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Studies on Microstructure, Mechanical Properties of Flyash Reinforced AL3003 MMCs

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***Abstract*— Generally, aluminum and aluminium alloys have high ductility and corrosion resistance. Aluminium 3003 alloy has modest strength and good corrosion resistance. The strength of this alloy can be increased by adding reinforcement. There is an increase in the applications of Al-MMCs having low density and low-cost reinforcements. Amid several reinforcements used, flyash is the least expensive particles are used in MMCs, which are low cost, and low density are obtainable in large measures of waste by-product in power plants. This study investigates the effect of A3003 matrix alloy reinforced with different weight fraction of flyash (1% ,3% and 5 %) fabricated through liquid metallurgy route and studied for their microstructure and mechanical properties of these MMCs and later were compared with as-cast 3003 alloy.The studies showed that as the reinforcement is increased upto 3 Wt %, the mechanical properties of the composites increased and further increase in reinforcement to 5 Wt % the strength of composite reduced slightly. The Microstructure showed uniform distribution of flyash particle distributed in the A3003 matrix. The current work gives insight of the casting technique and characterization of flyash reinforced Al3003 MMCs.**

Keywords— A3003 alloy, Flyash, Stir casting, Microstructure , Hardness ,Compression.

INTRODUCTION

A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. In the era of day to day technological advancement, in some way or the other, the environment is affected. Several investigators have developed composites by means of diverse reinforcements such as nitrides , oxides and carbides [1-6]. The fabrication of low-cost metal matrix composites reinforced with environment friendly material is the excellent invention in the field of material science. Aluminum- fly ash composite is metal matrix dispersion strengthened composite in which soft and ductile aluminum matrix is strengthened by hard and brittle fly ash particles. This lowers the cost, save the energy of minimal quantity aluminium production , also it is eco-friendly. Reinforcement in the metal matrix increases the strength, weight and durability of the material in comparison to the non-reinforced metal matrix. Aluminium alloys reinforced with fly ash material is one of the leading invention which has superior mechanical properties. This material has vast application in the field of automobile, aircraft and allied industries. 3003 aluminium alloy is an alloy in the wrought aluminium-manganese family (3000 or 3xxx series). 3003 is a general-purpose alloy with moderate strength, good workability, and good corrosion resistance. This study investigates the effect of A3003 matrix alloy reinforced with different Weight fraction of fly ash (1% ,3% and 5 %) fabricated through liquid metallurgy route and studied for their microstructure and mechanical properties of these MMCs and later were compared with as-cast 3003 alloy .The studies showed that as the reinforcement is added the strength of the composites increased upto 1 % and 3%, and later reduced drastically as the reinforcement percentage increased to 5%. MMC was manufactured with the help of a stir casting process.

Stir casting is a liquid state method for the fabrication of composite materials, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost-effective method of liquid state fabrication. The current work gives insight of the

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casting technique and characterization of fly ash reinforced Al3003 MMCs.

I. LITERATURE SURVEY

Narayana et al. [7] examined mechanical properties of silicon carbide (SiC) particulates and Short E-Glass fibers reinforced Aluminum 3003 matrix composites (AMCs) by vortex method of stir casting. The Hybrid MMCs is developed by reinforcing SiC particulates of 100 microns and short E-Glass fibers of 2-3 mm length with Al 3003 in different compositions. From the studies it was noticed that an improvement in mechanical properties of the reinforced alloys compared to unreinforced alloys.

Kumar et al. [8] studied mechanical properties of titanium dioxide (TiO2) particulates reinforced Aluminum 3003 matrix composites (AMCs) by friction stir process . Five samples were ready by addition of TiO2 with wt% ratio as 0%, 1.5%, 3%, 4.5%, and 6.0%. Microstructure analysis on the characteristics behavior of composite using various techniques like FESEM, XRD, EBSD and TEM was conducted and compared with the as-cast A3003 alloy. Mechanical and wear characteristics on chunk zone were assessed by performing tests for impact strength, bending strength, and wear resistance. Mechanical and tribological behavior of composite is found to be beneficial as compared with as-cast A3003 alloy.

