

Production of Aluminium Fly-Ash Composite Using Stire Casting Methods and Charecteristics

Samuel Dillu, Er Sunita Rajbhar

Abstract— In comparison to unaltered alloys, metal matrix composites (MMCs) exhibit significantly improved features such as high specific strength, specific modulus, soaking capacity, and good wear resistance. Composites with low density and low-cost reinforcing are gaining increased interest. Among the several materials employed, ash is one of the most affordable and low-density reinforcements available in huge amounts as a solid waste product of coal combustion in thermal power plants. As a result, composites reinforced with ash are expected to be prohibitively expensive for widespread use in automotive and small engine applications. As a result, it is envisaged that the inclusion of ash particles into aluminium alloys will encourage another use for this low-cost waste while also conserving energy intensive aluminium and therefore lowering the cost of aluminium products. Nowadays, particle reinforced aluminium matrix composites are gaining popularity due to their isotropic qualities and the ability to undergo secondary processing to enable the manufacturing of secondary components. The current work focuses on the beneficial use of plentiful industrial waste fly ash by dispersing it in aluminium to produce composites via the stir casting method.

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

I. INTRODUCTION

Traditional monolithic materials are limited in their ability to combine strength, hardness, and density in an honest manner. Composites are the most promising material of recent interest for addressing these inadequacies and meeting the growing demand for contemporary technologies. In comparison to unaltered alloys, metal matrix composites (MMCs) exhibit significantly improved features such as high specific strength, specific modulus, soaking capacity, and good wear resistance. Composites with low density and low-cost reinforcing are gaining increased interest. Among the several materials employed, ash is one of the most affordable and low-density reinforcements available in huge amounts as a solid waste product of coal combustion in thermal power plants[9] below. As a result, composites reinforced with ash are expected to be prohibitively expensive for widespread use in automotive and small engine applications. As a result, it is predicted that the inclusion of ash particles into Aluminium alloys will encourage alternative use for this low-cost waste while also allowing for the conservation of energy-intensive metal, lowering the cost of Aluminium goods[1]. Nowadays, particle reinforced Aluminium matrix composites are gaining popularity due to their isotropic qualities and the

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ability to undergo secondary processing to enable the manufacturing of secondary components. In comparison to unreacted alloys, cast Aluminium matrix particle reinforced composites have a greater specific strength, specific modulus, and good wear resistance[4]. To investigate the possibility of using fly-ash as a reinforcing material in Aluminium melts, R.Q. Guo and P.K. Rohatgi [7]-[8] discovered that fly-high ash's electrical resistivity, low thermal conductivity, and low density can be advantageous for the fabrication of lightweight insulating composites. By inserting reinforcing particles into the liquid matrix using the liquid metal technique, a particulate composite can be created[9][10]. The casting route is favored because it enables low-volume production. Stir stirring is the simplest and least expensive method of producing liquid state. The only drawback to this technique is the nonuniform distribution of annular material caused by low wetting capacity and gravity regulated separation. The size, shape, and volume percentage of aggregates, matrix materials, and the interface behavior all affect the mechanical properties of composites. Numerous researchers have examined these points. Rohatgi[1] reveals that when the volume proportion of fly ash in composites grows the neural value increases in Al-fly ash (precipitator type) composites. Additionally, they reported that when the fly ash volume percentage grew, the ash alloy's instability increased[3]-[10]. Aghajanian et al[11]. noted an improvement. Matrix and aggregated validation interfaces play a critical role in identifying the attributes of MMCs. Load transmission is necessary for strong and resilient interfaces. The roughness of the interface is determined by the deflection of the crack, and the transition is determined by the relaxation of the top stress near the interface[12][14]. The literatures contain extensive studies on the tribological properties of Al MMCs reinforced with SiC and Al_2O_3 [15-18]. However, data on the friction and wear properties of ash reinforced AMC are quite few. According to Rohatgi, adding fly ash particles to the active alloy significantly boosts its photo resistance to breakdown. They attributed the increase in aluminosilicate component wear resistance to fly ash particles. Fly-ash composed primarily of silica, refractory oxides such as silica alumina, and iron oxide are used as reinforcing phases in this work. A composite containing 13% fly-ash as the strong phase was created. Additionally, the commercially pure user was melted and poured. Then, fly-ash was analyzed for particle size and chemical content. The mechanical, physical, and wear properties of the material were compared to those of a commercially pure user. Additionally, composites were characterized using SEM and EDS.

