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MICROSTRUCTURE ANALYSIS OF STIRCAST ALUMINIUM FLYASH COMPOSITES

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Abstract:

Aluminium Flyash composites have been developed in the recent past. These composites uses low cost easily available Flyash as reinforcement. The property of such composites depends mainly on the characteristic nature of Flyash and its distribution in the matrix phase.
In the present research work microstructure analysis of Flyash powder is done and its distribution in the matrix is studied by both the Optical Microscopy and Scanning Electron Microscopy. The micrographs showed that Flyash contained solid spherical particles and were almost uniformly distributed in the matrix phase of stircast Aluminium composite.

Keywords: Microstructures, flyash, stir casting, composite.Introduction

Cast Aluminium matrix-particle reinforced composites are gaining significant acceptance because of higher specific strength, specific modulus, and good wear resistance as compared to un-reinforcedalloys. Particulates such as SiC, TiC, TiB_2 and Flyash have been used to reinforce Aluminium alloys to improve their mechanical properties and wear resistance. In recent years, the use of Flyash as a reinforcement material in Aluminium alloys has been reported to be desirable from both environmental and economic points of view due to its availability as a low cost waste material.
Flyash, being a waste material formed as a result of coal combustion inpower and metallurgical plants, needs ecological processing to avoid its dumpingat waste grounds or landfills. In view of a very interesting combination of physical andchemical properties, and from the economical and ecological standpoint,

Flyash is a very attractive material as a reinforcing phase in metal matrix composites.
There are two types of Flyash, namely, precipitator (solid particle) andcenosphere (hollow particle). The major chemical constituents of Flyash are SiO_2, Al_2O_3, Fe_2O_3 and CaO. Mineralogically, the Flyash constitutes the aluminosilicate glasses containing quartz, mullite, hematite, magnetite, ferrite, spinel, anhydride andalumina [1].
Incorporation of Flyash particles improves the wear resistance, damping properties, hardness and stiffness and reduces the density of Aluminium alloys [1– 7].
Aluminium Flyash composites have potential applications as covers, pans, shrouds, casings, pulleys, manifolds, valve covers, brake rotors, and engine blocks in automotive, small engine and the electromechanical industry sectors.
Liquid metal stir casting [2, 6, 8] and Infiltration techniques [9–11] are generally adopted for the synthesis of Flyash reinforced Aluminium metal matrix composites. Most of the previous studies [12– 16] carried out on processing of Aluminium Flyash composites have utilized only larger size particles of greater than 50 µm average particle size. Also a detailed study of available literature reveals that very few systematic investigations have been carried out to investigate the influence of varying percentage of Flyash particulates, on the mechanical properties of as cast composites especially with AA 2024 as matrix.
In this investigation, an attempt ismade to study the microstructure of Flyashparticle by optical and scanning electronmicroscopy. Also the influence of Flyash onthe density of as cast composites is studied. The composite is synthesized by the stircasting route by making use of locallyavailable Flyash derived from thecombustion of sub bituminous coal. TheFlyash used for the present study wascollected at an average load of 230MW fromJSW Energy, Toranagallu, Bellary District,Karnataka, India.

I. Experimental Details

Materials

Flyash reinforcement

Flyash, one of several coal combustion products, is the finely divided mineral residue resulting from the combustion of coal in electric generating plants. It consists of inorganic, incombustible matter present in the coal that has been fused during combustion into a glassy,

amorphous structure. The Flyash particles are generally spherical in shape andrange in size from 0.5 µm to 100 µm. It is most commonly used as a high-performance substitute for Portland cement or as clinker for Portland cement production. Besides, Flyash also serves as filler in wood and plastic products, paints and metal castings.
The precipitator Flyash is used as reinforcement for the present investigation which is a gray colored fine powder with

most of the particle size ranging below 45 µm and with density 1.1902gm/cc.
The Flyash samples were subjected to chemical analysis as per IS: 1727-1967 RA 2004 and the detailed chemical composition is as shown in Table: 1.

