ISSN (Print) : 2319-8613
ISSN (Online) : 0975-4024

A Comparative Study on Al-7Si-Fly Ash and Al-7Si-Graphite Composites Fabricated by Liquid Metallurgy

Nagaraj N[1] , Mahendra K V[2] and Madeva Nagaral[3]

[1]Research Scholar, Selection Grade Lecturer, Department of Mechanical Engineering, APS Polytechnic, Bengaluru -560082, Karnataka, India

[2]Professor and Principal, Jyothy Institute of Technology, Tataguni Post, Bengaluru-560062, Karnataka, India

[3]Design Engineer, Aircraft Research and Design Centre, HAL, Bengaluru-560037, Karnataka, India

***Abstract*— this work investigated the influence of Fly ash and graphite on the microstructure and mechanical behaviour of Al-7Si-Fly ash and Al-7Si-Graphite composites. The investigation reveals the effectiveness of incorporation of Fly ash and Graphite in the Al-7Si alloy for studying mechanical properties. The composites were fabricated using liquid metallurgy route. The Al-7Si-Fly ash and Al-7Si-Graphite composites were fabricated separately by introducing 6 wt. % of Fly ash and graphite particulates by two stage melt stirring process. In this reinforcement particulates were added in two steps to increase the wettability. The characterization was performed through Scanning Electron Microscope and Energy Dispersive Spectrum. The particle distribution was uniform in these composites. The hardness, ultimate tensile strength and yield strength of both Fly ash and Graphite composites were evaluated as per ASTM standards. Further, a comparative study has been made between the Al-7Si-Fly ash and Al-7Si-Graphite composites. Fly ash particulates reinforced composites were shown better results compared to graphite reinforced composites.**

Keyword - Al-7Si alloy, Fly ash, Graphite, Microstructure, Mechanical Properties

I. INTRODUCTION

Aluminum matrix composites (AMCs) have happened to awesome enthusiasm for the lightweight fields on account of their high particular solidness and high particular quality [1]. Aluminum based framework composites are alluring materials in air part, military businesses and car field. Aluminum composites are having great wear and quality properties with extreme quality equivalent to cast iron and density is lower than the steel, made these AMCs reasonable for various aviation applications. Expanding significance in research and applications on metal lattice composites is connected to cast composites with aluminum network and scattering fortification as SiC, B_4C, Al_2O_3, Graphite and fly ash particulates [2-4].

Contingent upon their application, the composite materials are portrayed, in connection to the matrix, by enhanced wear resistance, high quality properties, legitimate sliding attributes, imperviousness to warm stuns and exhaustion wonders with thought of diminished weight of the last item. Subsequently the utilization of hard clay particles fortified composites relies on upon innovative properties of composite additionally the expenses of its assembling and ecological part of the item.

Micro scale particulates are exceptionally temperate as a result of their low costs and simple scattering amid manufacture. The micron molecule fortified Al matrix composites possess the potential business use for its generally minimal effort and great mechanical properties. Micron molecule fortified metal lattice composite is normally delivered by powder metallurgy, high vitality ball processing, sputtering and mix throwing. Among these techniques, stir casting is viewed a role as the most gainful and prudent. In any case, this technique prompts development of auxiliary and different imperfections in composite materials. Poor wettability and non-uniform dissemination of auxiliary stage particles, isolation and grouping of the added substance particles in the base grid, feeble lattice support interface and nearness of porosity are some imperative basic deformities of blend threw composites [5-6].

Poor wettability of reinforcements in the liquid aluminum can't wet the whole surface of particles [7]. Along these lines, the fortification particles generally buoy or settle in the liquid grid metal. Albeit mechanical and manual blending is helpful to blend the fortifications into the Al soften, yet these particles moves towards the surface once mixing stops. So to maintain a strategic distance from this in this present review both fly ash and graphite fortification particles are preheated to a temperature of 300 degree Celsius.

A few procedures are accessible for expanding the wettability of strengthened materials in liquid metal. Since, the properties of aluminum metal framework composites are basically in view of good contact between the base and support materials. In the present examination an exertion has been made to concentrate the microstructure and mechanical conduct of Al-7Si-6wt. % of Fly ash and Al-7Si-6 wt. % of Graphite composites made-up by vortex technique. Here, composites are delivered by two phase particles mixing procedure to improve the wetting conduct and furthermore to accomplish the better holding between the Al-7Si amalgam lattice and Fly ash-Graphite particulates.

