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Fabrication and Characterization of Aa2024 Composites

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Abstract

The Aluminium alloy-based metal matrix composites (AMMCs) are fast emerging due to their favorable properties like light weight, low density, high specific strength, high hardness, high temperature and thermal shock resistance, superior wear and corrosive resistance and finally high strength as compared to ordinary alloys. Composites are fabricated using aluminium alloy (AA-2024) as base matrix and silicon carbide and Fly ash as reinforcements.

This aim and objective is to produce AMMCs through stir casting process and study of Microstructural characteristics and mechanical properties with aluminium matrix, reinforced with silicon carbide (SiC) and FlyAsh (FA). In this study, Aluminium (AA-2024) is reinforced with Silicon Carbide (SiC) particles with the addition of fly ash, which is limited to 5% per composite. The MMCs are fabricated using stir casting technique. Various specimens are developed undergoing different weight fractions of SiC and fly ash in AA-2024. Homogenization and heat treatment processes (aging and solution treatment) are performed on the specimen to obtain uniformity in the metal matrix. Microstructural analysis is done on the specimen and it was found that for different weight fractions of SiC and Fly ash in the matrix composite (5% Fly ash only, 5% Fly ash + 6% SiC, 5% Fly ash + 8% SiC), the phases are uniformly distributed. Successful incorporation of SiC and Fly ash in base AA2024 alloy is found by the micro structural examination in the Olympus microscope. Upon examination, it is observed that the fine grains in the matrix are Fly ash particles and the coarser grains are Silicon Carbide. And by conducting Brinell hardness tests and tensile tests it was fairly observed that the hardness was increased. It was observed that thereis increase in tensile strength but elongation of the hybrid metal matrix composites in comparison with unreinforced aluminum was decreased.

Keywords: *Hybrid Metal matrix composites, Homogenization*

1. Introduction

Unevenly reinforced aluminum matrix composites are fast evolving as engineering materials and challenging with common metals and alloys. They are gaining significant acceptance because of higher specific strength and good wear resistance as compared to ordinary unreinforced alloys [9]. Reinforcing particles used in this study are fly ash particles and silicon carbide are added externally. Because of good machining characteristics, higher strength and fatigue resistance than both 2014 and 2017. It's applications mainly in aircraft structures, especially fuselage structures under tension and wings.

Aluminium alloy 2024 is also used in high temperature applications such as in automobile engines and in other rotating and reciprocating parts such as piston, brake rotors and in other structural parts where light weight and high strength materials [8] is the requirement. One of the main limitation of this material system is that they show poor tribological properties. Hence there is need in the engineering society to develop a new material with greater wear resistance and better tribological properties, without much compromising on the strength to weight ratio led to the development of metal matrix composites.

2. Experimental Procedure:

2.1. Materials:

Silicon Carbide is the merely chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It's applications mainly are in abrasives, refractoriness, ceramics The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Silicon carbide is poised of tetrahedral of carbon and silicon atoms by means of strong bonds in the crystal lattice. This produces a very hard and strong material. The usage of fly ash as a reinforcement in metal and polymer matrices is that fly ash is a byproduct of coal combustion, available in very large quantities (80 million tons per year) at very low costs since much of this is currently land filled. At present the use of manufactured glass microspheres has limited applications due mainly to their high cost of production. The cost of material of composites can be reduced significantly by incorporating fly ash into the matrices of polymers and metallic alloys.

Fly ash is low density material and it is cheap. Availability of fly ash is more as it is solid waste derivative during combustion of coal in thermal power plants.The challenges and opportunities of aluminium matrix composites have been discussed[14].The addition of reinforcing phase radically improves the tribological and mechanical properties of aluminium and its alloy system[5-7]. The idea behind the development of hybrid metal matrix composites is to combine the desirable properties of aluminium, silicon carbide and fly ash. Aluminium contain useful properties such as high strength, ductility, high thermal and electrical conductivity but have low stiffness whereas silicon carbide and fly ash are stiffer and stronger and have excellent high temperature resistance but they are brittle in nature.