Sozhamanna et al. [9] studied usage of gasoline pressure penetration solution to produce A356 fly ash cenosphere MMCs with reinforcement scale fraction from 20 to 65 Wt %. The developed Al 356 fly ash cenosphere composites showed better mechanical and wear properties compared to as-cast A357 alloy. Based on the literature survey conducted it can be noted that very less work has been conducted on characterization of Al3003 MMCs.

II. OBJECTIVES

- Fabrication of Al3003/Flyash composites by stir casting method.
- Microstructure characterization of the composites using optical microscope
- Evaluation of mechanical properties of Al3003 composites.
- Comparing the results of mechanical of as cast alloy with Al3003 composites.
- Drawing conclusion based on the obtained results.

III. METHODOLOGY

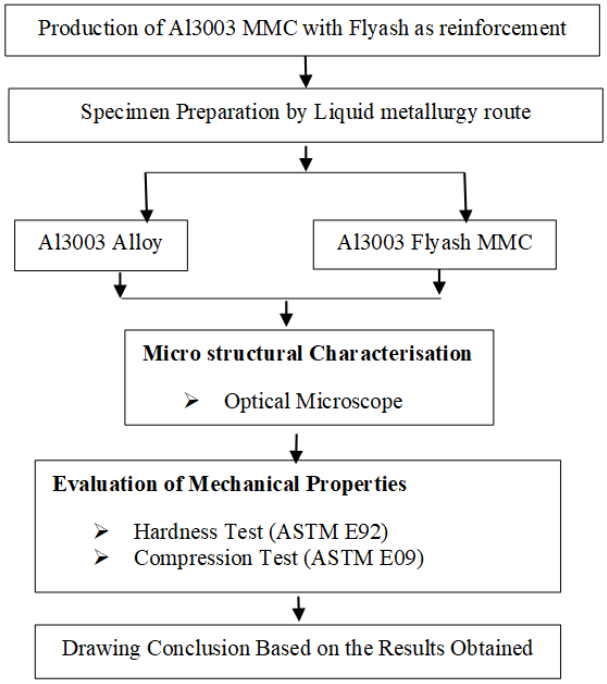

Figure 1. Flow Chart of Experimental Work

IV. EXPERIMENTAL SETUP.

A. *Stir Casting*

Liquid metallurgy route i.e. stir casting method is used to progress flyash reinforced composites. The aluminium 3003 alloy is sliced into small pieces and then fed into the graphite crucible of an induction furnace and heated to a temperature approximately 7500C . Once the aluminium is melted , flyash of measured proportion is fed into the furnace .Later the stirrer is stirred for 15 minutes to make sure the particles are distributed in the Al3003 alloy. Later the liquid alloy prepared is poured to the mould to prepare composites.

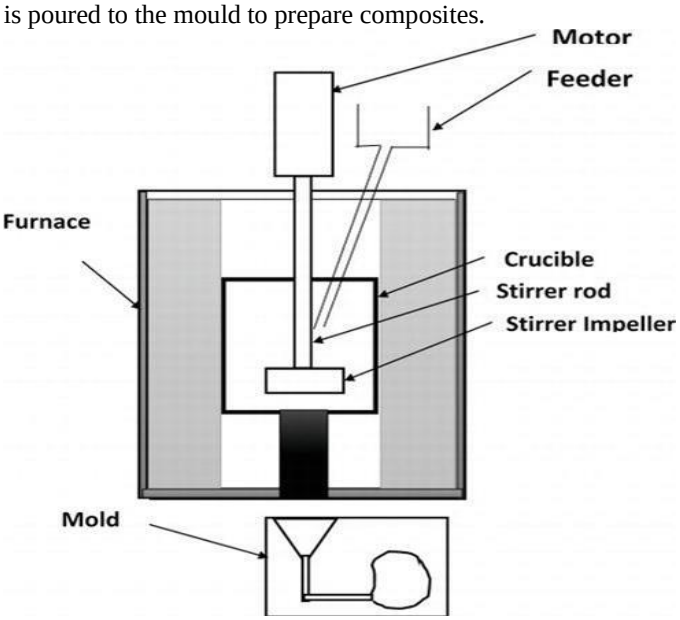

Figure 2. Stir Casting Setup[10]