II. EXPERIMENTAL DETAILS

In the current work, Al-7Si matrix system with the notional density of 2710 kg/m^3 was used. Fly ash particulates with theoretical density of 2300 kg/m^3 were used as reinforcements. The chemical ingredient of Fly ash is given in Table1. Graphite particulates with theoretical density of 2200 kg/m^3 were used as reinforcement.

Table1: Weight percentage of elements in the Fly ash

Elements	Weight %
C	21.51
O	52.75
Al	12.05
Si	13.69

Fig.1. Stir casting set up

Casting is the most commonly used fabrication method in MMCs, as it is low priced and suitable for mass production of components. The synthesis of metal matrix composite used in the study was conducted by vortex method in particular stir casting process. Initially Fly ash and graphite particulates were preheated for 300°C. In the current work, an effort is made to find out the mechanical nature of as cast Al-7Si alloy, Al-7Si-Fly ash and Al-7Si-graphite particulate composites. The composites made by 6 wt. % of Fly ash and 6 wt. % of graphite particulates were prepared. First calculated amount of aluminium Al-7Si was placed in a silicon carbide made crucible, which was placed in a furnace (electrical resistance fig.1) at an operating temperature of around 750 degree Celsius. To extract the unwanted entrapped gases from the molten matrix degassing was done by using C_2Cl_6. Once degassing is over, the Fly ash particles which were preheated in a pre-heater added to the melt by two stage reinforcement mixing method. This novel two stages incorporation of reinforcement into wrought Al-7Si alloy matrix will increase wettability of the matrix and hard reinforcement. Further, helps in uniform distribution of the particles. During addition of Fly ash particulates into the melt continuous stirring was carried out. Normally for all composite fabrication, 300rpm stirring speed was maintained. Stirring was done for 5 minutes, after that molten metal with Fly ash particulates was poured into cast iron die. Similarly, Al-7Si-Graphite composites were prepared by same route. The prepared castings were machined and initially micro structural studies were done by SEM. Once the Fly ash and graphite particles confirmed in the matrix, tensile behaviour of as cast Al-7Si alloy and its composites were evaluated as per ASTM standards.

Microstructure and mechanical behaviour of the Al-7Si-Fly ash and Al-7Si-Graphite composites were carried out. A metallographic examination was conducted by using scanning electron microscope. The sample preparation for microstructural study was carried out first by polishing the prepared specimens with SiC abrasion paper up to 1000 grit size, further polished with Al_2O_3 suspension using velvet cloth on a grinding machine. Finally, the specimens were polished by using 0.3 microns diamond paste. The polished surface was etched with Keller’s reagent and examined with a scanning electron microscope.

The tensile properties of the specimen were measured by using an electronic tensile testing machine at room temperature based on ASTM standard. Hardness of as cast Al-7Si alloy, Al-7Si-Fly ash and Al-7Si-graphite composites were conducted to know the influence of Fly ash and graphite particles in the matrix material. The polished specimens were tested for their hardness, using Brinell hardness testing machine having ball indenter for 250 kg load and dwell time of 30 sec. Five sets of readings were taken at different places of the specimen and an average value was used for calculation. Fig. 2 shows the tensile, hardness and microstructure specimens.

