Mechanical Properties of Al-7075/ Fly ash particle reinforced metal matrix composites

[1] Dr.M.Mahendra Boopathi , [2]R.Naveen Prabu , [3]M.Vijayaraj
[1,2,3]Department of Mechanical Engineering, CMS College of Engineering and Technology, Coimbatore-641 032, TamilNadu, India. e-mail: boomahe@gmail.com

Abstract

Metal matrix composites (MMCs) offer much higher specific strength, specific modulus, damping capacity, and wear resistance when compared to unreinforced alloys. Composites with low density and low cost reinforcements are gaining popularity. Among the numerous compositions used, fly ash is the most cost-effective and low-density reinforcement readily available as a solid waste byproduct of coal combustion in thermal power plants in substantial quantities. As a result, it is expected that composites reinforced with fly ash would overcome the cost barrier for broad usage in vehicle and small engine applications. .As a result, the incorporation of fly ash particles into aluminium alloy is expected to inspire yet another application of this low-cost waste by-product, while also having the ability to save energy-intensive aluminium, decreasing the cost of aluminium items. Particulate reinforced aluminium matrix composites are gaining popularity due to their low cost and advantages such as isotropic properties and the possibility of secondary processing, which allows for the production of additional components. The present research focuses on exploiting widely available industrial waste fly-ash by dispersing it in aluminium to create composites using the stir casting technique.
Key words: particulate composites fly ash, SEM, Mechanical properties

Introduction

In the recent years, usage of ceramic particle - reinforced metal matrix composites (MMCs) is steadily increasing because of their advantages like isotropic properties and the possibility of secondary processing, facilitating fabrication of secondary components.

Aluminium matrix composites (AMMCs) have gained wide acceptance in the past three decades due to their high specific strength and stiffness and superior wear resistance.[1] There has been increasing interest in composites containing low density and low cost reinforcements.

Dry sliding wear behaviour of silicon particles reinforced aluminium matrix composites was reported during the research in the context whose results showed that silicon particle- reinforced composites exhibited reduced wear loss than the unreinforced alloy specimens. Quartz(SiO2p) reinforced chilled metal matrix composite for automotive applications were developed .The mechanical properties of the chilled

composites were superior to those of the matrix alloy. Strength and hardness increase with increase in dispersoid content and this may be possibly because of the occurrence of a more uniform distribution of SiO2 particles within the matrix.[2]

Among various dispersoids used, fly ash is the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Fly ash particles are classified into two types, precipitator and cenosphere. Generally, the solid spherical particles of fly ash are called precipitator fly ash and the hollow particles of fly ash with density less than 1.0 g/cm3 are called cenosphere fly ash. The precipitator fly ash, which has a density in the range of 2.0-2.5 g/cm3 can improve various properties of selected matrix materials, including stiffness, strength and wear resistance and reduce the density. Cenosphere fly ash, which consists of hollow fly ash particles, can be used for the synthesis of ultralight composite materials due to its significantly low density, which is in the range of 0.4-0.7 g/cm3, compared with the densities of metal matrices, which is in the range of 1.6-11.0g/cm3.[3] One common type of fly ash is generally composed of the crystalline compounds such as quartz, mullite, hematite, glassy compounds such as silica glass, and other oxides. [9] Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications.[1] 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.[5,6] In view of the above said advantages with fly ash additions as reinforcements in AMMCs, the present investigation makes an attempt to synthesize the pure aluminium– fly ash (ALFA) composites (5, 10 and 15% fly ash by weight) with stir casting route and focused to characterize the enhanced mechanical properties in terms of hardness, density and compression strength for these newly developed ALFA composites.[8]

Experimental work

Raw materials

The matrix material used in the experiment investigation was Al 7075.The fly ash was collected from thermal power plant, Mettur , Salem in Tamil Nadu , India. The particle size of the fly as received condition lies in the range from (0.1-100 μm).

Melting and casting

The aluminum fly ash metal matrix composite was prepared by stir casting route.