II. COMPOSITE

Composite material is a material composed of two or more distinct phases (matrix phase and strong phase) and differs significantly from any component in bulk properties. Many common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of

scattered phases in their composition, although they are not considered as composite materials because their properties are similar to their base components (Physical) has the same property of steel as that of pure iron). The favorable properties of composite materials are high hardness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, superior wear resistance, etc.

A MATRIX PHASE

1. Primary stage, a continuous character,
2. Usually more ductile and less rigid phase,
3. Holds the strong phase and shares a load with it.

B REINFORCING PHASE

1. The second phase (or phase) is written in a discontinuous form in the matrix,
2. It is usually stronger than the matrix, so it is sometimes called the reinforcement phase.

Composites as engineering materials generally refer to materials with the following characteristics:

- These are made artificially (thus, except for natural materials such as wood).
- These include at least two different species with a well-defined interface.
- Their properties are influenced by the volume percentage of the components.
- At least one of these assets is not held by the individual component.

The overall performance depends on:

- a) Properties of Matrix and Reinforcement,
- b) Size and distribution of components,
- c) Size of the components,
- d) Nature of interface between components.

- **Classification of Composites**
Composite materials are classified;

1. Based on the matrix content,
2. Depending on the filler material

III. Stir casting method of manufacturing MMC

Liquid state fabrication of metal matrix composites involves the dispersed state in the molten matrix metal, followed by its solidification.

To provide high levels of mechanical properties of the composite, good interfacial bonding (wetting) must be achieved between the dispersed state and the liquid matrix.

Wetting correction can be achieved by coating dispersion phase particles (fibers). Proper coating not only reduces interfacial energy, but also prevents chemical contact between the dispersed state and the matrix.

The simplest and most effective method of liquid state formation is Stir casting.

3.1 Stir casting

Stir casting is a liquid phase method of manufacturing composite materials, in which a dispersed phase (ceramic particles, small fibers) is mixed with a molten matrix metal by means of mechanical stirring.

Liquid composite materials are then cast by conventional casting methods and can also be processed by traditional metal forming technologies.

3.1.1 Stir casting is characterized by the following characteristics:

- The dispersed phase content is limited (usually no more than 30 vol.%).

The distribution of phase scattered throughout the matrix is not completely homogeneous:

1. Local clusters of dispersed particles (fibers)
 2. Gravitational separation of the dispersed state can occur due to the difference in density of dispersed and matrix phase.
- Technology is relatively simple and low cost.

If in the semi-solid state, the distribution of the scattered phase can be improved.

The method is called re-casting using a metal composite material in a semi-solid state. The high viscosity of the semi-solid matrix material enables better mixing of the dispersion phase.

3.2 MATERIALS STRENGTHENING SYSTEM

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

3.3 A MIXED STRUCTURE'S FIBER 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.

3.4 The expression of the organized composition's 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.

3.5 Partnership Composites with Stable Mechanisms

Particulate reinforced composites have a particle size greater than 1 μm , 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, a large number of clutters is 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).

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 1 μm to 100 μm [22] with a specific surface area, typically between 250 and 600 m^2/kg . The specific gravity of fly ash varies in the range 0.6–2.8 g cm^{-3} . 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 coals, 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} [23]. Coal fly ash has many uses [24] 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.

3.6 FLY ASH

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3.7 The chemical composition of the substance has an effect.:

Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The main difference between these classes is the amount of calcium, silica, alumina and iron content in the ash. The chemical properties of fly ash are largely influenced by the chemical content of burned coal (ie, anthracites, bituminous and lignite).

a) Class F fly ash

Class F fly ash is typically produced by the combustion of harder, older anthracite and bituminous coal. This fly ash is naturally pozzolanic, containing less than 13% lime (CaO). Due to their pozzolanic properties, the glassy silica and alumina in Class F fly ash require the presence of a cementing agent such as Portland cement, quicklime, or hydrated lime, as well as water, to react and form cementitious compounds. Alternatively, by adding a chemical activator to a Class F ash, such as sodium silicate (water glass), a geopolymer can be formed.

b) Class C fly ash

In addition to possessing pozzolanic properties, fly ash produced by the combustion of younger lignite or sub bituminous coal possesses some self-cementing properties. Class C fly ash will harden and gain strength over time in the presence of water. The lime content of Class C fly ash is typically greater than 20%. (CaO). In contrast to Class F fly ash, which requires an activator, self-cementing Class C fly ash does not. Class C fly ashes typically have a higher alkali and sulphate (SO_4) content.

