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Mechanical Properties of Fly Ash Reinforced Aluminium 6061 Composite

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Abstract: *In this paper, the consequences of an experimental study of effect of particle size of fly ash particles on mechanical properties of fly ash reinforced aluminium alloy (Al6061) composites samples, processed by stir casting route reported. Fly ash is one of the most promising inexpensive and low density reinforcement available in large quantities among other reinforcement. Even though, it is a solid waste by-product obtained from thermal power plants. Fly ash has been used as filler in aluminum, polyester, epoxy, polyurethane and various rubbers. This development is largely due to the advantages of fly ash such as low density, strong filling ability, excellent fluidity and good processibility of the filled materials. Three sets of composite samples were prepared with 5, 10 and 15 weight percentage of fly ash with particle sizes in the ranges of 5-20, 25-30 and 50-60µm in each set. Mechanical properties like ultimate tensile strength (UTS), ultimate compression strength (UCS) and hardness were found to increase with the increase in weight percent of fly ash particles and decrease with the increase in the particle size of the reinforcement. However, there was a slight decrease in UTS with composites having 15% fly ash.*
Keywords: *Al6061, Fly ash, Mechanical properties, Metal Matrix Composites, Hardness*

I. Introduction

Composite materials in general are well-known engineering materials with most of them possessing the compensation of higher specific weight and specific modulus **[1,2]** and also better thermal stability, fatigue properties and wear resistance **[3,4]** compared to various of the metals and alloys. It is seen that the higher cost of manufacturing of continuous fiber reinforced metal matrix composites has led to the use of particle reinforced and whisker reinforced MMCs **[5].** In this regard, the filler material having lower density and cost such as fly ash has been a strong reinforcement material for producing AMMCs. Health hazards can be caused by the fly ash generated from the power plant in India. It is estimated that of the 90Mt of coal combustion by-products generated annually, only 25% is currently used, much of it is in form of extenders in cement and in polymers; the remainder ending up in land filling or surface impoundments. It is therefore anticipated that the fly ash particles as reinforcement in aluminum alloys would promote yet another use of this low-cost waste by-product **[6.7].** The stir casting method is widely used among the different processing techniques available. Stir casting usually involves prolonged liquid-reinforcement contact, which can cause substantial interface reaction **[8].**

Charles and Arunachalam[9] conducted experiments on 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 containing aluminium with disperoids silicon carbide added in varying proportions (10%, 15%, and 20% vol. %) and fly ash maintained at 10 vol. %.They found that addition of disperoid particles resulted in an increase in hardness and wear resistance. **Basavarajappa et al. [10]** studied mechanical properties of as cast aluminum alloy composite reinforced with SiCp and graphite particles. Their result revealed that as the reinforcement content increased the mechanical properties such as ultimate tensile strength, yield strength, hardness and compressive strength of the composite increased predominantly but the density of the composite decreased. The increased strength of aluminium 2024/SiCp-Graphite composite was attributed to synergistic influence of the dislocation density generated due the differences in coefficient of thermal expansion between the constituents of the composite.

Massardier et al. [11] investigated the mechanical properties of aluminium based composite reinforced with performs elaborated by Elf-Atochem. These performs consisted randomly oriented hexagonal and monocrystalline a-alumina platelets. The volume fraction of the platelets in a perform was varied between 15 and 35%.Two aluminium matrixes (either an A9 pure aluminium matrix (99.9% Al) or a 6061 aluminium alloy (1%Magnesium, 0.6% Silicon)) were used to prepare composites by the squeeze-casting technique. The influence of the variable parameters of the material on the tensile properties of composites was studied. Their investigation concluded that there was an increase in young modulus, 0.2% proof stress, flow stress and ultimate tensile strength was observed over the unreinforced metal. Those improvements were obtained at the expense of the tensile ductility. **Sudarshan et al. [12]** intentional description of A356 Al-Fly ash particle composite with fly ash particles of narrow range (53-106 µm) and wide size range (0.5-400 µm) and reported that addition of fly ash show the way to increase in hardness, elastic modulus and 0.2% proof stress. They also conducted that composites with narrow size range fly ash particle show superior mechanical properties compared to composites with wide range fly ash particles.

In order to revise the influence of the particle size of fly ash as reinforcement on the aluminium alloy (Al6061) composite can be concluded as of the above literature review. In the present study, fly ash has been chosen in different sizes and to study its effect on mechanical properties. Albeit some of previous investigations showed that the mechanical properties will be improved with increase in particle size. For this reason an effort is made to the influence of these parameters on the various properties so as to investigate it is an attractive and valuable engineering material.

