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EXPERIMENTAL STUDY ON TENSILE AND HARDNESS PROPERTIES OF AL-CU ALLOY WITH GRAPHITE AND FLY ASH COMPOSITE MATERIAL

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Abstract

Metal Matrix Composites are engineered materials, produced by the combination of two or more different materials to gain improved properties. In the current analysis, an Al–4.5% Cu alloy be used as the fly ash and graphite and matrix is reinforcement. Aluminum copper alloy matrix composite repels the much concentration due to their high thermal conductivity, lightness, moderate making temperature etc. graphite powders and fly ash are used since its low density and high strength. The composite was formed using stir casting approach. The fly ash was added in 3%, 6%, and 9 % by weight and graphite was added in 3%, 6%, and 9 % by weight to the molten metal. The composite was tested for hardness, mechanical properties, . Microstructure investigation was done using a scanning electron microscope to gain the distribution of graphite and fly ash in the aluminum matrix. The results found an increase in tensile strength and hardness with increasing the graphite and fly ash content.

Keywords: *Aluminium Alloy, Copper, Fly Ash, Graphite ,Stir Casting, …*

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1. INTRODUCTION

The aluminium is used as an engineering material is usually taken to comprise the design, characterization [1-3], production and the application of materials ,and the scope has now a days been widened to include devices and application of materials. Aluminium has good mechanical properties and light weight material.

Demand for developing metal matrix composite for use in high performance application. such as aerospace, automobiles, electronics and computer industries to replace the existing materials have been significantly increased among these composites[3-5]. Aluminium alloy matrix composite attracts much attention due to their lightness, high thermal conductivity, moderate casting temperature etc.

Various kinds of ceramic materials like copper, fly ash, graphite magnesium are extensively used to reinforce aluminium alloy matrix. Superior properties of these materials refractoriness, high hardness, high compressive strength, wear resistance etc. make them suitable for use as reinforcement in matrices of composites.

A significant improvement in the properties of aluminium alloy reduced fuel consumption because light weight as made huge demand for automobile industry [6-7]. This growing requirement of materials with high specification mechanical properties with weight savings as fuel significant research activities in recent times targeted primarily for further development of aluminium based composite.

In this study aluminium 6061 with 4.5% copper alloy will be melted in the furnace of 860 ^{0}C degree of temperature and after it reach molten metal stage a different weight of fly ash and graphite will be added to the molten metal by stirring process[8-14], keeping a speed of 450rpm up to 15min after that the molten metal will pour into the 25mm diameter casting die. Finally the specimen is fabricated at different weight percentage and to be carried out for mechanical properties [15-19].

2. EXPERIMENTAL PROCEDURE

Aluminium with 4.5% Cu was selected as the matrix material. The chemical composition of Al–4.5% Cu alloy is given in Table 1.Fly ash was used as the reinforcement and its composition is given in Table 2.The average particle size was found to be 10 μm. The density of fly ash was found to be 2.09 g/cm^3. Fig. 1 shows SEM micrographs of fly ash particulates

Table 1: Chemical composition of Al–4.5% Cu alloy

Cu	Mg	Si	Fe	Mn	Ti	Zn	Al
4.5	1.00	0.60	0.65	0.10	0.10	0.20	Balance

Table 2: Chemical composition of fly ash in weight percentage

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Loss on ignition
30.40	58.41	8.44	2.75	1.43

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Chemical composition of graphite is the purest form of carbon. The metal matrix composite was prepared by stir casting. The billets of Al–4.5% Cu alloy were taken in a graphite crucible and melted in an electric furnace. The temperature was slowly increased to 860 °C. The melt was degassed at 800 °C with a solid dry hexachloroethane (C_2Cl_6, 0.5 wt. %) degasser. The molten metal was stirred to create a vortex and the particulates were introduced. The degassed molten metal was kept below the stirrer and stirred near about 450 rpm. The preheated fly ash particles were poured into the melt. Small pieces of Mg chips (0.5 wt. %) were introduced to the molten metal to see to it that good wet ability of particles with the molten metal. The percentage of fly ash added in terms of 3, 6, and 9 wt. % and also the percentage of graphite added was 3, 6, and 9 wt. %. The stirred scattered molten metal was put into preheated S.G. iron moulds 25 mm in diameter and 200 mm height, cooled to room temperature in atmospheric pressure.