2.2. Preparation of Specimens:

In a stir casting process, the reinforcing phases are dispersed into molten Aluminum by mechanical stirring. Stir casting of metal matrix composites was initiated in 1999 [12] Mechanical stirring in the furnace is a key element of this process. The ensuing molten alloy with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

Figure 1.Crucible in Stir casting machine

Figure 2.Inside Die when casted

Figure 3.Specimens after casting

Specimen Compositions:

1. **AA 2024 base matrix**
2. **AA2024 + 5 % fly ash**
3. **AA2024 + 6% SiC + 5 % fly ash**
4. **AA2024 + 8% SiC + 5 % fly ash**

(items 2–4: **Hybrid MMC's**)

2.3. Heat Treatment:

2.3.1. Homogenization:

Heat treating processes for aluminium are precision processes. Prepared composites are to be carried out in furnaces properly designed and built to provide the thermal conditions required, and effectively equipped with control apparatus to assure the desired continuity and uniformity of temperature-time cycles. To ensure the final desired characteristics, process details must be established and controlled carefully for each type of product.

2.3.2. Solution Heat treatment:

The prepared specimen has to subjected to a heat treatment process whereby the alloying constituents are taken into solution and retained by rapid quenching. Consequently because of heat treatment i.e. ageing or natural ageing at room temperature precipitation of the constituents takes place thereby achieving increased hardness and strength

2.4. Microstructure Characterization of AA2024/FA/Sic Composites:

The high thermal conductivity united with low thermal expansion and high strength gives the composite material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities keep their strength to very high temperatures, approaching 1600°C with no strength loss.It is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. At present materials has been developing into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics and numerous high-performance applications. Prepared mounted specimens are shown in figure 4.

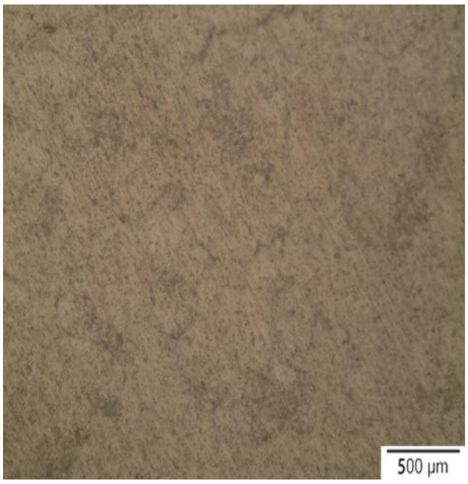
Figure 4. Mounted Specimens for Microstructures

3. Results and Discussions:

3.1. Microstructures:

Different types of optical microscope are generally used to inspect flat, polished and etched specimens like inverted microscope and reflection microscope. Recording the image is achieved using a digital camera working through the eyepiece. Usually, microstructure analysis of metals confirms structure and property relationships. Examinations are completed according to detailed procedures and applicable industry standards to assure reliable results.

Alloy AA2024 without reinforcement Multi-phase microstructure with inter-metallic particles uniformly distributed. The microstructure shows the uniform distribution of flyash in the matrix with a very little agglomeration. The microstructure witnesses the uniform distribution of flyash and SiC particles. Large amount of agglomeration of flyash and little agglomeration of SiC is observed. The microstructure witnesses the uniform distribution of flyash and SiC particles. Large amount of agglomeration of flyash and higher percentage of SiC is observed compared to earlier structure.



igure 5. Microstructure of AA2024 Alloy

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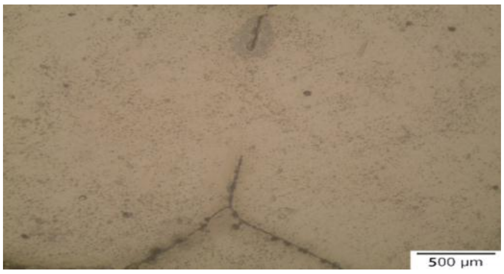