II. Experimental Procedure

A. Specimen preparation

In this work, fly ash reinforced aluminium alloy (Al6061) composites, processed by stir casting route was used. The three types of stir cast composites had a reinforcement particle sizes of follows 5-20µm, 25-30µm and 50-60µm are selected after the sieve analysis. The required quantities of fly ash (5, 10 and 15 Wt. %) were taken in a powder container. Then the fly ash was preheated to 400^{o}C and maintained at that temperature for about 15 minutes. Weighed quantity of Al6061 was taken from the ingot and melted in a crucible at 775^{o}C which is above its melting temperature (675^{o}C). Molten metal was stirred by mechanical stirrer to create a vortex and the weighed quantity of preheated fly ash particles were slowly added to the molten alloy. A small amount of Mg (0.5-0.6weight percent) was added to ensure good wet ability and to remove oxygen from fly ash particles with molten metal. After mixing, the melt will be poured into a mould for the preparation of specimens. The mechanical test will be conducted as per the ASTM standards. After mixing, the melt was poured into a prepared mould for the preparation of specimen. The composite which is from the mould was taken after cooling.

Al6061 having good casting properties and strength is selected as a matrix material having a chemical composition given in Table 2.1. Fly ash collected from Raichur thermal power plant will be used as reinforcement and its composition is given in Table 2.2.

Table2.1: Chemical composition of Al6061 alloy (weight percentage)

Mg	Si	Fe	Cu	Ti	Cr	Zn	Mn	Al
0.91	0.76	0.24	0.21	0.08	0.11	0.05	0.04	Balance

Table2.2: Chemical composition of Fly ash used in present study (weight percentage)

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Loss of ignition
29,56	59.8	4.99	3.1	1.44

B. Testing for Mechanical Properties

The tests were conducted as per ASTM standards. The tensile tests were conducted in accordance to ASTM E-8standards at room temperature using a universal testing set up. The tensile test specimens of nominal diameter 12.5 mm and gauge length of 62.5 mm with gauge length of the specimen parallel to the longitudinal axis of casting. The compression tests were conducted as per ASTM-E-9.The specimen's size of nominal diameter of 15mm and 20 mm height were machined from ingot composite. The hardness tests were conducted in accordance with the ASTM-E-10standards.

III. Results And Discussion

A. Tensile strength

The results of the Tensile strength test carried out as per ASTM E8-95 on all the MMCs taken up for investigations are shown in figure 3.1 and Table 3.1 The percentage improvements with different weight fractions of reinforcements are also given. It can be noted that the tensile strength increased with an increase in the weight percentage of fly ash. But there was decrease in percentage improvement with the increase in content of reinforcement. Therefore the fly ash particles help in strengthening the matrix, acting as barriers to the dislocations when taking up the load applied. However, as the size of the fly ash particles increased, there was decrease in tensile strength which is evident from decrease in percentage improvement. Better bonding of smaller size fly ash particles with the matrix compared to the larger size ones may be the reason for this behavior. The decrease in the tensile strength of the samples with fly ash weight fraction beyond 10 % may be due to the poor wet ability of the reinforcement with the matrix.

Reinforcement	Weight percent of reinforcement	Ultimate Tensile Strength (UTS) in Mpa
Fly ash of particle size 5-20µm	0	124
	5	129
	10	133
	15	131
Fly ash of particle size 25-30µm	0	124
	5	128
	10	130
	15	129
Fly ash of particle size 50-60µm	0	124
	5	126
	10	128
	15	127

Table3.1 Results of Tensile test carried on various MMCs

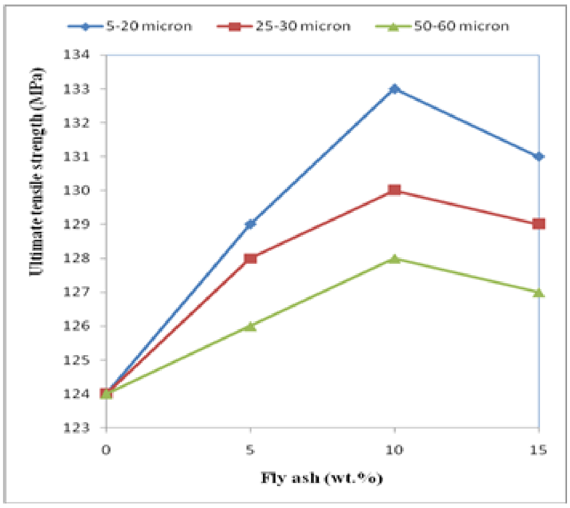

Fig 3.1 Fig. 3.1 UTS with the wt % of fly ash

B. Compressive strength

The results of the Compression strength test carried out as per ASTM-E9-95 on all the MMCs taken up for investigations are shown in figure .3.2 it can be observed that the compressive strength increased with an increase in the weight percentage of fly ash particles. This may be due to the hardening of the base alloy by fly ash particles. The decrease in compressive strength was observed as the size of the fly ash particles increased. Decrease in percent improvement was observed with the increase in particle size of reinforcement.