B. *Microstructural Characterization*

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Microstructural analysis of Al3003 alloy and its composites were characterized using optical and scanning electron microscope.

C. *Mechanical Testing*

- The hardness test was conducted using brinell hardness tester .The sample was placed below the stand. Ball indenter of 5mm diameter was used .A major and minor load was applied by using lever mechanism for about 20 seconds and later released. The indentation diameter was measured using traveller's microscope .
- The compression test was conducted using universal testing machine. The compression test was conducted to measure compressive load .

V. RESULTS & DISCUSSION

A. *Hardness Test results of A3003 alloy and its Flyash composites*

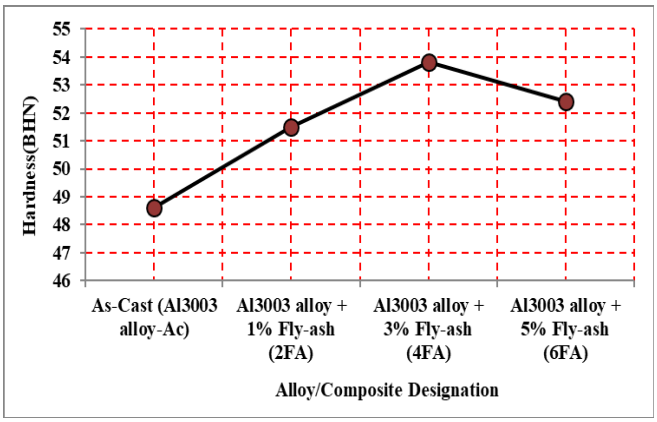

Figure 3. Hardness test values of A3003 alloy and its Flyash composites

Figure 3 shows the hardness test plot of A3003 alloy and its flyash composites .From the figure 3 we can see that there is a slight increase in hardness values of the flyash composites compared to as-cast 3003 alloy. The percentage increase in hardness values of Al3003 alloy reinforced with 1% ,3 % and 5% Flyash was found to be 5.96 %, 10.69 %, and 7.81 % respectively . The increase in hardness values was due even dispersal of flyash in the A3003 matrix alloy. From the figure we can observe that as the percentage of flyash increases, the hardness increases upto 3% and then reduces when the percentage of flyash increased upto 5%.This is due to the clustering of flyash particle as the percentage is increased upto 5% as seen in Figure 4. Also fly ash acts as strengthening to matrix leading to improvement in hardness [11].

B. *Microstructural characterization of A3003 alloy and its Flyash composites using Optical Microscope*

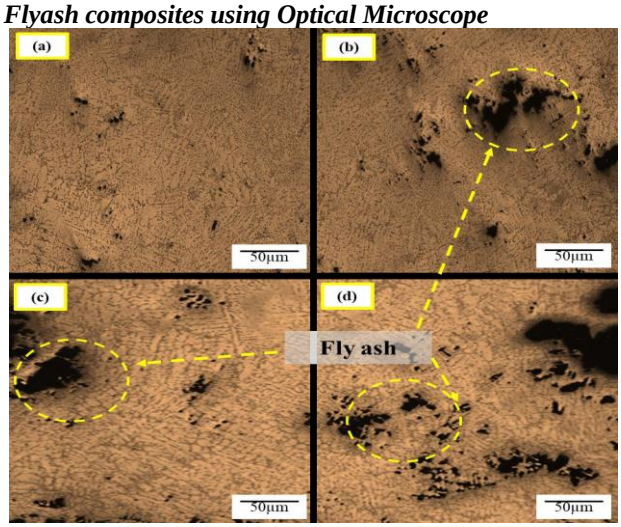

Figure 4. Microstructure Characterization of A3003 alloy and its fly ash composites using Optical Microscope, Where (a) A3003 alloy (b) Al303 alloy + 1% Flyash (c) Al303 alloy + 3% Flyash (d) Al303 alloy + 5 % Flyash