Figure 6. Microstructure of AA2024+5% Fly Ash Alloy

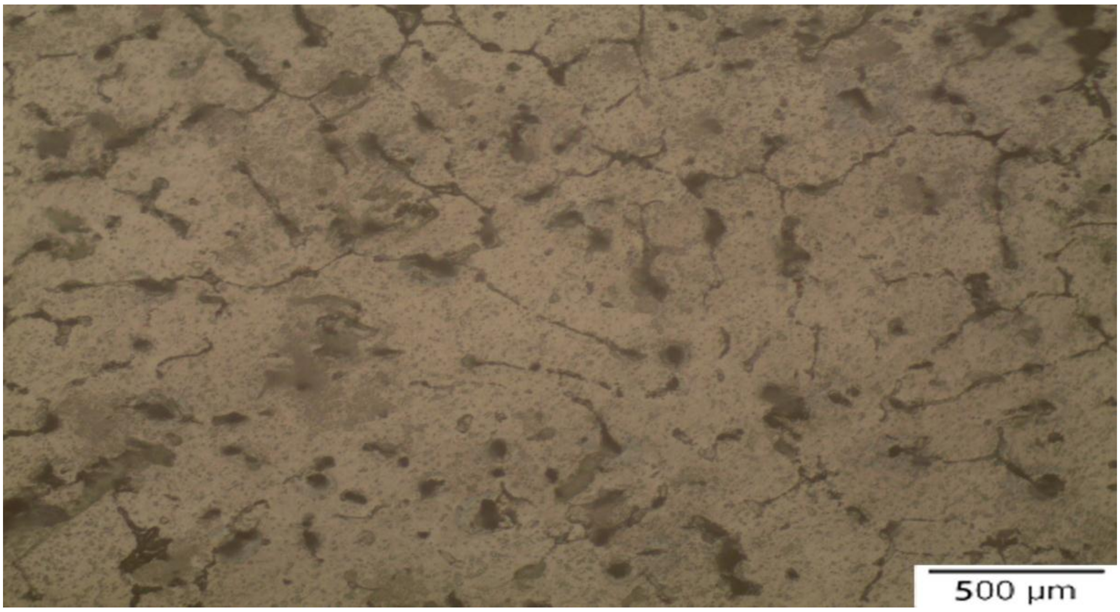

Figure 7. Microstructure of AA2024 Alloy + 6% SiC + 5% Fly Ash

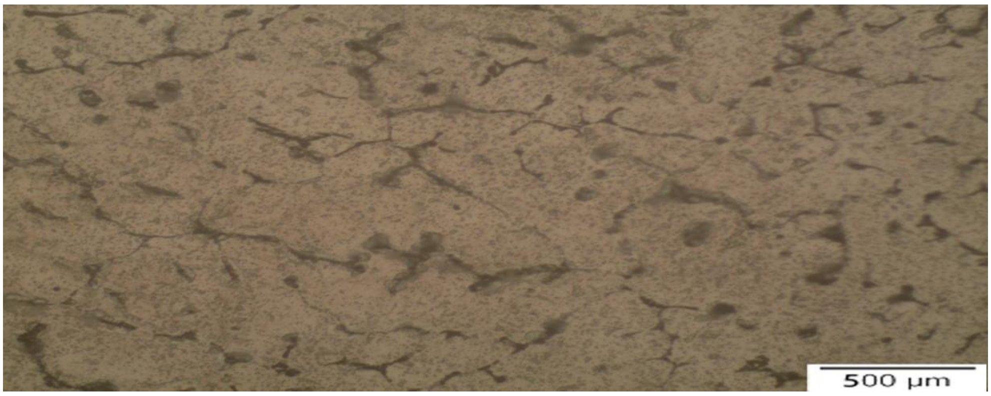

Figure 8.Microstructure of AA2024 Alloy + 8% SiC + 5% Fly Ash

3.2.Hardness:

Hardness measurements were carried out on the pure metal and composite samples by using Brinell hardness test machine. Brinell hardness measurements were carried out in order to examine the influence of particulate weight fraction on the matrix hardness. Load applied was 60 kgf and indenter used was round steel ball of diameter 2.5mm. Samples used for the hardness tests are shown in Table 1.