Aluminium matrix

The Aluminium alloy selected for the matrix material is AA2024.The total quantity being used is 12kgs.
This alloy has good specific strength and excellent fatigue resistance properties. It is extensively used in applications like aircraft structural components, aircraft fittings, hardware, truck wheels and parts for the transportation industry.
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Synthesis of Aluminium Flyash composite

The required amount (3000gms) of ingots of AA 2024 was melted in a graphite crucible by electric resistance furnace of 5kW rating. The melt temperature wasraised to 850^0C and the scum powder (all clean powder) in small quantities is added to the melt to remove the slag or flux. The totalmelt is then degassed by adding dry Hexa Chloroethane tablet weighing 10gms (C_2Cl_6, 0.3 wt. %). The Flyash particles were preheated to 400^0 C for 1 hr to remove the moisture.
After degassing, preheated Flyash particles with different wt% were added to the vortex formed in the melt by stirring. A mild steel stirrer with vertical axis was used. The rpm of the stirrer was maintained at 350–400 and stirring is continued for about 10min to allow for proper mixing of the Flyash in the melt. The melt temperature was maintained at 800-850^0 C during the addition of the particles. The pouring temperature was kept at 850^0 C and the time of pouring was 5mins.
The melt was poured in the greycast iron moulds which were preheated to 300^0C.The ALFA composites were synthesized by varying amount of Flyash from 2.5 to 7.5 % wt.

Results and Discussion

Powder characteristics

Scanning Electron Microscopy(SEM) is one of the best and most widely used techniques for the chemical and physical characterization of Flyash.
Characterization of powders fortheir shape, size, and size distribution is important for the synthesis of metal matrix composites because it determines the final porosity and strength properties of the composites.
An SEM photograph of precipitator Flyash is as shown in figure 1.This figure shows the typical appearance of rounded particles with size as low as 5µm,andranging upto as high as 105µm but most of the particles were below 45 µm.
The metallographic section of the as cast specimen was prepared by treating the surface with Keller's reagent and then the microstructure of the Aluminium Flyash composite was studied by both SEM andoptical microscope.
The microstructure photographs (figures: 2-5) clearly show uniform distribution of the Flyash particles with minimal voids for higher percentage of Flyash in the Aluminium matrix. Hard and fine precipitates of ceramic were also discovered along the grain boundary in the matrix of Aluminium solid solution with average grain size between 25 to 30 µm.

Density of cast composite

Table:2 indicates the tabulated values of density for different types of ascast composite specimens. The variation of density of the Aluminium Flyash composites as a function of Flyash weight per cent is shown in figure 6. This figure indicates that the density decreases with an increase in the Flyash content. A total of 4.67% decrease in density is noticed for specimen with 7.5%wt of Flyash as compared to the specimen with only Aluminium.

Conclusions

1. Aluminium Flyash compositescontaining up to 7.5 wt % Flyash were easily stir casted with fair distribution of Flyash in the Aluminium matrix material.

2. The optical and scanning electron microscopy images showed that the precipitator Flyash used for the present work containing the solid spherical particles with size as high as 105 µm,but most of the particles were below 45 µm. Also a fair distribution of Flyash in the Aluminium matrix material is observed in the microphotographs.

3. The measured as cast density of the specimens decreases with increasing Flyash content. A total of 4.67% decrease in density is observed for composite specimen containing 7.5% wtof Flyash compared with the Aluminium matrix density.

4. As stir casting is a high temperature liquid state processing technique there are possibility of chemical reactions between Flyash and Aluminium matrix with improper wetting. This could beavoided by properly controlling process parameters.