3.8 Based on size, shape and structure:

a) Precipitator Fly Ash

It is spherical in nature the spheres are solid and the density is in the range of $2.0\text{--}2.5\text{ g cm}^{-3}$.

b) Cenosphere Fly Ash

It is also spherical in shape, but they are spherical in color, so the density of such fly ash is much lower than that of the precipitator fly ash. The density here is less than 1 g cm^{-3} ($0.3\text{--}0.6\text{ g cm}^{-3}$).

c) Why FLY ASH?

1. The preference for using fly ash as a filler or consolidation in metal and tool matrices is that fly ash is a by-product of coal combustion, which is available in very large quantities (80 million tons per year) at very low cost. Because it is too much. Currently the land is vacant. Currently, there are limited equipment in use for manufactured glass microphases, mainly due to the high cost of production. Therefore, the material cost of the composites has been significantly reduced by incorporating fly ash in matrices of polymer and metallic alloys. However, little information is available to aid in the design of composite materials, although only an attempt has been made to include fly ash in both adapter and metal matrices. Cenosphere fly ash has lower density than talc and calcium carbonate, but slightly higher than glass. Cenosphere is likely to cost much less than glass. The nanosphere may be one of the lowest cost filler in terms of cost per cell.

2. High electrical resistivity, low thermal conductivity and low density of fly-ash can be helpful for making light weight platelet composites.

3. Fly ash as filler in Al casting reduces cost, reduces density and increases cough, cough, wear and abrasion resistance [23]. This is an improvement in machinability, shago capacity, coefficient of coefficient, etc., which are required in various industries, such as automotive.

4. As the production of Al is reduced with the use of fly ash. This reduces the generation of greenhouse gases as they are generated during bauxite and blackmina cuts.

VI. Experiments Details

The aim of this study is the potential application of fly-ash as a low-cost adsorbent for the removal of metal ions, especially, Cu^{2+} , Pb^{2+} , Cr^{3+} , Cd^{2+} , Co^{2+} and Ni^{2+} , from mine wastewater. was to be examined. To maximize its adsorption capacity, different modification procedures of coal fly-ash samples were designed, and the results compared. Samples of pristine and modified coal fly-ash were characterized, and their adsorption properties were compared along with their properties and problems in preparation. The optimal preparation was decided in further study. The fly-ash system alone was examined at pH conditions and in the presence of each metal ion solution to reduce the possibility of metal hydroxide formation during adsorption studies. Other adsorption properties such as adsorption amount, adsorption kinetics and the effect of temperature on adsorption were investigated. The maximum adsorption capacity of a given adsorbent for each metal ion was also studied in both synthetic water samples and mine water. The adsorption kinetic model was also investigated. To estimate the potential application of fly-ash, column studies and adsorption/desorption cycles of the material was also investigated. To increase its applicability in real

environmental systems, some preliminary studies on fly-ash powder moulding were also conducted.

First, 400 g of commercially pure Aluminum was melted into a resistant 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 (13%) was prepared by a mixed casting route. For this, we took 400 grams of commercially pure active and 52 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 the melting of fly-ash particles. The molten temperature was maintained at 953K – 993K while adding particles. Then melted clay graphite was applied to 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-13% 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. The detention time for defect measurement was 30 seconds.

The wear characteristics of a commercially pure Al and Al-13% fly-ash composite was 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-13% fly-ash composite. Was tested 68.68 N load and 500 rpm for 10 minutes.

VII. Results

1. Commercially pure Al was melted and poured.
2. Al-13% fly-ash composite was manufactured by the stir casting method.
3. Chemical composition analysis was done for fly-ash.
4. Particle size analysis was performed for fly-ash use.
5. Density and neural measurements were performed for both commercially pure Al samples and Al-13% fly-ash composite samples.
6. The wear characteristics of both commercially pure Al and Al-13% fly-ash composite was evaluated and compared.

