metal matrix composites (MMCs) have greatly improved properties including high specific strength; Specific modulus, soaking capacity and good wear resistance compared to unmodified alloys. There is increasing interest in composites with low density and low-cost reinforcement. Among the various dissenters used, fly ash is one of the most inexpensive and low-density reinforcements available in large quantities as a solid waste product during the combustion of coal in thermal power plants. Therefore, composites with fly ash as reinforcement are likely to pose a cost constraint for wide-spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles into aluminum alloys in aluminum products will promote another use of this low-cost waste by product and, at the same time, has the potential to conserve energy intensive aluminum and thus, reduces the cost.

The mechanical properties of composites are influenced by the size, shape, and volume fraction of the reinforcement, matrix material, and reaction at the interface. These aspects have been discussed by many researchers. Rohatgi reports that with an increase in the volume percentage of fly ash, the hardness value increases in Al-fly ash precipitator type composites. He also reports that the tensile elastic modulus of ash alloys increases with an increase in the volume percentage of fly ash. Have studied Al_2O_3 particle reinforced Al MMCs with different particle volume percentages (25, 36, 46, 52 and 56) and reported improvements in elastic modulus, tensile strength, compressive strength and fracture properties with an increase in reinforcement content. The interface between the matrix and the reinforcement plays an important role in determining the properties of MMCs. Hardening and hardening depends on the load transfer on the interface. The crack at the interface is affected by deflection and ductility is affected by the relaxation of peak stress near the interface.

In-depth studies on tribal characteristics of reinforced Al MMCs such as SiC and Al_2O_3 are available in the literature. However, reports on friction and wear characteristics of fly ash reinforced AMC are very limited. Rohatgi has reported that adding fly ash particles to aluminum alloys greatly increases its abrasion resistance. They attributed the improvement in resistance to the hard aluminosilicate component present in fly ash particles.

II. EXPERIMENT DETAIL

First, 400 g of commercially pure Aluminium was melted into a resistance hot muffle furnace and poured into an earthen graphite crucible. For this the melt temperature was raised to 993K and was destroyed by purifying hexachloroethane industries. Then fire-fly ash (10%) was prepared by a mixed casting route. For this we took 400 grams of commercially pure active and 40 grams of fly ash. The fly ash particles were preheated to 373K for two hours to remove moisture. The commercially pure user was melted by raising its temperature to 993K and was destroyed by purifying the hexachloroethane brands. It was then melted using a mild steel stirrer. The melt was formed at the time of the formation of the vortex in the melt due to melting of fly-ash particles. The molten temperature was maintained at 953K – 993K while adding particles. Then melted clay graphite were applied in the crucible. Particle size analysis and chemical composition analysis were done for fly ash. Defect testing and density measurements were performed for both commercially pure Al and Al-10% fly ash composite. The injury bone was determined by a Brinell defect testing machine with a 500 kg load and a 10 mm diameter steel ball indent. Detention time for defect measurement was 30 seconds.

The wear characteristics of a commercially pure Al and Al-10% fly ash composite were evaluated using a wear testing machine. For this, cylindrical samples of 1 cm diameter and 2.1 cm length have been prepared from cast active and Al-10% fly ash composite. Was tested 68.68 N load and 500 rpm for 10 minutes. SEM and EDS analysis was performed for both.

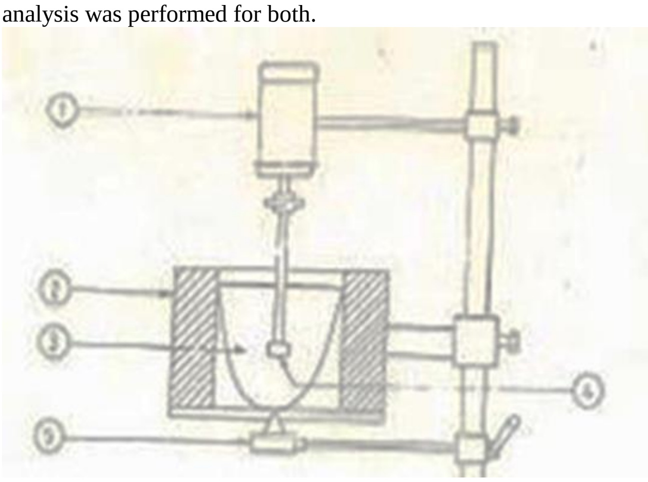


Figure stir casting

2.1 STRENGTHENING MECHANISM OF COMPOSITES

The reinforcement mechanisms of composites vary with different types of reinforcing agent morphology such as fiber, particulate or diffuse type reinforcing elements.