Figure 4: Microstructure characterization of A3003 alloy and its composites using Optical Microscope. From Figure 4(a) we can see paralleled fine grains in A3003 as-cast alloy. From 1(b-d) shows the optical micrograph of A3003 alloy reinforced with 1%, 3% and 5% Flyash . From the micrographs we can see the even dispersal of Flyash in the A3003 matrix. These observations are in agreement with other researchers [12].

C. *Compression Test results of A3003 alloy and its Flyash composites*

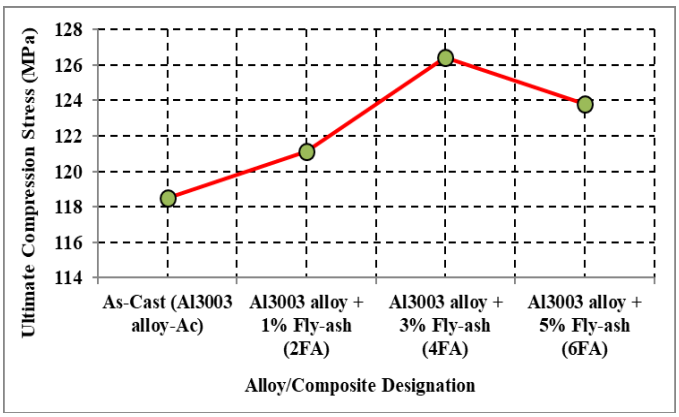

Figure 5: Compression test values of A3003 alloy and its Flyash composites

Figure 5 shows the compression test plot of A3003 alloy and its flyash composites .From the figure 3 we can see that there is a slight increase in hardness values of the flyash composites compared to as-cast 3003 alloy. The percentage increase in compression values of Al3003 alloy reinforced with 1% ,3 % and 5% Flyash was found to be 2.19 %, 6.66 %, and 4.47 % respectively . The increase in compression strength values was due even dispersal of flyash in the A3003 matrix alloy. From the figure we can observe that as the percentage of flyash increases, the compression strength increases upto 3% and then reduces when the percentage of

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flyash increased upto 5%.This is due to the clustering of Flyash particle as the percentage is increased upto 5% as seen in Figure 4. Also fly ash acts as strengthening to matrix leading to improvement in compression strength [13].

VI. CONCLUSION

From the tests conducted in order to determine the mechanical properties of Flyash reinforced Al3003 composites of different weight fractions (1% ,3 % and 5%) of the reinforcement, it was found that:

1) The Optical Micrographs of polished specimens, the following was observed:

- The dispersal of Flyash is found to be uniform in A3003 matrix
- The Flyash Particles has caused good wetting with the A3003 matrix which further leads in the improvements of the hardness and compression properties.

2) Flyash particles as a reinforcement helped in increasing the hardness (BHN) of A3003 from 48.6 (BHN) as per the following:

- 1% Flyash – 51.5 (VHN) (5.96 % increase)
- 3% Flyash – 53.8 (VHN) (10.69 % increase)
- 5% Flyash – 52.4 (VHN) (7.81 % increase)

3) Flyash particles as a reinforcement helped in increasing the Compression strength (UCS) of A3003 from 118.5 (UCS) as per the following:

- 1% Flyash – 121.1 (UCS) (2.19 % increase)
- 3% Flyash – 126.4 (UCS) (6.66 % increase)
- 5% Flyash – 123.8 (UCS) (4.47 % increase)

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