5. The Aluminium Flyash composites can be effectively used for weight saving applications because of their lowdensity.

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Tables and Figures

Table: 1 Chemical component in Flyash reinforcement

Sl. no	**Parameter**	**Quantity(% wt)**
1	Silicon Dioxide(SiO_2)	26.73
2	Alumina(Al_2O_3)	24.94
3	Iron oxide(Fe_2O_3)	18.10
4	Calcium oxide (CaO)	7.43
5	Magnesium oxide (MgO)	2.075
6	Sulfur tri oxide(SO_3)	2.81
7	Sodium oxide(Na_2O)	0.0648
8	Potassium oxide(K_2O)	0.049322
9	Loss on ignition% by mass	2.62
10	Bulk density	1.1902gm/cc

Table: 2 Variation of density of as cast specimens with Flyash % wt

Sl.no	Type of specimen	Flyash (% wt)	Green density(gm/cc)
1	AA 2024-0	0	2.78
2	AA 2024-2.5	2.5	2.78
3	AA 2024-5	5.0	2.73
4	AA 2024-7.5	7.5	2.65

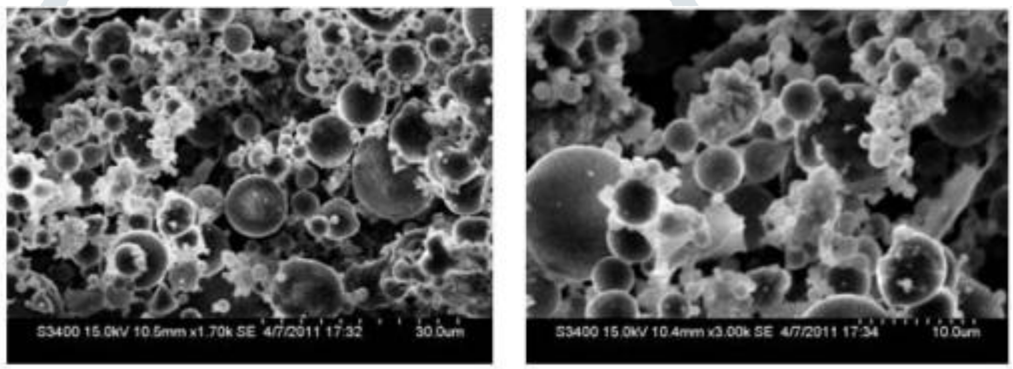
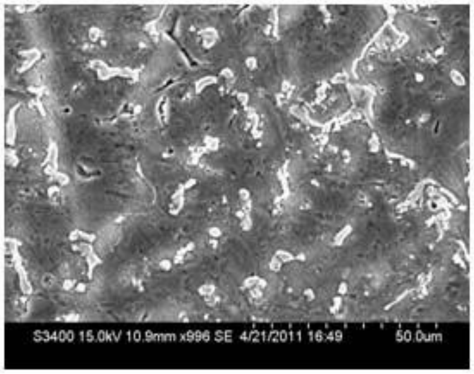
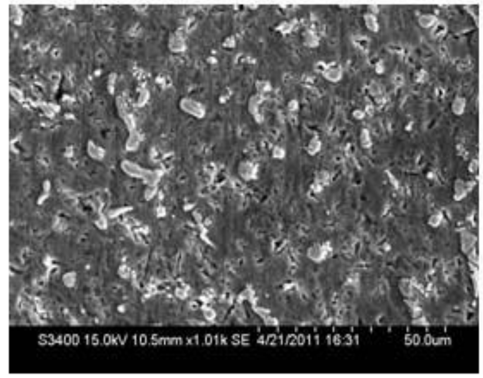


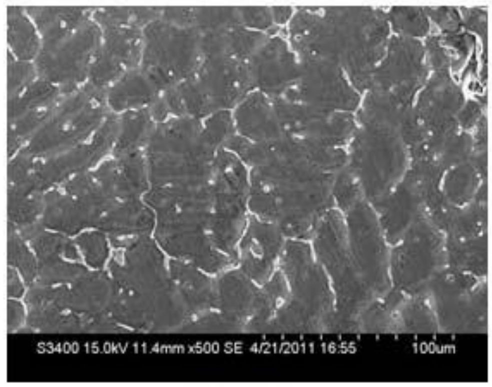
Fig: 1 Scanning Electron Microscopy Photographs of precipitator Flyash