2.1.1 STRUCTURE OF FIBER STRUCTURE OF MIXED STRUCTURE

In this type of composite, the reinforcing phase carries the bulk of the load and transfers the load to the reinforcing phase by the mechanism of the matrix seam. The high strength of the reinforcing phase restricts the free elongation of the matrix, particularly in its vicinity, while the latter is free to elongate at some distance from the former.

This type of non-uniform deformation of the matrix causes a shear stress at the matrix reinforcement interface resulting in tensile stresses in the reinforcing phase. Thus, the stress is transferred to the reinforcing phase. Fibers can be either continuous or closed in the matrix. In the former case the load is directly applied to the strong phase and the stress is constant over its entire length. In the case of unsaturated fibers, the stress in the fiber increases to a zero value at the end of the maximum value at the center and thus the developed average tensile strength is always lower than that of continuous fibers. For the same when fracture of the reinforcing phase, therefore the strength of the closed fiber reinforced composite increases with increasing fiber length and the continuous fiber reinforcement of artifacts. Also, the strength of the fiber reinforced composite will be maximum when the fiber is aligned in the direction of applied stress i.e., in the impaction state. So, the strength of such a mixture depends on the volume fraction of the reinforcing element present in the composite, which can be determined by the simple rule of mixing.

2.1.2 The expression of the composition of the organized composition

In the dispersion strengthening, the mixed second stage reinforcing agents are finely dispersed in a soft ductile matrix. Strong particles restrict the motion of clutter and strengthen the matrix. The main reinforced philosophy here is by strengthening the matrix by forming clutter loop around the dispersion particles. Thus, it is difficult for the dislocations to move around the particles. The degree of strengthening depends on many factors such as the volume% of the dispersion phase, the degree of dispersion, the size and shape of the dispersion phase, the differential particle spacing, etc. The load in such composite is mainly carried by matrix materials.

2.1.3 Strong Mechanisms of Partnership Composites

Particulate reinforced composites have a particle size greater than 1μm, so it strengthens the composites in two ways. The first one is particles to carry loads along the matrix material and the second method is the creation of an incompatible interface between the particles and the matrix. So, many clutters are generated at the interface, thus the material becomes stronger. The degree of reinforcement depends on the volume, distribution, size, and particle size etc. of the particulate (volume fraction).

2.2 FLY ASH

Fly ash is one of the residues generated in coal combustion. It is an industrial by-product recovered from the flue gas of coal-fired power plants. Depending on the source and makeup of the coal to be burned, the components of the fly ash produced vary greatly, but all fly ash contains substantial amounts of silica (silicon dioxide, SiO_2) (both amorphous and crystalline) and lime (calcium oxide, CaO). Belongs to. In general, fly ash has SiO_2, Al_2O_3, Fe_2O_3 as major components and Mg, Ca, Na, K etc. as minor components. Fly ash particles are mostly spherical in shape and range from 1100m to 100m with a specific surface area, typically between 250 and 600 m2 / kg. The specific gravity of fly ash varies in the range 0.6–2.8 g / cc. The physical properties of fly ash mainly depend on the burning and burning conditions of coal. Class F fly ash is generally produced from high-rank (high carbon content) coals such as anthracite and bituminous coils, while class C fly ash is produced from low-grade coals. Fly ash particles are classified into two types, precipitators and Cenospheres. Typically, solid spherical particles of fly ash are called precipitator fly ash and hollow particles of fly ash with density less than 1.0 g/cm^3 are called cenosphere fly ash. A common type of fly ash is usually composed of crystalline compounds such as quartz, mulit and hematite, glassy compounds such as silica glass and other oxides. Precipitator fly ash, which has a density in the range 2.0–2.5 g/cm^3, can improve various properties of selected matrix materials, including hardness, strength, and wear resistance, and reduce density. Cenosphere fly ash, which consists of hollow fly ash particles, can be used for the synthesis of ultra-light composite materials due to its low density, which ranges from 0.4–0.7 g/cm^3 compared to metal densities. Is in Matrices, which range in the range 1.6–2.0 g/cm^3. Coal fly ash has many uses including cement additives, as masonry blocks, as concrete mixtures, as a material in lightweight alloys, as a concrete aggregate, as a flux, as a concrete aggregate, In roadways / runway construction, structural fillings are included. Materials, as roofing granules, and in grouting. The largest application of fly ash is in the cement and concrete industry, however, creative new uses for fly ash are being actively sought, like the use of fly ash for the manufacture of MMC.