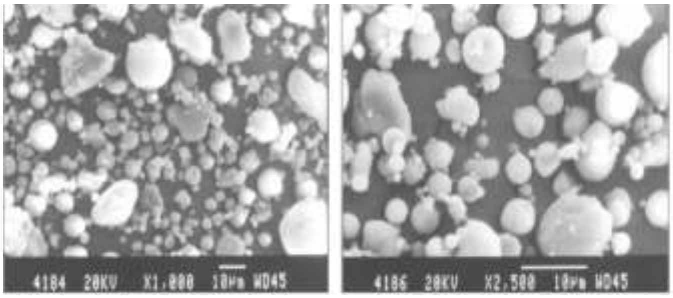

Fig 1: SEM of fly ash particulates

Composites that were produced were subjected to solutionisation and age hardening (T6). The castings were heated to 525 °C and held for 17 hours, tempered in warm water, then reheated to 175 °C and kept for 18 hours. They were sectioned and test samples were prepared for various tests. Archimedes principle was used to measure the densities of the specimens. Brinell hardness tester determines their hardness. The load of 250 kg using a 5 mm steel ball indenter was used to measure the hardness. Scanning electron microscope is used to determine the microstructure of the MMC'S. at various locations across the specimen to examine the distribution of fly ash and graphite in the matrix. Tensile strengths is determined using a 20 kN computerized UTM with an electronic extensometer as per ASTM E-8 standards. Online plotting of load versus extension was done continuously through a data acquisition system (DAS).

3. RESULTS AND DISCUSSION

3.1 Tensile Properties

Table 3 shows the variation of tensile strength of the composites with the different weight fractions of fly ash and graphite particles. It can be noted that the tensile strength increased with an increase in the weight percentage of fly ash and graphite. Therefore the fly ash particles act as barriers to the dislocations when taking up the load applied (Basavarajappa et al., 2004; Seah et al. 1995). The hard fly ash particles obstruct the advancing dislocation front, thereby strengthening the matrix (Suresh et al., 2003). However, as the size of the fly ash particles increased, there was 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 amd graphite posses higher strength and toughness.

Table 3: Shows the tensile test result of 25mm diameter rod

Compo sition %	Peak load (KN)	Load at yield (KN)	Yield stress(N /mm^2)	% of Elong ation	Tensile strength (N/mm^2)
Flyash-3% Graphite-3%	21.90	19.90	165.30	3.78	181.98
Flyash -3% Graphite-6%	10.20	8.60	141.37	3.89	161.67
Flyash -3% Graphite-9%	14.80	12.3	99.26	2.06	119.4
Flyash -6% Graphite-3%	18.40	15.00	122.22	2.72	149.92
Flyash -6% Graphite-6%	18.90	16.60	133.96	3.74	152.52
Flyash -6% Graphite-9%	19.10	17.30	141.45	3.85	156.66
Flyash -9% Graphite-3%	20.40	20.00	122.22	2.72	161.67
Flyash -9% Graphite-6%	20.90	20.60	133.96	3.74	171.57
Flyash -9% Graphite-9%	20.10	20.30	141.45	3.85	181.98