AA2024-2.5



AA2024-5



AA2024-7.5

Fig: 2 Scanning Electron Microscopy Photographs of as cast specimens showing distribution of Flyash in the Aluminium alloy matrix

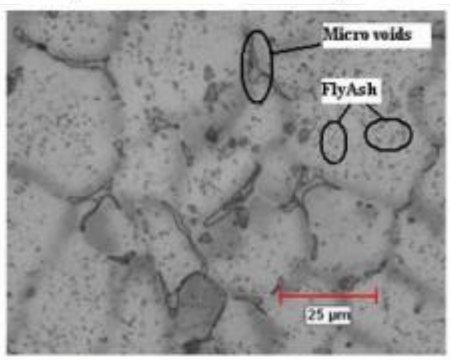


Fig:3 Optical microphotograph of AA 2024-2.5 [500 X]

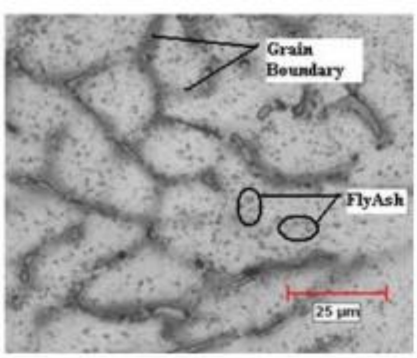


Fig: 4 Optical microphotograph of AA 2024-5 [500 X]

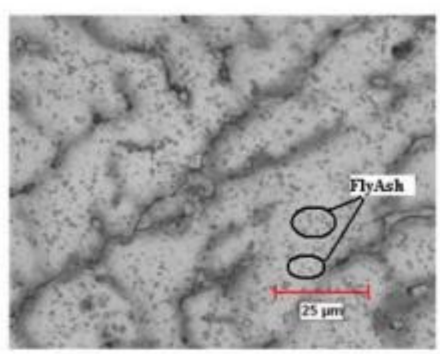


Fig: 5 Optical microphotograph of AA 2024-7.5 [500 X]

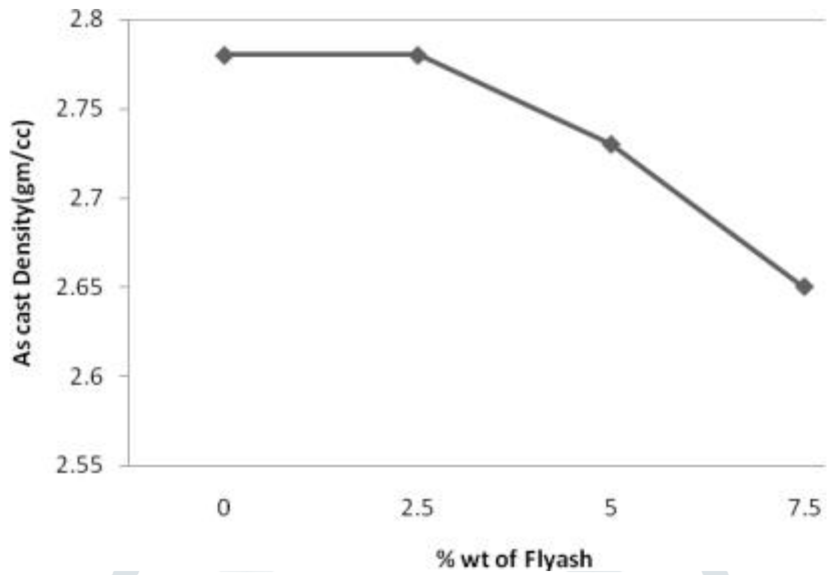


Fig: 6 Variation of as cast density of specimens with % wt of Flyash