III. RESULTS & DISCUSSION

3.1 CHEMICAL ANALYSIS OF FLY ASH

COMPOUNDS	PERCENTAGE(%)
SiO_2	67.2
Al_2O_3	29.6
Fe_2O_3	0.1
CaO	1.4
MgO	1.7

3.2 PARTICLE SIZE ANALYSIS OF FLY ASH

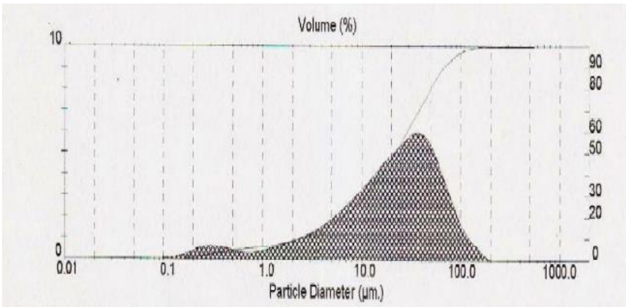


Fig 3.2 PARTICLE SIZE ANALYSIS

The above table shows that the inclusion of fly ash particles in the aluminum matrix leads to a reasonable increase in hardness. The reinforcement of the composite may be due to dispersion as well as particle reinforcement. Thus, fly ash in the form of filler in Al castings reduces the cost, reduces the density and increases the hardness which are required in various industries such as automotive etc.

` The size, density, type of reinforcing particles and its distribution have a clear effect on the properties of the particle. The above figure shows the size limit of fly ash particles. The size range of the particles is very wide. The size ranges of fly ash particles indicate that the as-prepared composite can be considered as a reinforcing dispersion as well as a particle reinforced composite.

As seen from the particle size distribution there are very fine particles as well as being coarse (1–100μm). Thus, the reinforcement of the composite may be due to dispersion reinforcement as well as particle reinforcement. Dispersion reinforcement is caused by the incorporation of very fine particles, which help restrict the motion of clutter, while in particle strengthening, there is a load sharing mechanism.

3.3 DENSITY AND HARDNESS MEASUREMENT

SPECIEN	DENSITY (gm/cm^3)	HARDNESS (BHN)
As Cast Al	3.398	16

Al-10% fly ash composite	2.807	18

TABLE 3.3

The above table shows that the inclusion of fly ash particles in the aluminum matrix leads to a reasonable increase in hardness as well as a reasonable decrease in density.

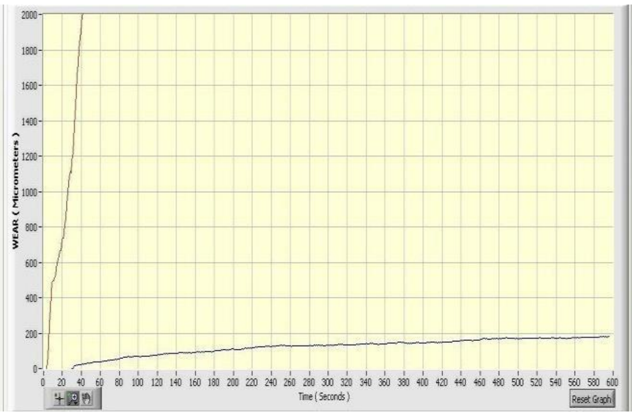
Reinforcement of the composite may be due to dispersion reinforcement as well as particle reinforcement.

Thus, fly ash in the form of filler in Al castings reduces the cost, reduces the density, and increases the hardness which are required in various industries such as automotive etc.

3.4 WEAR BEHAVIOR

In the graph given below color coding is as follows: -

(1) Blue for Al-5% fly ash (2) Red for Al-10% fly ash
(3) Black for Al-15% fly ash (4) Green for Al-20% fly ash



Wear behavior of MMCS with different % of Fly ash at 20N load and 240rpm.