Fig 2: Casted composite rods of diameter 25mm

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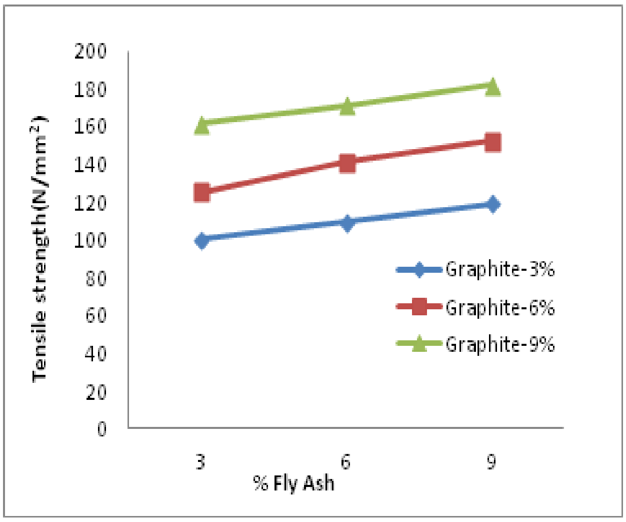
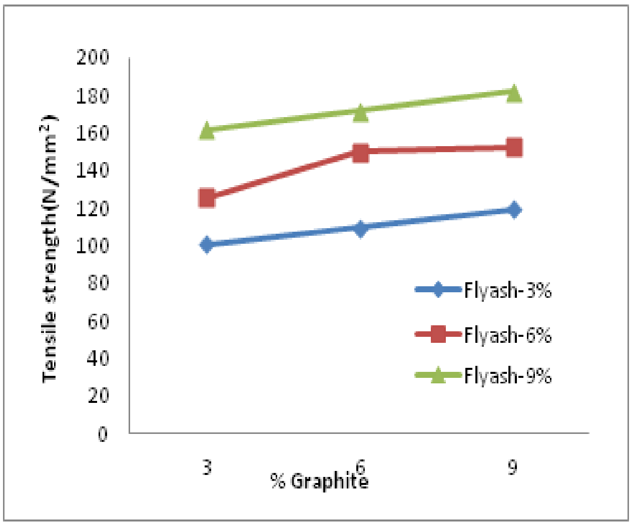


(a)



(b)

Fig 2: Tensile properties of composite (a) Tensile strength v/s % of fly ash in 25mm diameter(b) Tensile strength v/s % of graphite in 25mm diameter

3.2 Hardness Test

It is found that the hardness increases with an increase in the weight percentage of fly ash and also that the hardness increases with an increase in the weight percentage of graphite. From table.4, shows hardness test conducted ball diameter 5mm and load 2452.5N, it can be noted that the hardness of the composite increased with the raise in weight fraction of the fly ash and graphite particles. Thus the hard fly ash particles help in increasing the hardness of the aluminium alloy (Al6061) matrix.

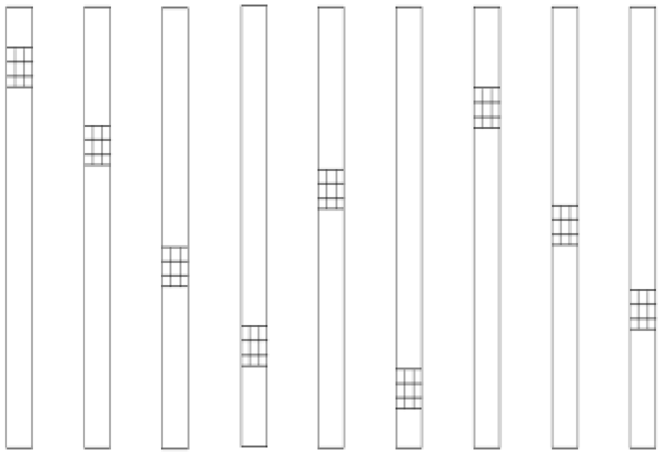
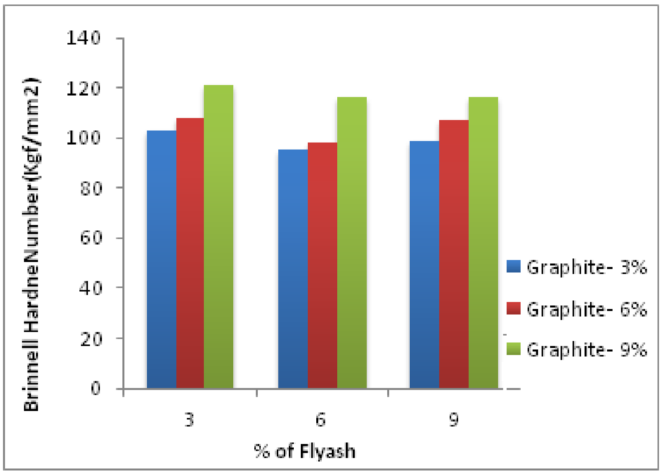


Fig 3: shows circular cross section of 200 mm length and 2mm diameter specimen for hardness test.



