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Fabrication and Experimental Investigation on Hardness and Density Properties of Aluminium Hybrid Composites

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ABSTRACT: In this work, carbon nano tube(CNT) –Fly ash(FA) reinforced aluminium composites were fabricated by powder metallurgy technique. Green compacts of Al-16wt.% FA - 0.75 wt.% CNT composite were fabricated under varying compaction loads were sintered over a series of temperatures (300°C,400°C 500°C) and sintering time(1,3 and 6 hr) to analyse the effect of sintering temperature and sintering time. The surface morphology was studied using scanning electron microscope for analyse the distribution of reinforcements. Scanning electron microscopy (SEM) analysis revealed the uniform dispersion of FA-CNTs in the composite samples. Hardness and density properties of the composites are also evaluated. It was found that the composite prepared at sintering temp 500 °C and sintering time 6 hr showed good result.

KEYWORDS: Hybrid composites, Powder metallurgy, Aluminium, Fly ash, , Multi wall carbon nano tube, Scanning electron microscope.

I. INTRODUCTION

A composite material is a multiphase material that is artificially made and the constituents phases must be chemically dissimilar and separated by a distinct interphase. Composites have been created to improve combinations of mechanical properties such as stiffness, toughness and ambient and high temperature strength. A relatively new fiber-reinforced composite is the hybrid, which is obtained by using two or more different kinds of fibers in a single matrix; hybrids have a better all-around combination of properties than composites containing only a single fiber type. [1]. Fly ash is one of the residues generated in the combustion of coal, It is an industrial by product recovered from the flue gas of coal burning thermal power plant. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica(silicon dioxide) and lime(calcium oxide). [2]. In recent years, fly ash has been attracting great attention for its functional and structural applications. Fly ash proves to be an excellent reinforcement for composites due to excellent mechanical, thermal properties and light weight structure [3]. M.Ramachandra et.al[5] has worked on the effect of reinforcement of fly-ash on sliding wear, slurry erosive wear and corrosive behaviour of aluminium matrix composite and found that fly-ash improves abrasive wear resistance of Al alloy and reduces the coefficient friction. Since the discovery of carbon nanotubes (CNT) in 1991 and the realization of their unique physical properties, including mechanical, thermal, and electrical, many investigators have endeavored to fabricate advanced carbon nanotubes (CNTs) composite materials that exhibit one or more of these properties. The multi-walled carbon nanotubes (MWCNTs) with a diametrical range of 5-40 nm are known for their exceptional mechanical properties. MWNT whose modulus is comparable to that of diamond (1.2 TPa), are reported to have strengths 10- 100 times higher than the strongest steel at a fraction of the weight [5]. In this work, carbon nano tube(CNT) -Fly ash(FA) reinforced aluminium composites were fabricated by powder metallurgy technique. Microstructural characterization and hardness and density properties were presented and discussed.



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II.EXPERIMENTAL PROCEDURE

Forty five grams of Al powder (99.7% pure) with 0.75% Multi-wall carbon nano tubes (outer diameter and inner diameter ranges between 10 and 15 nm and between 2 and 6 nm, respectively, and 0.1 to 10 μ m length, Chengdu chemicals Co. Ltd , China) and 16% Fly ash were placed in 250 ml stainless steel mixing jars containing stainless steel milling balls(8 mm diameter) giving an ball-to-powder weight ratio of 8:1. The jars then agitated using a planetary ball

mill at 250 rpm for 2 hr milling time. 3 ml of methanol were added as a process control agent (PCA) in order to

minimize cold welding of the Al particles and also to prevent powders sticking to the balls and jar walls. 15 g of the ball-milled powders were cold compacted in a cylindrical die of 25 mm diameter at 140 kN, 120 kN, 100 kN, 80 kN, 60 kN. Compacted billets of 25 mm diameter and 13 mm height were sintered at 500 °C,400 °C,300 °C for 1 hr,3 hr,6 hr. The macro hardness of the green composite and sintered composite was evaluated using a Vickers hardness tester. The density of the green composite is also evaluated.

III. RESULTS AND DISCUSSION

SEM AND XRD STUDY

The micrographs shown in figure depict the microstructure of as received FA, CNT and pure Al. powders. X-ray diffraction of the composite samples shows no major aluminium carbide formation. The X-ray diffraction patterns are overlapped and shown in Fig.



Fig.1-SEM Micrograph of powders of as received Fly-ash, CNT powder and pure aluminium powder.



Fig.2: SEM micrograph of the composite (Al-0.75% CNT-16% FA)



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Fig 3. XRD of composite samples

Evaluation of Hardness and Density

The relation between green hardness with compact load was shown in the below table 1 and fig 1. It was found that the hardness and density of the green composite increased with compact load. The relation between sintered hardness with compact load is also shown in the below table 1 and fig 4. It was found that sintering temperature 500 $^{\circ}$ C and sintering time 6 hr shown

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Table I	Cireen densu	v and nardness	(AI+I	0%FA+U/7%		(Z nour n	an munng))
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Compact load	Average Hardness(VHN)	Density(g/cm ³)
140	42.618	2.465
120	40.433	2.37
100	31.648	2.385
80	27.98	2.262
60	No clear image	2.109





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Table 2: Sintered hardness at sintering temperature 500°C

Compact Ioad (KN)	Sintered hardness (1 hr sintering time)	Sintered hardness (3 hrs sintering time)	Sintered hardness (6 hrs sintering time)
140	40.8423	41.25	43.72
120	38.5958	39.15	40.785
100	34.4978	36.56	37.53
80	29.93	30.01	30.98



Fig.5 Variation of sintered hardness vs compact load at 500°C

Table3: Sintered hardness at sintering temperature 400°C

Compact Ioad (KN)	Sintered hardness (1 hr sintering time	Sintered hardness (3 hrs sintering time)	Sintered hardness (6 hrs sintering time)
140KN	34.568	35.76	37.44
120KN	33.15	34.32	35.15
100KN	30.69	31.42	33.71
80KN	27.04	27.21	28.9



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Compact Ioad (KN)	Sintered hardness (1 hr sintering time	Sintered hardness (3 hrs sintering time)	Sintered hardness (6 hrs sintering time)
140KN	31.359	33.522	35.16
120KN	26.931	28.06	33.25
100KN	29.40765	30.65	30.90
80KN	24.13955	25.254	26.25

Table4:	Sintered	hardness	at sintering	temperature	300°C
Tablet.	Sincicu	nai uness	at sintering	<i>comperature</i>	300 C



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Fig 7 Variation of sintered hardness vs compact load at 300°C

IV. CONCLUSION

The conclusions drawn from the present investigation are as follows:

1)Fly ash, the thermal power plant residue from coal burning can be successfully used as a reinforcing material to produce Aluminium metal matrix composite.

2) There was homogeneous dispersion of fly ash and CNT in aluminium matrix which improves the hardness of the matrix material.

3) It was found that green density and hardness increased with compact load and sintered hardness depends on sintering temperature and sintering time..

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