FIG 3.4 (a) – Wear Vs Time (RED-FOR Al, BLUE-FOR Al-10% FLY ASH)

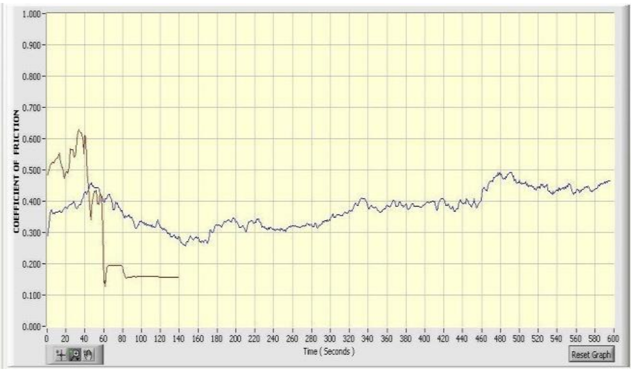


FIG 3.4 (b) COF Vs Time (RED-FOR Al, BLUE-FOR Al-10% FLY ASH)

For FIG 3.4 (a)

This figure clearly indicates that the wear rate is significantly improved with the addition of fly-ash.

The addition of fly ash acts as a barrier to the movement of clutter and thus increases the odor of the aggregation. Thus, the addition of fly ash particles to the hue greatly increases its wear resistance. The hardness aluminosilicate component present in fly ash particles improves wear resistance.

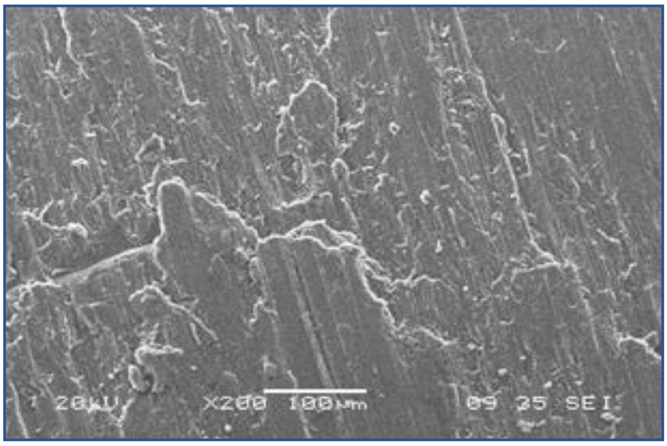
For FIG 3.4 (b)

This figure compares the typical friction coefficient of cast Al and Al - 10% fly ash composite. Al-10% represents a lower friction coefficient than fly ash composite cast Al. Thus, the friction coefficient decreases considerably with the inclusion of fly ash in al melt.

From the material point of view, the factors affecting the coefficient of friction are the mechanical properties of the matrix, the chemical stability of defects and particles, and the structure and strength of the interface. And these and tribal parameters (such as load and speed, environment, and properties of counter-face materials) The interactions between are responsible for the overall behavior.

3.5 SEM ANALYSIS

SEM photographs were taken to analyze the surfaces of the cast Al and Al – 10% fly ash composite.



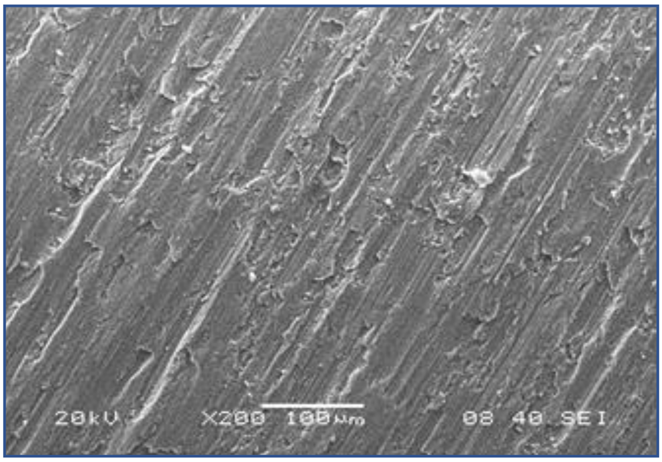


FIG 3.5 (b) SEM microstructure of Al-10% fly ash composite

SEM analysis shows that there is more wear in the case of cast Al than Al – 10% fly ash composite. This is due to the fact that wear is metal wear in the case of cast Al where oxidative wear is predominantly wear in the case of Al – 10% fly ash composite.