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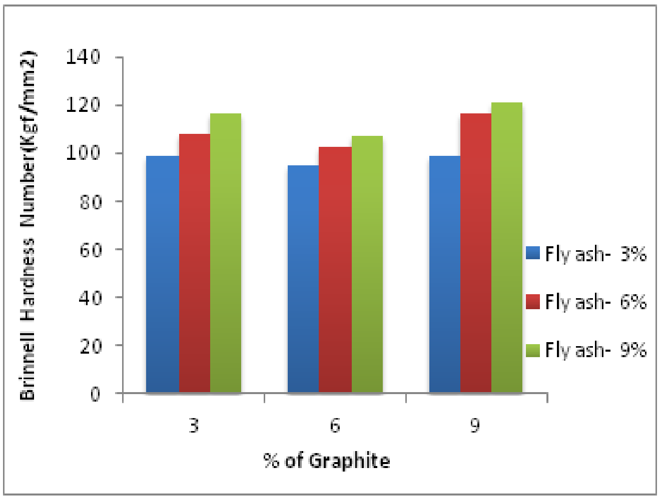

(b)

Fig 4: Hardness properties of composites (a) Brinell Hardness Number v/s % of graphite Test results of 25mm diameter (b) Brinell Hardness Number v/s % of Flyash Test results of 25mm diameter.

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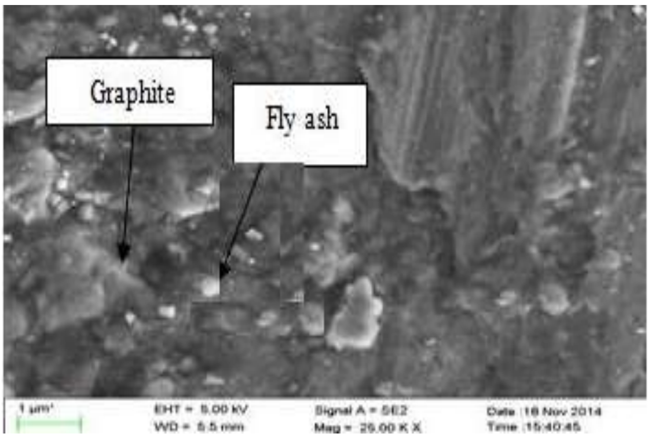
Table 4: Shows Brinell hardness test result of 25mm diameter rod

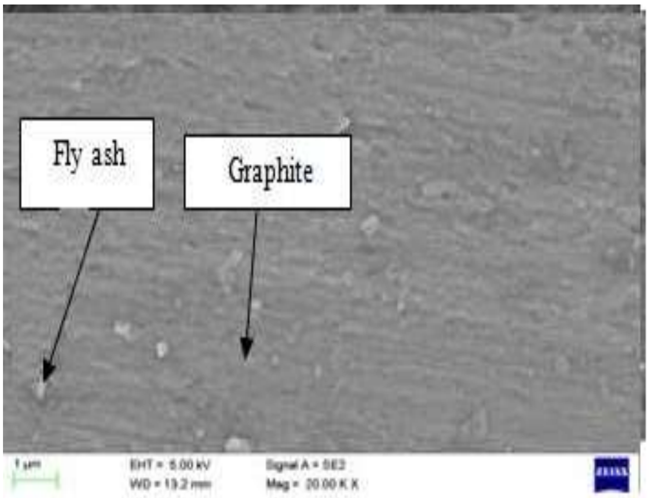
Sl. no	Composition %	Dia of Indentation 'd' (mm)	Brinell Hardness Number (N/mm2)
1	Flyash 3% Graphite 3%	2.10	578.79
2	Flyash 3% Graphite 6%	1.96	667.08
3	Flyash 3% Graphite 9%	1.74	774.99
4	Flyash 6% Graphite 3%	1.72	804.42
5	Flyash 6% Graphite 6%	1.68	931.95
6	Flyash 6% Graphite 9%	1.65	990.81
7	Flyash 9% Graphite 3%	1.55	1000.62
8	Flyash 9% Graphite 6%	1.43	1020.24
9	Flyash 9% Graphite 9%	1.38	1039.86