Fig.1 Stir casting Unit

Fig 2 Melting

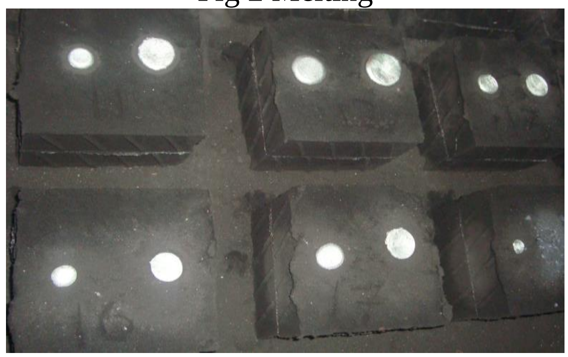

Fig 3 Casting

For this we took 500gm of commercially pure aluminum and desired amount of fly ash particles. The fly ash particle was preheated to 300 C for three hour to remove moisture. Commercially pure aluminum was melted in a resistance furnace. The melt temperature was raised up to 720 C and it was degassed by purging hexa chloroethane tablets. Then the melt was stirred with the help of a mild steel turbine stirrer. The stirring was maintained between 5 to 7 min at an impeller speed of 200 rpm .The melt temperature was maintained 700 C during addition of fly ash particles. The dispersion of fly ash particles were achieved by the vortex method. The melt with reinforced particulates were poured into the preheated permanent metallic mold. The pouring temperature was maintained at 6800C.The melt was then allow to solidify the moulds. The composites were made with a different amount of fly-ash (i.e.5, 10, 20, wt %), 1.5% of Magnesium were added to increase the wettability of fly ash particles.

Results and discussions

Microstructural characterization.

Scanning electron microscopy Micro structural characterization studies were conducted on unreinforced and reinforced samples. This is accomplished by using scanning electron microscope. The composite samples were metallo graphically polished prior to examination. Characterization is done in etched conditions. Etching was accomplished using Keller's reagent. The SEM micrographs of composite and wear debris were obtained using the scanning electron microscope

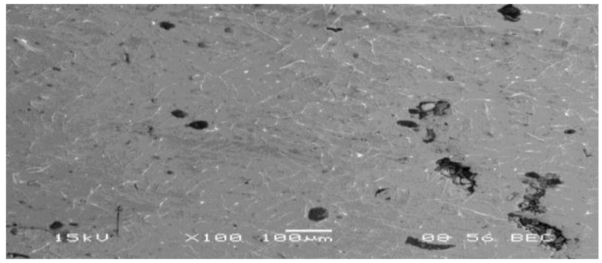

Fig 4. Al+ 5% fly ash composite

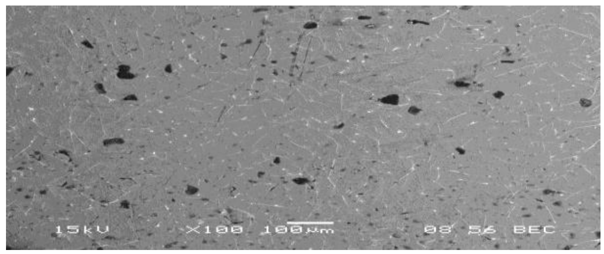

Fig.5. Al+ 10% fly ash composite

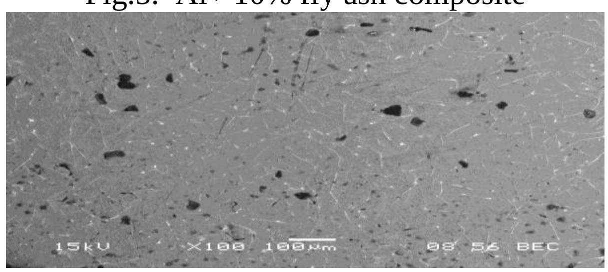

Fig.6 Al+ 15% fly ash composite

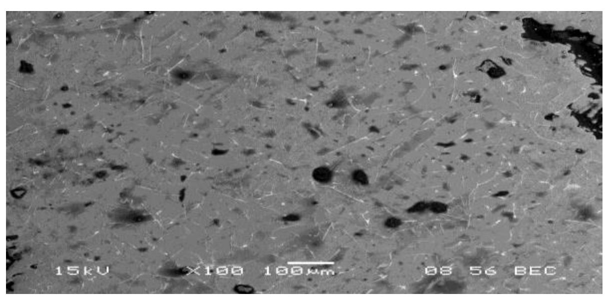

Fig.7. Al+ 20% fly ash composite

Mechanical properties observation.

Hardness

The hardness of the composite increased with the increase in weight fraction of the fly ash particles. Thus the hard fly ash particles help in increasing the hardness of the aluminium alloy (Al7075) matrix .

Fig.8 Hardness Specimen

Tensile test

The variation of tensile strength of the composites with the different weight fractions of fly ash particles. It can be noted that the tensile strength increased with an increase in the weight percentage of fly ash. Therefore the fly ash particles act as barriers to the dislocations when taking up the load applied .