VIII. Conclusion

Alternative methods for making aluminium matrix composites have been identified, with the stir casting method receiving particular interest. This method briefly discusses the weight or volume fraction of Al Fly-Ash in the composite, the Al Fly-Ash particulate size, the Al Fly-Ash preheating temperature, the preheating and melting temperature of Al matrix, the stirring speed all through agitation of the composite liquid phase, the use of flux, wetting agent, the preheating temperature of the mould, and the trying to pour temperature of the composite slurry into the mould.

References

- [1] P.K. Rohatgi, JOM 46 (11) (1994) 55–59.
- [2] T.P.D. Rajan, R.M. Pillai, B.C. Pai, K.G. Satyanarayana, P.K. Rohatgi, Proceedings of National Conference on: Recent Advances in Materials Processing (RAMP-2001), India, 2001, pp. 327–334.

- [3] P.K. Rohatgi, R.Q. Guo, P. Huang, S. Ray, Metall. Mater. Trans. A 28 (1997) 245–250.
- [4] Akbulut, M. Darman, F. Yilmaz, Wear 215 (1998) 170.
- [5] S. Skolianos, T.Z.Kattamis, Mater.Sci.Engg.A163 (1993) 107.
- [6] M.K.Surappa, S.C.Prasad, Wear 77 (1982) 295.
- [7] R.Q.Guo, P.K.Rohatgi, Fuel and energy Abstracts, (1997) 828.
- [8] R.Q.Guo, P.K.Rohatgi, Fuel and energy Abstracts, (1997) 157.
- [9] M.J.Koczak, M.K.Prem Kumar, JOM 45 (1993) 44.
- [10] P.C.Maity, P.N.Chakraborty, S.C.Panigrahi, Scripta Metall. Mater. 28 (1993) 549.
- [11] M.K. Aghajanian, R.A. Langensiepen, M.A. Rocazella, J.T. Leighton, C.A. Andersson, J. Mater. Sci. 28 (1993) 6683–6690.
- [12] T.W. Clyne, P.J. Withers, An Introduction to Metal Matrix Composites, Cambridge University Press, Cambridge, UK, 1993, pp. 166–217.
- [13] E.A. Feest, Composites 25 (1994) 75–86.
- [14] T.P.D. Rajan, R.M. Pillai, B.C. Bai, J. Mater. Sci. 33 (1998) 3491–3503.
- [15] L. Cao, Y. Wang, C.K. Yao, The wear properties of an SiC–whisker reinforced aluminium composite, Wear 140 (1990) 273–277.
- [16] B.N. Pramila Bai, B.S. Ramashesh, M.K. Surappa, Dry sliding wear of A356-Al–SiCp composites, Wear 157 (1992) 295–304.
- [17] Manish Narayan, M.K.Surappa, B.N. Pramila Bai, Dry sliding wear of Al alloy 2024–Al₂O₃ particle metal matrix composites, Wear 181–183 (1995) 563–570.
- [18] Ravikiran, M.K. Surappa, Oscillations in coefficient of friction during dry sliding of A356 Al-30% wt. SiCp MMC against steel, Scripta Mater. 36 (1997) 95–98.
- [19] S.Bandyopadhyay, T.Das, and P.R.Munroe, Metal Matrix Composites -The Light Yet Stronger Metals For Tomorrow, A Treatise On Cast materials, p-17-38.
- [20] T.W.Clyne, (2001), Metal Matrix Composites: Matrices and Processing, Encyclopedia of Materials : Science and Technology, p- 8
- [21] Composite Materials: Engineering and Design by F.L.Matthews and R.D.rawlings, Chapman & Hall publication
- [22] Neville AM. Properties of concrete. 4th ed. NY, USA: John Wiley & sons, Inc.; 1996.
- [23] T. Matsunaga, J.K. Kim, S. Hardcastle and P.K. Rohatgi, Crystallinity and selected properties of fly ash particles, Materials Science and Engineering A325 (2002) 333–343
- [24] 2004 Coal combustion product (CCP) production and use survey, American Coal Ash Association. ([http://www.aaa-usa.org/PDF/2004_CCP_Survey\(9-9-05\).pdf](http://www.aaa-usa.org/PDF/2004_CCP_Survey(9-9-05).pdf)).

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