3.3 Microstructure

As the microstructure plays an important role in the overall performance of a composite and the physical properties depend on the microstructure, reinforcement particle size, shape and distribution in the alloy, prepared samples were examined using Optical Metallurgical Microscope (Model : NIKON Epiphot 200)



(a)



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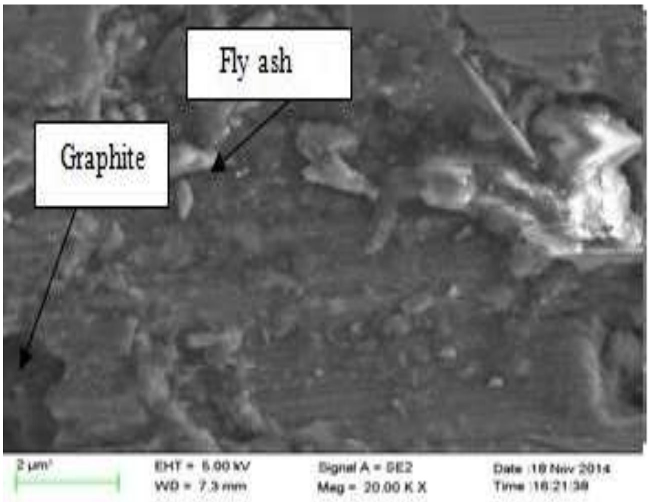

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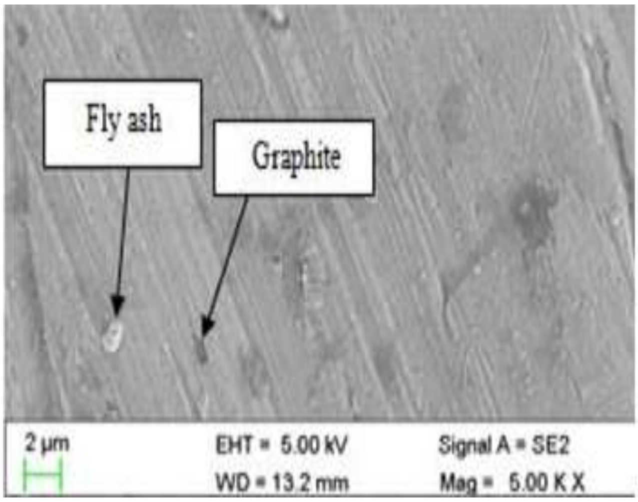

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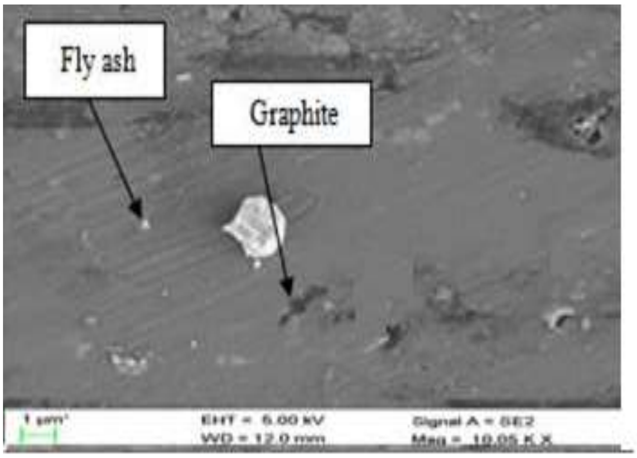