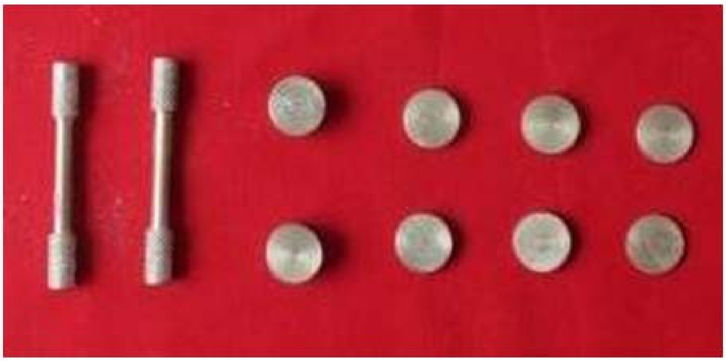
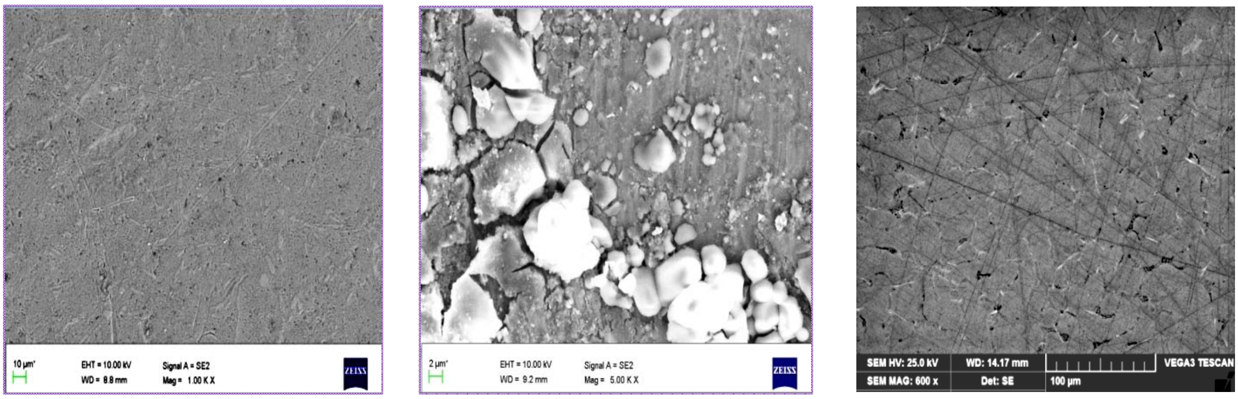


Fig.2. Specimens used in the present study

III.RESULTS AND DISCUSSION

A. Microstructural Studies



(a) (b) (c)

Fig.3. Showing scanning electron photographs of (a) as cast Al-7Si alloy (b) Al-7Si -6 wt. % of Fly ash (c) Al-7Si -6 wt. % of graphite composites

Fig. 3 (a-c) shows the scanning electron micrographs of as cast Al-7Si, Al-7Si-6 wt. % Fly ash and Al-7Si-6 wt. % graphite composites. Although some agglomeration of Fly ash particulates could be observed in Al-7Si-6wt. % Fly ash composites, the distribution generally appeared to be fairly homogeneous throughout the aluminium matrix. Fig. 3c shows the uniform distribution of graphite particulates in the Al-7Si alloy.

Fig. 4 a-b is energy dispersive spectrographs of Al-7Si-6wt. of Fly ash and Al-7Si-6 wt. % of graphite composites respectively. The EDS analysis confirmed the presence of Fly ash and Graphite in the Al matrix alloy. The EDS analysis confirmed the presence of Al, Si. O and C in the Al matrix alloy. Fly ash contents O, Fe, Ca and C as the major elements, which is confirmed by EDS. The presence of graphite shows in the form of Carbon (C), which is evident from the EDS graph 4b.

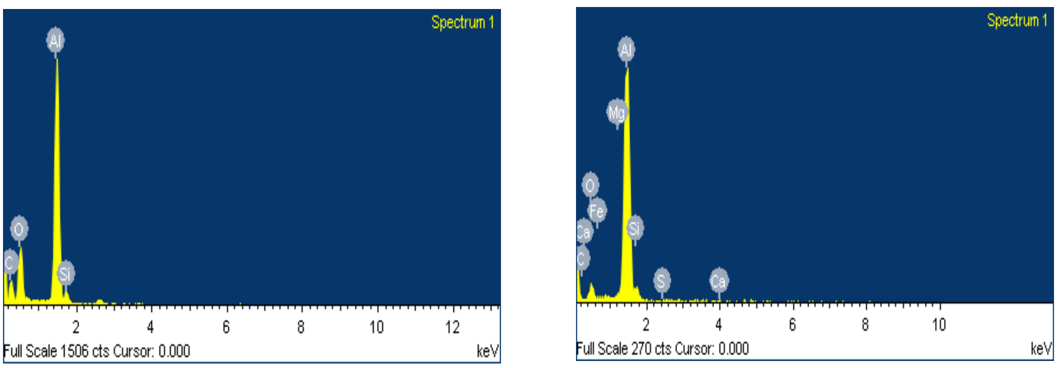


Fig.4. Showing the Energy Dispersive Spectrographs of (a) Al-7Si-6 wt. % Fly ash and (b) Al-7Si-6 wt. % Graphite composites