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Table 1. Hardness

S.NO	% Wt	BHN Value
1.	Pure AA2024	98.47
2.	5% Fly Ash	116.227
3.	6% SiC + 5% Fly ash	126.727
4.	8% SiC + 5% Fly ash	138.673

The Bar graph of the experimental hardness of the composites according to the SiC, fly ash and their mixtures is shown in Figure 9. Increasing drift of hardness was observed with increase in weight fraction of SiC, fly ash and their mixtures. It is observed that the maximum hardness is observed at Al/ (8%SiC+5%fly ash), which may leads to the deformation when subjected to strain. Amalgamation of fly ash particles with this drastically improves the hardness and also the deformation of the Al matrix. It is observed that the fact that the combination of SiC with flyash particles possess higher hardness than the aluminium. Addition of magnesium improves the wettability between the reinforcement particles and enhances the mechanical properties of the composites by solid solution strengthening. In addition, mechanical stirring in the semisolid state enhances the uniform distribution between them.

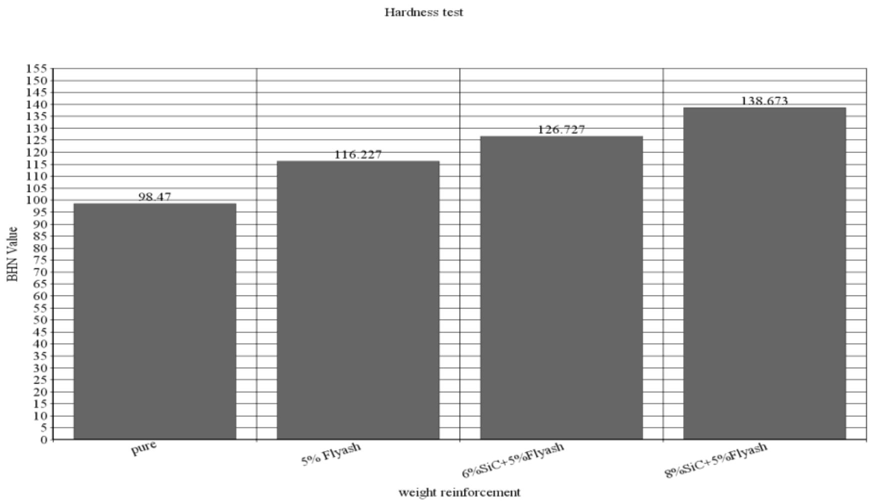

Figure 9. Hardness Test Comparison

4. Conclusion:

Al-fly ash, Al-SiC-fly ash (various concentrations) composites were successfully fabricated by stir casting process. Wetting of reinforcements with the aluminium matrix was further improved by the addition of magnesium. Based on the experimental results the following conclusions have been drawn:

- Tensile strength and hardness were determined for the test materials. Increase in area fraction of reinforcement in matrix result improved after the heat treatment process have been undergone by the specimens of tensile strength and hardness

- With the addition of SiC and fly ash with higher percentage the rate of elongation of the hybrid MMCs is decreased significantly
- Optical micrographs revealed that both the SiC and flay ash particles are well distributed in aluminium matrix

From the above results we can conclude that instead of Al-fly ash composites, the Al-SiC-flyash composites could be considered as an exceptional material in sectors where lightweight and enhanced mechanical properties are essential.

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