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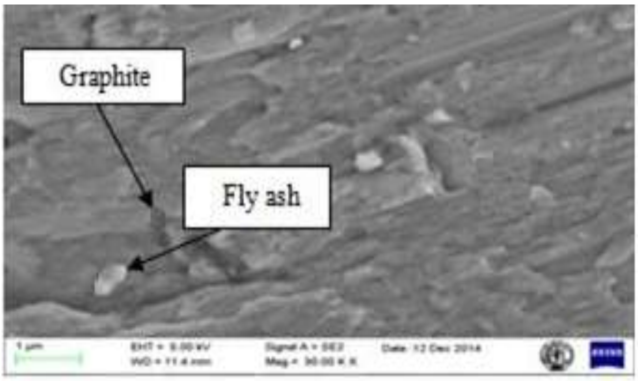

(f)

Fig 5: SEM photomicrograph (a)diameter 25mm flyash3%,graphite 3% (b)diameter 25mm fly ash 3% graphite 6% (c)50mm diameter fly ash 6% graphite 3% (d) diameter 25 mm flyash6% graphite 6% (e) diameter 25mm fly ash 9% graphite 3% (f) diameter 25mm fly ash 9% graphite 6%.

4. CONCLUSION

1. MMC's containing up to 9% fly ash and 9% graphite particles were easily fabricated. A uniform distribution of fly ash and graphite was observed in the matrix.
2. As the percentage of graphite increases the tensile strength also increases.
3. As the percentage of fly ash increases the tensile strength also increases.
4. As the percentage of graphite increases the hardness also increases.
5. As the percentage of fly ash increases the hardness also increases

REFERENCES

[1] Eyre t.s., tribol. Int., (1976), 203.
[2] BHANSALI K.J., MEHRABIAN R., J. Metals, 34 (1982), 30.
[3] HOSKING F.M., PORTILLO F.F., Wunderlin R., MEHRABIAN R., J. Mater. Sci., (1982), 477.
[4] DEONATH S.K., BHAT R.T., ROHATGI P.K., J. Mater. Sci., (1980), 1241.
[5] MAJUMDAR B.C., YEGNESHWARAN A.H., ROHATGI P.K., Mater. Sci. Eng., 68 (1984), 885.
[6] POZA P., LLORCA J., Mater. Sci. Eng., A206 (1996), 183.
[7] PRADER P., DEGISCHER H.P., Mater. Sci. Technol., 16(2000), 893.
[8] IAN J.H., Metal Powder Rep., 10(1990), 689.
[9] ROHATGI P.K., GUO R.Q, J. Metall. Mater. Trans. B, 298 (1998), 519.
[10] SANNINOA.P.,RACKH.J,Wear,216(1995),
[11] DEUIS R.L., SUBRAMANIAN C., YELLUP J.M., Wear, 201 (1996), 132.
[12] GUO R.Q., ROHATGI P.K., Metal. Mater. Trans. B, 29B (1998), 51
[13] DIPTI KANTA DAS,PURNA CHANDRA MISHRA,SARANJIT,SINGH,SWATI,PATTNAIK,., MATERSCI. G,17(2014),40712(AL1)
[14] DIPTI KANTA DAS,PURNA CHANDRA MISHRA,SARANJITSINGH,RATISH THAKUR,MATER SCI.ENG,16(2014),40712(AL2)
[15] Wanlin GUO, Jun YIN, Hu QIU, Yufeng GUO, Hongrong WU, Minmin XUE,MATER SCI.,16(2014),64(GR31)
[16] Tuck Wah Ng, Chun Yat Lau, Esteban Bernados-Chamagne, Jefferson Zhe Liu, John Sheridan and Ne Tan,MATER SCI,14(2012),7(GR14)
[17] Marcin Go´rny and Edward Tyrała.,MATER SCI.22,(2013),305(GR7)
[18] N.A. WARNER,MATER SCI.(2008),10.(GR55)
[19] Basavaraju.S, Arasukumar.K,Dr.Chandrashekhar Bendigeri,Dr.C.K.Umesh, International Journal of Innovative Research in Science, Engineering and Technology vol1 (2012).
[20] Prakash C.H. and Pruthviraj R.D, Research Journal of Chemical Sciences, Vol. 1(6), 88-90, Sept. (2011)