B. Hardness Measurements

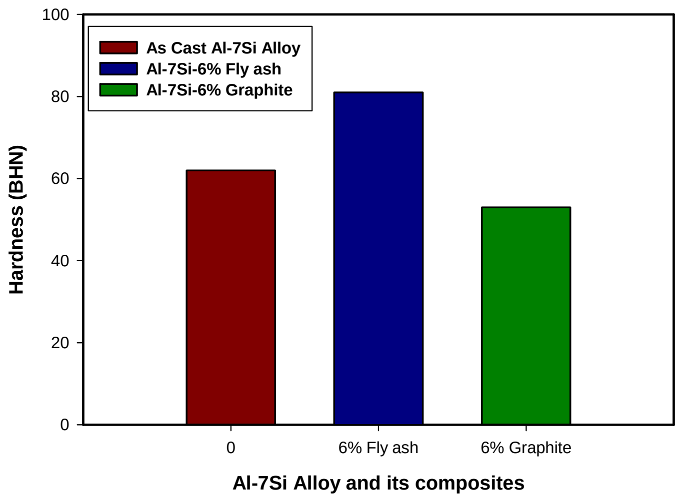


Fig.5. Comparison of hardness of Al-7Si-Fly ash and Al-7Si-graphite composites

The hardness of as cast Al-7Si, 6wt. % Fly ash and 6wt. % graphite composites are evaluated using ball indenter of diameter 5mm at an applied load of 250kg with dwell time 30 seconds for each sample at different locations. The hardness variation of samples for as cast Al-7Si with 6 wt. % of Fly ash and 6 wt. % of graphite is illustrated in Fig. 5. The hardness of Al-7Si-Fly ash composites is higher than the Al-7Si alloy (62 BHN), due to presence of Fly ash particles. Also, it can be attributed to the higher hardness of Fly ash particles compared to aluminium alloy. In fact, the hardness of composite depends on the hardness of the reinforcement and the matrix. This increase in hardness is mainly due the coefficient of thermal expansion (CTE) of ceramic particles is less than that of aluminium alloy [8, 9]. So, an enormous amount of dislocations are generated at the particle-matrix interface during solidification process, which further increases the matrix hardness. The higher the amount of particle-matrix interface, the more is the hardening due to dislocations. Further, the hardness of Al-7Si-6 wt. % graphite composites decreased as compared to Al-7Si base matrix and Al-7Si-Fly ash composites. This is mainly due to the softness of graphite particulates, which structure is arranged in the form of layer by layer.

C. Ultimate Tensile and Yield Strength

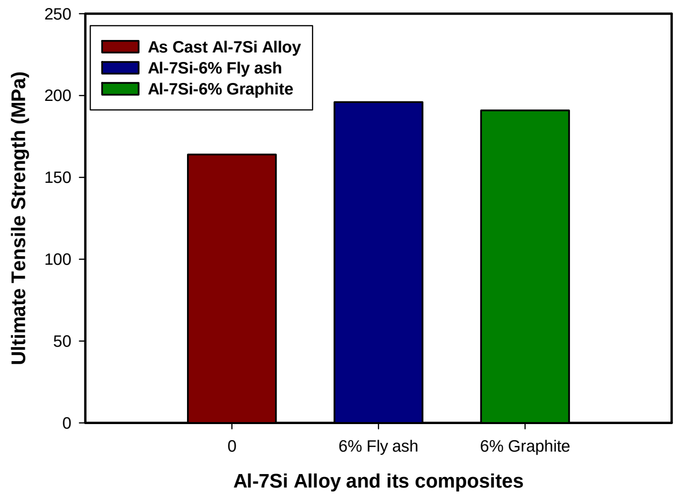


Fig.6. Comparison of ultimate tensile strength of Al-7Si-Fly ash and Al-7Si-graphite composites

The tensile behavior of all the prepared samples of composites is determined to examine the tensile properties like ultimate tensile strength and yield strength. The specimens were loaded hydraulically in the computerized universal testing machine. The loads at which the specimen has reached the yield point and broken were noted down.

Fig. 6 and 7 shows the variation of ultimate tensile strength (UTS) and yield strength of base alloy, when reinforced with 6 wt. % of Fly ash and graphite particulates. The ultimate tensile strength of Al-7Si- Fly ash composite material increases as compared to the cast base alloy Al-7Si. The microstructure and properties of hard Fly ash particulates control the deformation of the composites. Due to the strong interface bonding, load from the matrix transfers to the reinforcement resulting in increased ultimate tensile strength [10]. This increase in ultimate tensile strength mainly is due to presence of Fly ash particles which are acting as barrier to dislocations in the microstructure. Further, Al-7Si graphite composites are showing higher UTS and YS compared to the base alloy and slightly lesser than the fly ash reinforced composites.

