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Evaluation on Mechanical Properties of Aluminum Based Metal Matrix Composite

Thimmaiah A G[a], Muthanna K P[b] , Abhishek M A[c], Guruprasad H S[d] & Suhas K H[e]

[a]*Asst prof, Department of Mechanical Engineering, Coorg Institute of Technology, Karnataka, India.*
[b]*Asst prof, Department of Mechanical Engineering, Coorg Institute of Technology, Karnataka, India.*
[c]*UG Scholar, Department of Mechanical Engineering, Coorg Institute of Technology, Karnataka, India.*
[d]*UG Scholar, Department of Mechanical Engineering, Coorg Institute of Technology, Karnataka, India.*
[e]*UG Scholar, Department of Mechanical Engineering, Coorg Institute of Technology, Karnataka, India.*

ABSTRACT

In recent years, Aluminum based metal matrix composites are extensively used engineering materials in aerospace and automotive industries, since they have characteristics like high strength to weight ratio, hardness and wear resistance. The result of experimental investigation of aluminum based composites with silicon carbide (SiC) and fly ash, by stir casting is reported in this paper. The casted components are machined to specimen dimensions and are subjected to material testing and mechanical properties. In the present experimentation, the weight fraction of fly ash is varied by keeping SiC percentage (3%). The results show that better strength and hardness is achieved, by making weight of fly ash up to 9% and is reinforced to the metal matrix composite.

Keywords - *Mechanical properties, Silicon carbide, fly ash, composite material.*

1. INTRODUCTION

A composite material is made by combining two or more materials in such a way that the resulting materials have desired properties. Recent days composite materials are widely used for many number of applications like engineering structures, aerospace, marine application and so on. Metal matrix composite (MMC), normally particle reinforced aluminum composites are getting more importance. Since it is economical and exhibit isotropic properties. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus and is having good wear resistance as compared to unreinforced alloys. In the present experimentation, fly ash is used as reinforcing phase. The fly ash which is a waste product in power plant is the cheapest form of reinforcement available in large quantities. Stir casting technique appears to be the best technique to introduce fly ash particles into matrix by forming vortex.

Sandeep Kumar Ravesh [1] et.al. Conducted an experiment on Hybrid metal matrix composites with A6061 as matrix metal and ceramic metal such as Silicon carbide as reinforcement and Fly ash. Up on experimentation they found out that enhancement in the mechanical properties such as tensile strength, hardness, impact strength when silicon carbide weight percentage was varied and fly ash weight percentage was constant. It was noted that elongation was decreased and brittleness was increased. H.C.Anilkumar [2] et.al. Studied the behaviour of the Aluminum (6061) metal matrix composites with of Fly ash particles of different size as reinforcement material. They reported that, the mechanical properties such as tensile strength, compression strength and hardness improved for finer particle size. The same was decreased with increase in fly ash particle size. Author observed ductility of the composite decreased with the increase in the weight fraction of reinforcement of fly ash and also decreased with the increase in particle size of fly ash. On the contrary if the weight fraction of fly ash was increased more than 15% the tensile strength started to decline. Basavaraju.S [3] et.al, studied the behavior of aluminum alloy LM25 as matrix metal and Silicon carbide, Graphite, and Fly ash as reinforced material. When reinforcing, the weight percentage of Silicon carbide was varied, in mean while the weight percentage of graphite and the fly ash were kept constant. It is observed that the hardness of material enhanced due to addition of SiC-Graphite. The highest wear measure was for 8% SiC. NeelimaDevi.C [4] et.al. Experimented the mechanical characterization of aluminum silicon carbide composites. Author prepared the specimens with different Sic weight ratio’s and concluded that maximum tensile strength was found at a weight ratio of 15% SiC, also the weight was two times lesser than same dimension of aluminum specimen and also stated that it is very much useful in practical aerospace application.

2. OBJECTIVES

1. To obtain a better composite material using waste materials like fly ash.
2. To study the effect of different weight percentage of reinforcement like SiC and fly ash on mechanical properties of the prepared material.
3. And after arriving at the material properties, concluding the best one.

The work is associated with the study of mechanical properties of Al-SiC-fly ash MMC of aluminum alloy of grade 6061 with the addition of varying percentage of composition of fly ash by stir casting. The mechanical behavior and characteristic changes are taken in to consideration.

3. EXPERIMENTATION

3.1 Materials

Aluminum alloy Al 6061 is used as the matrix element, silicon carbide and fly ash as reinforcement. The chemical composition of aluminum alloy and fly ash are presented in table 1 and table 2 respectively.

Content	Al	Cu	Mg	Si	Fe	Mn	Ni	Pb	Sn	Ti	Zn
%	97.99	0.206	0.729	0.533	0.191	0.076	<0.05	0.024	0.011	0.094	0.064

Table 3.1: Chemical composition of Al 6061 [2].

Content	SiO_2	$Al2O_3$	$Fe2O_3$	CaO	MgO	TiO_2
%	62.56	19.90	3.79	7.56	1.24	1.20

Table 3.2: Chemical composition of fly ash [2].