Reinforcement	Weight percent of reinforcement	Ultimate Compressive Strength (UCS) in Mpa
Fly ash of particle size 5-20µm	0	388.8
	5	498.8
	10	517..4
	15	535.8
Fly ash of particle size 25-30µm	0	388.8
	5	444.3
	10	472.1
	15	527.6
Fly ash of particle size 50-60µm	0	388.8
	5	416.6
	10	449.8
	15	488.8

Table3.2 Results of UCS test carried on various MMCs

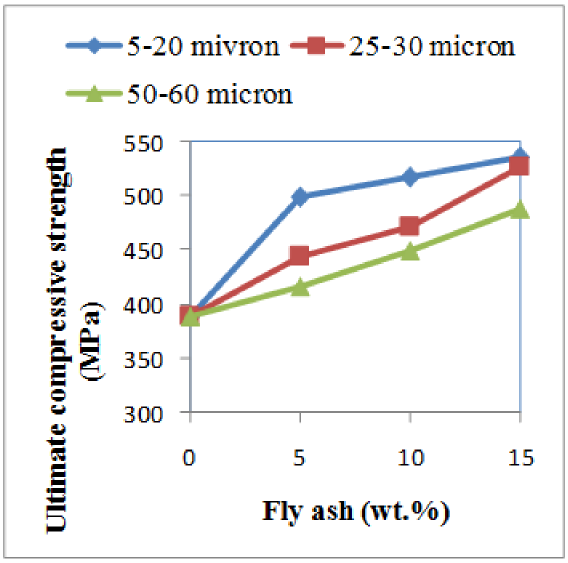

Fig 3.1 Fig. 3.2 UCS with the wt % of fly ash

C. Hardness

The results of the Brinell hardness test carried out as per ASTM E10 on all the MMCs taken up for investigations are shown in figure .3.3 and Table 3.3 The percentage improvements with different weight fractions of reinforcements are also given. The influence of weight percent of reinforcement on the hardness of Al6061 alloy is evident. From Figure 3.3, it can be noted that the hardness of the composite increased with the increase in weight fraction of the fly ash particles. Increase in percent improvement of hardness was observed with decrease in particle size of reinforcement. Thus the hard fly ash particles help in increasing the hardness of the aluminium alloy (Al6061) matrix.

Reinforcement	Weight percent of reinforcement	Brinell hardness (BHN)
Fly ash of particle size 5-20µm	0	47.5
	5	65.5
	10	76.3
	15	84.9
Fly ash of particle size 25-30µm	0	47.5
	5	62.4
	10	68.8
	15	80.4
Fly ash of particle size 50-60µm	0	47.5
	5	56.8
	10	62.4
	15	76.3

Table3.3 Results of Hardness test carried on various MMCs

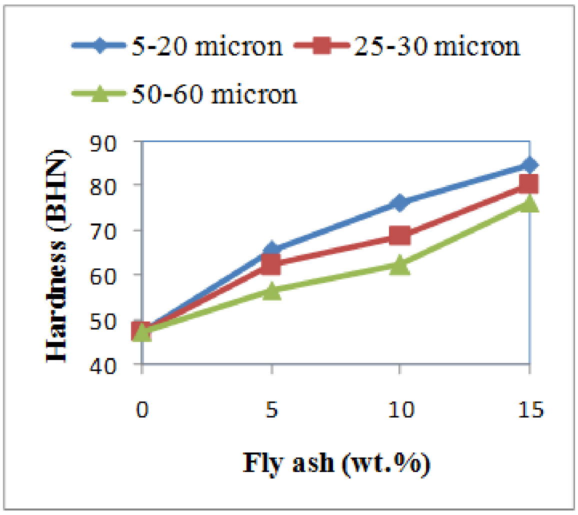

Fig 3.3 Hardness with the wt % of fly ash

D. Ductility

The results of the ductility test carried out on all the MMCs taken up for investigations are shown in figure.3.4 and Table 3.4 the percentage improvements with different weight fractions of reinforcements are also given. Figure 3.4 Shows that the ductility of the composite decreased with the increase in weight fraction of the fly ash. This may be due to the hardness of the fly ash particles or clustering of the particles. The various factors including particle size, weight percent of reinforcement affect the percent elongation of the composites even in defect free composites.