Thermodynamic analysis indicates that there is a possibility of a chemical reaction between aluminum melt and fly ash particles. As these fly ash particles include alumina, silica, and iron oxide, they are likely to undergo chemical reduction during their contact with the melt, as follows:

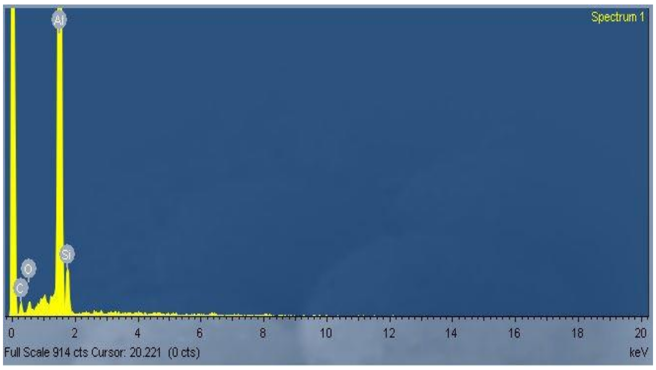
$2Al\ (l) + 3/2SiO_2\ (s) = 3/2\ Si\ (s) + Al_2O_3\ (s)$ …… (1)

$2Al\ (l) + Fe2O_3\ (s) = 2Fe\ (s) + Al_2O_3\ (s)$ …… (2)

Elements (Si and Fe) formed by reacting with the matrix and reducing the alloy. Gibbs free energy and heat of reactions are highly exothermic in nature. As a result of this reaction (Eq. (1)) greater amounts of eutectic silicon are seen in the composites.

3.6 EDS (Energy Resistant Space Shuttle) Microanalysis

Fig 3.6 Energy Resistant Space Shuttle Microanalysis



Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
C K	3.39	0.1817	20.14	2.64	35.46
O K	1.98	0.5478	3.89	1.00	5.14
Al K	80.78	1.2315	70.77	2.47	55.48
Si K	2.41	0.5007	5.20	0.46	3.91
Totals			100.00		

TABLE 3.6 (a)

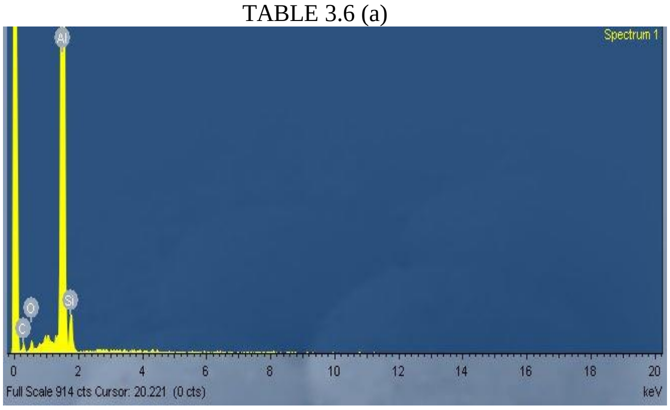


FIG 3.6(b) EDS microanalysis for Al-10% fly ash composite

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
C K	2.79	0.1771	17.65	3.38	31.81
O K	2.10	0.5624	4.19	1.20	5.67
Al K	80.39	1.2386	72.73	3.14	58.34
Si K	2.39	0.4935	5.43	0.57	4.18
Totals			100.00		

TABLE 3.6 (b)

An increase in the amount of eutectic Si indicates the incorporation of fly ash in Al-Melt.

IV. CONCLUSION

1. It has been concluded from the study that we can use fly ash for the production of composites and convert industrial waste into industrial money. It can also solve the problem of storage and disposal of fly ash.
2. Al can be successfully added by the stir casting route to produce fly ash composites up to 10% by weight.
3. The hardness of pure Al increased from 16 BHN to 18 BHN with 10% fly ash.

In addition to fly ash in Al Melt, there was an appreciable decrease of density3.398 g / cm3 to 2.807 g / cm3.

4. The inclusion of fly ash in Al melt significantly reduced both the friction coefficient and the wear rate.
5. The compaction is strengthened due to dispersion strengthening and particle reinforcement.

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