Silicon carbide is the only chemical compound of carbon and silicon. It is an excellent abrasive. It is less dense, more in strength, high elastic modulus, more thermal conductivity, excellent thermal shock resistance. Improved temperature performance and the fact that they reported only a 35% loss of strength at 135^0C and its melting point is 270^0C.

Fly ash is one of the most expensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. They contain mostly silicon dioxide (sio2), aluminum oxide/alumina (al2o3) and iron oxide (fe2o3). Fly ash particles are mostly spherical in shape and range from less than 1µm to 100 µm. It is having high electrical resistance and low thermal conductivity.

3.2 Specimen preparation

In this work, Al-Fly ash-SiC composites were produced by varying % of fly ash (3%, 6% and 9 %) by stir casting route. The setup is shown in figure 3.1.

1. Required amount of fly ash of by weight should be measured and kept aside.
2. Then the fly-ash were heated to $450\text{-}600^0$C and maintained at that temperature for about 20 minutes to remove the moisture content.
3. Then weighed quantity of aluminium was melted in a crucible at $750\text{-}800^0$C.
4. The molten metal should be degassed at a temperature of 780^0C using solid dry hexachloroethane tablets. (Less than.5% weightage).
5. Then the molten metal was stirred to create a vortex and the weighed quantity of pre heated flyash particle were slowly added to the molten metal maintained at greater than 720^0C with continuous stirring at a speed of 350-500 rpm to a time of 6-8 minutes.
6. During stirring magnesium about 2% should be added to ensure good wettability.
7. Then the melt with the reinforced particles were poured in to moulds the poring temperature should be maintained at 680^0C.

Fig 3.1: Stir casting.

4. RESULTS AND DISCUSSION

4.1 Tensile test

The table 4.1 and graph 4.1 shows the variation of tensile strength obtained by UTM with varying percentage of fly ash and SiC in Al6061 alloy. From the obtained results and graphs it is evident that the tensile strength increases with the increase in weight percentage of reinforcement. It's because the reinforcement particles donates the strength by holding the molecules in the matrix and thereby resisting the deformation of the material.

Sl No	Nomenclature	Initial Diameter (mm)	Initial Length (mm)	Final Length (mm)	% Elongation	Ultimate Load (KN)	Ultimate Tensile Stress (Mpa)
1	Al6061 + 0% reinforcement	8	50	62.4	24.8	17.670	320.000
2	Al6061 + 3% Sic + 3%FLY ASH	8	50	62	24	15.090	394.000
3	Al6061 + 3% Sic + 6%FLY ASH	8	50	60	20	17.460	398.000
4	Al6061 + 3% Sic + 9%FLY ASH	8	50	57	14	17.940	403.000

Table 4.1: Tensile test results.

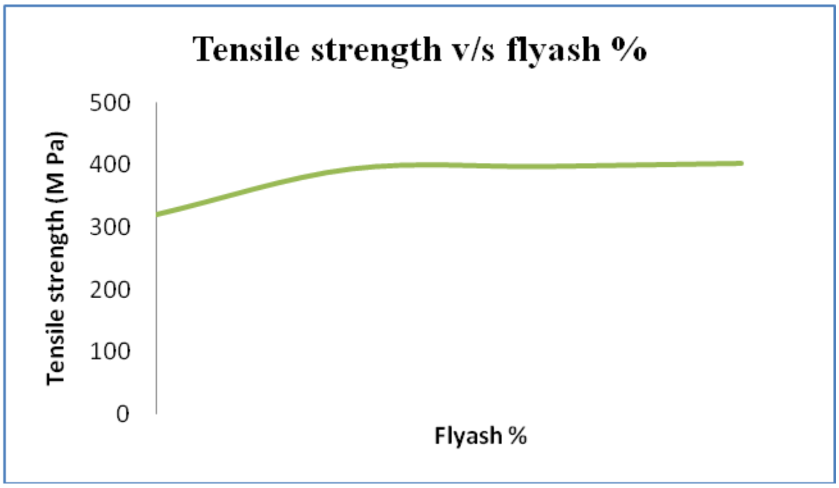

Fig 4.1: Tensile Strength V/S fly ash weight %.

4.2 Compression test

The table 4.2 and graph 4.2 shows the variation of compressive strength obtained by UTM with varying percentage of fly ash and SiC in Al6061 alloy. The results clearly indicates -that the compressive strength increases with the increase in weight Percentage of reinforcement. It's because the reinforcement particles resists the compression and thereby resisting the deformation of the material.

Sl No	Nomenclature	Initial Diameter (mm)	Area (mm2)	Ultimate Load (KN)	Ultimate Compressive Stress (Mpa)
1	Al6061 + 0% reinforcement	19.00	283.385	139.70	480
2	Al6061 + 3% Sic + 3%FLY ASH	19.00	283.385	151.90	523
3	Al6061 + 3% Sic + 6%FLY ASH	19.00	283.385	164.64	532
4	Al6061 + 3% Sic + 9%FLY ASH	19.00	283.385	167.27	546

Table 4.2: Compression Test Results.