Reinforcement	Weight percent of reinforcement	% Elongation
Fly ash of particle size 5-20µm	0	9.6
	5	7.2
	10	6.4
	15	5.9
Fly ash of particle size 25-30µm	0	9.6
	5	6.7
	10	5.4
	15	4.8
Fly ash of particle size 50-60µm	0	9.6
	5	6.1
	10	5.3
	15	4.5

Table3.4 Results of Ductility test carried on various MMCs

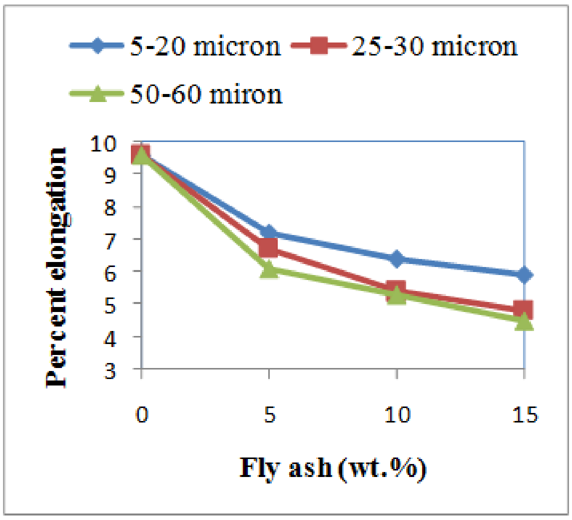

Fig 3.4 Ductility with the wt % of fly ash

IV. Conclusion

Following conclusions are made after various mechanical and micro structural analyses as follows.

1. MMCs with fly ash as reinforcement are successfully produced and tested for various mechanical and tribological properties. But the fly ash content can be increased up to 15 by weight percent.
2. The mechanical properties are found to increase with the increase in weight percent of the fly ash.
3. Ultimate Tensile Strength was increased with the increase in weight percent of fly ash. However there was decrease in strength of composites with 15 weight percent of fly ash reinforcement. With the particle size of 5-20 µm, there was improvement in strength by 3.9 %, 6.4 % with increase in fly ash content of 10 by weight percent. But with 15 weight of fly ash there was decrease in strength.
4. Ultimate Compression Strength and Hardness were found to increase with the increase in percentage of fly ash particles. But there was observable decrease in the values of these with the larger fly ash particles.
5. The ductility of the composite decreased with the increase in weight fraction of the fly ash.

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References

[1]. ASM International Advanced Material Process, 143960, 1983, 21-23.
[2]. G. Ganeshan, K.Raghu Kandan, R.Karthikeyan and B.C.Pai, Development of processing maps for 6061 Al/5% SiCp composite materials, Material Science Engg, 369, 2004, 230-235.
[3]. Deo Nath, R.T.Bhat and P.K. Rohtagi, Particle distribution control in cast aluminium alloy-mica composites, Journal of Material Science, 22, 1987, 170-176.
[4]. V.B. Tungikar, S.K Basu, G.D. Rathod and S.R. Kajale, Finite-Element Modeling of Transient Thermal Stresses in layered composites, Journal of Inst, Engg, (I) 84, 2004, 82-84.
[5]. UmitCocen and KazimOnel, “Ductility and Strength of Extruded SiCp/Alluminium AlloyComposites.” Composite Science and Technology, 62, 2002, 275-282.
[6]. Anilkumar H.C, H. Suresh Hebbar(2011), ‘Mechanical Properties of Fly ash Reinforced Aluminium alloy (Al6061) Composites is published in International Journal of Mechanical and Materials Engineering (IJMME), vol. 6, No.1,41-45.
[7]. Acharya,S. K., Mahanta,P. K., Pattanaik,P. K.(2002).“Wear Behaviour of Aluminium Fly ash Composite.” Journal of Institution of Engineers (1ndia), 83, 50-53.
[8]. Y. Sahin. 2003, Wear behavior of aluminium alloy and its composites reinforced by SiC properties using statistical analysis, Material and Design, Volume 24, 95-103.
[9]. Charles, S., and Arunachalam,V. P. (2004). “Property Analysis and Mathematical Modeling of Machining Properties of Aluminium Alloy Hybrid (Al-Alloy/SiC/flyash) Composites Produced by Liquid Metallurgy and Powder Metallurgy Techniques.” Indian Journal of Engineering and Material Science, 11, 473-480.
[10]. Basavarajappa, S., Chandramohan, G., Dinesh. (2004). “Mechanical properties of MMCs- an experimental investigation.” International Symposium of Research Studies on Materials and Engineering, Indian Institute of Technology Madras, Chennai, India, 1-8.
[11]. Massardier V., Fougeres R., Merle P. (1993). “Mechanical properties of aluminium-based metal matrix composites reinforced with a-alumina platelets.” Journal De Physique IV, 111, 3,703-708.
[12]. Sudarshan, Surappa,M.K., (2008).“Dry Sliding Wear of Fly ash Particle reinforced A356 Al Composites.” Wear 265, 349-360.