The hard fly ash particles obstruct the advancing dislocation front, thereby strengthening the matrix . However, as the size of the fly ash particles increased, therewas decrease in tensile strength. Good bonding of smaller size fly ash particles with the matrix is the reason for this behavior. The observed improvement in tensile strength of the composite is attributed to the fact that the filler fly ash posses higher strength. The decrease in the tensile strength of the samples with fly ash weight fraction beyond 15 % is due to the poor wettability of the reinforcement with the matrix

Fig.9 UTM

Table 1

Material	***Hardness (BHN)***	***Tensile Strength (MPa)***	***Elongation %***
Al7075	62.8	134.8	8.0
Al7075+5%Fly ash	65.9	149.9	7.8
Al7075+10%Fly	71.8	162.2	7.5

ash			
Al7075+15%Fly ash	74.2	170.8	7.3
Al7075+20%Fly ash	75.6	164.8	7.0

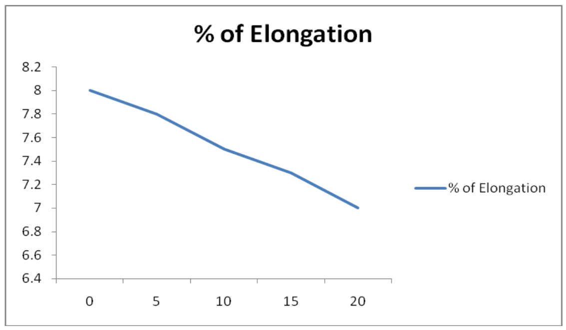

Fig.9

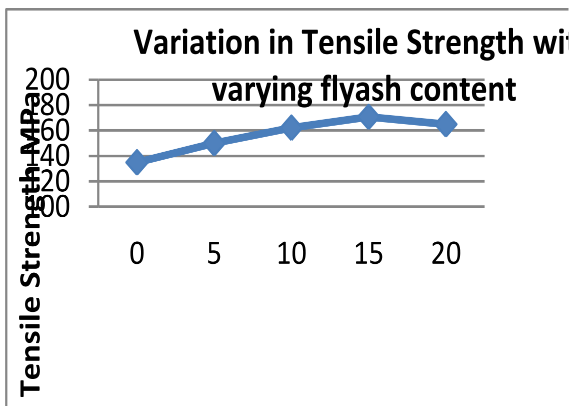

Fig.10

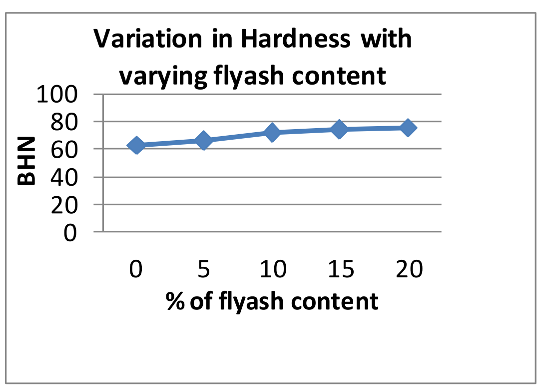

Fig.11

Conclusion

The stir casting procedure employed to manufacture the composites may have resulted in a homogeneous dispersion of the reinforced fly ash particles.Tensile strength, compression strength, and hardness rose as the weight fraction of reinforced fly ash increased and declined as the particle size of the fly ash increased.The increased dislocation density can be ascribed to the improvement in mechanical characteristics.The tensile strength of composites containing more than 15% weight fraction of fly ash particles, on the other hand, was shown to be decreasing fly ash.The composite's ductility reduced.

References

1. Ahlatci, H, Candan, E, Cimenoglu, H. 2004. Abrasive wear and mechanical properties of Al-Si/SiC composites, Wear, 257, 625-632.
2. Basavarajappa, S., Chandramohan, G, Dinesh, A. 2004, Mechanical properties of mmc’s- An experimental investigation, Int. symposium of research on Materials and Engineering, IIT, Madras, December 20, 1-8.
3. Charles, S., Arunachalam, V.P. 2004, Property analysis and Mathematical modeling of machining properties of aluminium alloy hybrid (Al-alloy/SiC/fly ash) composites Produced by liquid metallurgy and powder metallurgy techniques.
4. Hebbar, H.S., Ravindra K.G., 2008. Study of the Mechanical and Tribological Properties of Aluminium Ally- SiCp Composites Processed by stir casting method, IISc Centenary-International Conference on Advances in Mechanical Engineering(IC-ICAME), Bangalore, India, July 2-4.
5. Mahagundappa, M.B., Shivanand, H.K., Muralidhara, M. 2006. Influence of Reinforcements and Thermal Ageing on the Mechanical Properties of Al (2024) Based Hybrid Composites, India Foundry Journal, 52, 20-43.
6. Mahendra, K.V., Radhakrishna, K. 2007, Fabrication of Al-4.5% Cu alloy with fly ash mmc and its characterization, Material science Poland, 25, 57-68.
7. Sudarshan, Surappa, M.K. 2008. Synthesis of fly ash particle reinforced A356 Al composites and their characterization, Material Science and Engineering, A, 480, 117-124.
8. Suresh, K.R., Niranjan, H.B., Jebraj, M.J. Chowdiah, M.P. 2003, Tensile and wear properties of aluminium composites, Wear, 255, 638-642.