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CHARACTERISATION OF ALUMINIUM FLY ASH COMPOSITES USING STIR CASTING TECHNIQUE

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Abstract
Metal matrix composites (MMCs) possess significantly improved properties including high specific strength, specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste byproduct during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles in aluminum alloy will promote yet another use of this low-cost waste by-product and at the same time, has the potential for conserving energy intensive aluminum and thereby, reducing the cost of aluminum products. Now a days the particulate reinforced aluminum matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. The present investigation has been focused on the utilization of abundantly available industrial waste fly-ash in useful manner by dispersing it into aluminum to produce composites by stir casting method.

Introduction
Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles in aluminium alloy will promote yet another use of this low-cost waste by-product and, at the same time, has the potential for conserving energy intensive aluminium and thereby, reducing the cost of aluminium products. Now a days the particulate reinforced aluminium matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys. While investigating the opportunity of using fly-ash as reinforcing element in the aluminum melt, R.Q.Guo and P.K.Rohatagi observed that the high electrical resistivity, low thermal conductivity and low density of fly-ash may be helpful for making a light weight insulating composites. The particulate composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy route by casting. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non-uniform distribution of the particulate due to poor wet ability and gravity regulated segregation.[1,2]
Mechanical properties of composites are affected 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 the increase in volume percentages of fly ash, hardness value increases in Al–fly ash (precipitator type) composites. He also reports that the tensile elastic modulus of the ash alloy increases with increase in volume percent (3–10) of fly ash. Aghajanian have studied the Al_2O_3 particle reinforced Al MMCs, with varying particulate volume percentages (25, 36, 46, 52 and 56) and report improvement in elastic modulus, tensile strength, compressive strength and fracture properties with an increase in the reinforcement content. The interface between the matrix and reinforcement plays a critical role in determining the properties of MMCs..[3]

Composite
Composite materials are a combination of two or more chemically distinct and insoluble phases having properties and structural performance superior to those of the constituents acting independently. Composite has two phases namely matrix phase and reinforcing phase.

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Matrix phase
1. The primary phase, having a continuous character,
2. Usually more ductile and less hard phase,
3. Holds the reinforcing phase and shares a load with it.

Reinforcing phase
1. Second phase is imbedded in the matrix in a discontinuous form,
2. Usually stronger than the matrix, therefore it is sometimes called reinforcing phase.

Classification of composite

On the basis of Matrix:-
1. Metal Matrix Composites (MMC)
2. Ceramic Matrix Composites (CMC)
3. Polymer Matrix Composites (PMC)

On the basis of Material Structure:-
1. Particulate Composites
2. Fibrous Composites
3. Laminate Composites

Metal matrix composite (MMCs)

Metal Matrix Composites are composed of a metallic matrix (Al, Mg, Fe, Cu etc.) and a dispersed ceramic (oxide, carbides) or metallic phase (Pb, Mo, W etc). Ceramic reinforcement may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas Metallic Reinforcement may be tungsten, beryllium etc. MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of other applications. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The biggest disadvantages of MMCs are their high costs of fabrication, which has placed limitations on their actual applications. There are also advantages in some of the physical attributes of MMCs such as no significant moisture absorption properties, non-inflammability, low electrical and thermal conductivities and resistance to most radiations. MMCs have existed for the past 30 years and a wide range of MMCs have been studied.[5]

Stir casting

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.[6]

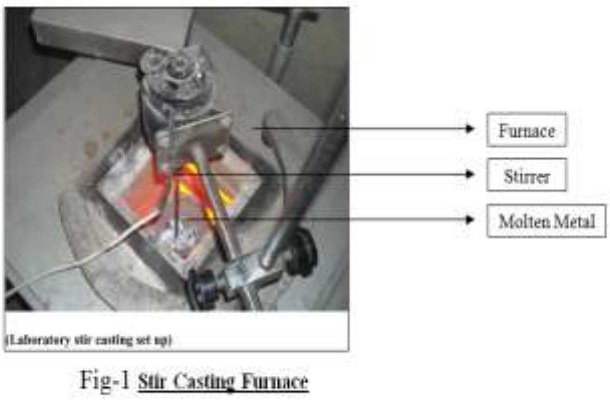

Fig-1 Stir Casting Furnance

Strengthening mechanism of composites

The strengthening mechanisms of the composites are different with different kind of reinforcing agent morphology such as fibers, particulate or dispersed type of reinforcing elements.[7]