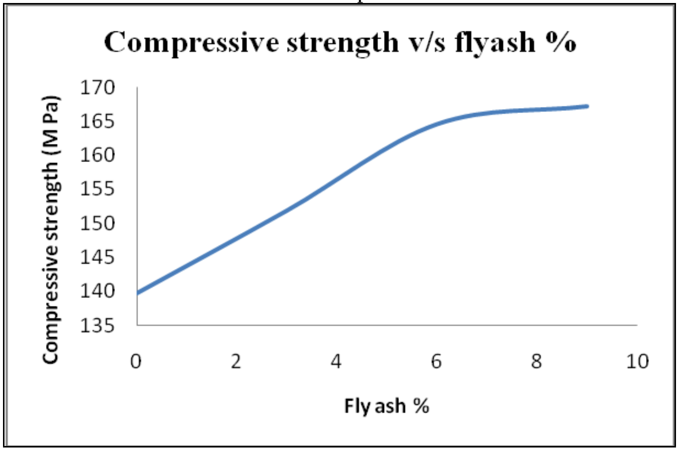

Fig 4.2: Compressive strength v/s fly ash weight %.

4.3 Hardness test

Table 4.3 and graph 4.3 shows the results of hardness with varying percentage of fly ash. It can be observed that the hardness value increases with increasing % of fly ash and SiC, it may be due to the harder particle of fly ash and SiC present in the matrix and also due to the good bonding between the matrix and reinforcements.

Sl No	Nomenclature	Load (Kgf)	BHN
1	Al6061 + 0% reinforcement	250	50
2	Al6061 + 3% Sic + 3%FLY ASH	250	58
3	Al6061 + 3% Sic + 6%FLY ASH	250	70
4	Al6061 + 3% Sic + 9%FLY ASH	250	79

Table 4.3: Hardness Test Results

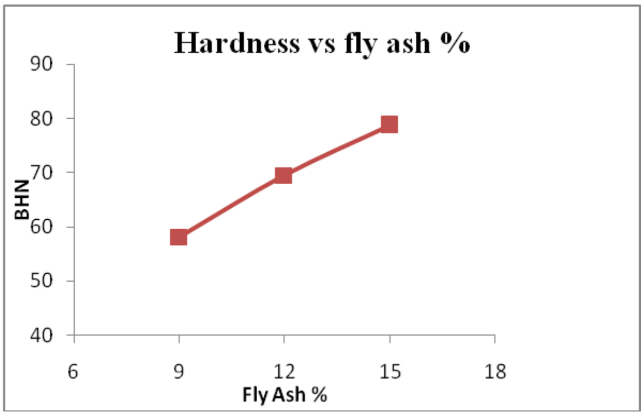

Fig 4.3: BHN V/S fly ash Weight %.

4.4 Wear test

The below shown results evidences that the reinforcement enhances the wear resistance property of the material and also it is clear from the graph that the wear loss decreases with increase in fly ash %.

Sl No	Nomenclature	Time (Min)	Weight loss (gms)
1	Al6061 + 0% reinforcement	3	0.026
2	Al6061 + 3% Sic + 3%FLY ASH	3	0.022
3	Al6061 + 3% Sic + 6%FLY ASH	3	0.018
4	Al6061 + 3% Sic + 9%FLY ASH	3	0.016

Table 4.4: Wear test Results.

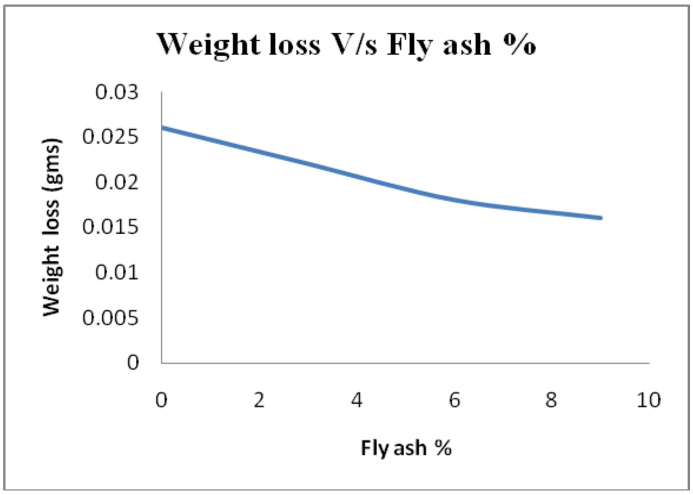

Fig 4.4: Weight loss V/S fly ash weight %.

5. CONCLUSION

Based on the observation and results obtained through experiments the following conclusions can be drawn.

- From the study it is concluded that we can use fly ash for the production of composites and clearing the fly ash storage issues.
- Fly ash up-to 9% by weight can be successfully added aluminium 6061 alloy by stir casting route to produce composites.
- Hardness of aluminium (Al6061) is increased from 50BHN to 88BHN with addition of fly ash.
- The Ultimate tensile strength has improved with increase in fly ash content. Whereas ductility has decreased with increase in fly ash content.
- Compressive strength increases with increase in reinforcement weight percentage.

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