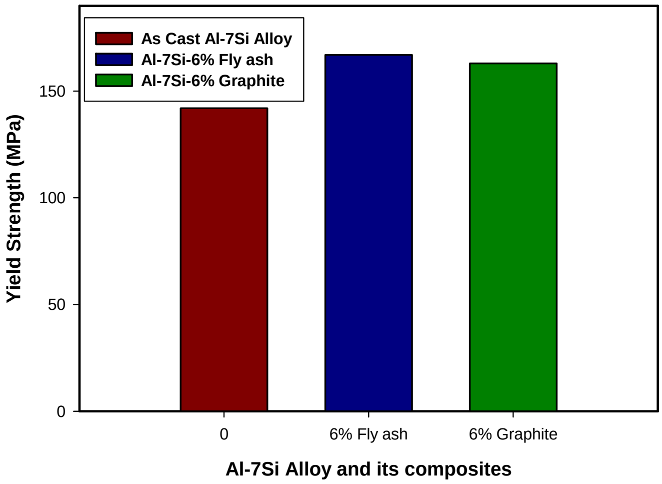


Figure 7: Comparison of yield strength of Al-7Si-Fly ash and Al-7Si-graphite composites

IV. CONCLUSIONS

The present work entitled, "A comparative study on Al-7Si-Fly Ash and Al-7Si-Graphite Composites Fabricated by Liquid Metallurgy" has led to the following conclusions:

- Al-7Si-Fly ash and Al-7Si-Graphite composites with 6 wt. % were successfully synthesized via melt stirring method involving two step additions.
- Two step addition methods is adopted to introduce Fly ash and Graphite particulates into Al-7Si matrix during melt stirring has contributed in homogeneous distribution of Fly ash and Graphite particulates with no clustering or agglomeration as evident from SEM microphotographs.
- The Energy Dispersive (EDS) analysis confirmed the presence of Fly ash and Graphite particles in Al-7Si-Fly ash-Graphite composites.
- Al-7Si-Fly ash composites have shown higher hardness when compared to the hardness of Al-7Si alloy.
- The hardness of Al-7Si-Graphite composites decreases with 6 wt. % of Graphite particulates in the Al-7Si alloy matrix.
- Al-7Si-6 wt. % Fly ash composites more enhanced ultimate and yield strength compared to Al-7Si matrix system and 6 wt. graphite reinforced composites.

REFERENCES

[1] William F Smith and Javad Hashemi. Material science and engineering, Tata McGraw Hill, Publishing company limited, 2008.
[2] Abhishek Kumar, Shyam Lal, Sudhir Kumar, Fabrication and characterization of A359/Al_2O_3 metal matrix composite using electromagnetic stir casting method, 2013, JMR&T, Elsevier
[3] G. Ramu, Ranjit Bauri, Effect of equal channel angular pressing (ECAP) on microstructure and properties of Al–SiC_p composites, Materials & Design, 2009
[4] M. Ramachandra K, Radhakrishna, Synthesis-microstructure-mechanical properties-wear and corrosion behavior of an Al-Si (12%)—Flyash metal matrix composite, Journal of material science (2005)
[5] Pardeep Sharma, Satpal Sharma, Dinesh Khanduja, A study on microstructure of aluminium matrix composites, Journal of Asian Ceramic Societies (2015)
[6] Mahendra K V, K. Radhakrishna, 2010, Characterization of Stir Cast Al-Cu-(Fly ash+SiC) Hybrid Metal Matrix Composites, Journal of Composite Materials.
[7] S.Rajesh, A .Gopala Krishna, P.Rama Murt Raju, M.Duraiselvam, Statistical analysis of dry sliding wear behavior of graphite reinforced aluminium MMC's, Procedia Materials Science, 2014.
[8] Viney Kumar, Rahul Dev Gupta, N K Batra, Comparision of mechanical properties and effect of sliding velocity on wear properties of al6061, Mg4%, fly ash and al6061, mg4%, graphite 4%, fly ash hybrid metal matrix composite, Procedia materials science (2014).
[9] Hiroki Kurita, Takamichi Miyazaki, Akira Kawasaki, Yongfeng Lu, Jean-Francois Silvain, Interfacial microstructure of graphite flake reinforced aluminium matrix composites fabricated via hot pressing, Composites:Part-A, 2015.
[10] S.Suresha, B.K.Sridhara, Effect of silicon carbide particulates on wear resistance of graphitic aluminium matrix composites, Materials and Design, 2010.