Dispersion strengthening mechanism of strengthened composite

Dispersion strengthening is a means of strengthening a material by adding finely divided hard insoluble particles into the soft metal matrix as a result of which the resistance to the motion of dislocation is increased.

Experimental works procedure

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Electric furnace was used for making aluminium fly ash composites. The Graphite Crucible which was made of clay particles was kept inside the furnace. The inner surface of the crucible was coated with graphite (in the form of paste) before kept inside the furnace. When the temperature of the furnace reaches 770°C, aluminium alloy 6063 was placed inside the graphite crucible. The melt was stirred using graphite rod and the degassing agent was dropped into the melt and pushed down until it reaches the bottom of the graphite crucible. The function of the Degasser was to remove the excess Hydrogen and other unwanted elements such as Sodium, Calcium and Lithium. If Magnesium is present in the melt to an excessive extent, the excessive Magnesium likewise can be regarded as a contaminant. If the level of magnesium that is present is not excessive and it is desirable to effect removal of Hydrogen and other unwanted elements without significantly altering the level of Magnesium that is present in the melt. Hydrogen was removed from the melt by diffusion into the rising gas bubbles. This occurred as a result of the difference in partial pressure between the melt and the gas, the rate of diffusion was determined by the partial pressure difference between the gas and the melt, as well as by the surface area of contact between the gas and the melt. The contact time between the gas and the melt was also an important consideration.[4]

5% of fly ash (ie.70g from the total weight of the aluminium) was added little by little to the aluminium alloy-6063 melt for production of composite material. Initially the fly ash particles were preheated to remove the moisture. Matrix material melt was stirred vigorously to form a vortex at the surface of the melt, and the reinforcement particle was introduced at the side of the vortex. The melt temperature was maintained about 800-900°C during the addition of fly ash particles. Then the melt was casting in a die. The temperature of the die was preheated about 300°C in order to prevent cracking during hot metal pouring. The casting was removed from the die after solidification. For the 10% of aluminium fly ash composite, the above mentioned procedure was followed by taking 140 grams instead of 70 grams. For the comparison of aluminium fly ash composites with aluminium alloy, a separate casting was made by the same procedure without addition of fly ash.

Specimens were prepared from the aluminium fly ash composites and unreinforced aluminium alloy for performing the test such as wear, tensile strength, hardness and microstructure

Fig-2 Aluminium Alloy Melt

Fig-3 Casting

Fig-2 Aluminium Alloy Melt

Works done

Aluminium alloy 6063 casting was made.

Aluminium (5%, 10%) fly ash composites were made by stir casting method.

Particle size analysis was done for fly ash used.

Hardness measurement was carried out for Aluminium fly ash composite samples and comparison was done with the unreinforced aluminium alloy.

The wear characteristics of Aluminium fly ash composite samples were evaluated and compared with unreinforced aluminium alloy.

Tensile test was performed on the fly ash aluminium composite and compared with aluminium alloy 6063.

Microstructures of composites and unreinforced aluminium alloy were observed by using suitable coloring etchant (1gm of sodium hydroxide and 4 gms of potassium permanganate in 100ml distilled water) and comparison of 5% and 10% composites with unreinforced aluminium alloy were done

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Results & discussions

The following analysis and tests were performed for comparing the composites with the unreinforced aluminium alloy and found better improvement in 5% and 10% aluminum fly ash composites due to the addition of reinforcing particles (fly ash particles)
Chemical analysis of aluminum alloy6063
Chemical analysis of fly ash
Particle size analysis of fly ash using sieve shaker apparatus
Hardness measurement
Wear behavior
Tensile strength
Microstructure

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