EVALUATION OF MECHANICAL PROPERTIES FOR AL-Pb/FLY ASH METAL MATRIX COMPOSITES

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ABSTRACT
Metal Matrix Composites (MMCs) are highly attractive for large range of hi-tech engineering applications because of their useful properties. Generally metal matrix composites are formed with two constituents, one being a metal and the other material either being a different metal or other material like ceramic or organic compound. Stir casting is the most commonly used method for production of particulate reinforced cast metal matrix composites. A recently developed modification of stir casting has been used in the present investigation to produce aluminum-lead matrix composites reinforced with Fly ash. The weight of the reinforcement material Pb and Fly ash are varied from 0 to 10% and different test samples are prepared. Many tests are conducted to evaluate the experimental result on the Al-Pb/fly-ash composites
KEYWORDS: Mechanical behavior, Fly-ash, Aluminum composite, Stir casting

1. INTRODUCTION

Metal matrix composites (MMCs) have been observed to possess the ability to tailor their physical, mechanical and tribological properties for a given application. Among the metal matrix composites, the aluminum matrix composites have low density, high stiffness, low cost, ease of improvement, low melting point, high workability, corrosion resistance, and availability of variety of alloy systems. In most of the aluminum metal matrix composites, the reinforcement is fly-ash in the aluminum MMCs in order to impart low density, low thermal conductivity, higher damping capacity, higher electrical resistance, improved machine ability, and higher hardness or higher wear resistance to the resulting composite to meet specific requirements. The anti-welding, anti-scoring and other bearing features of aluminum are inferior. These features can be improved by the addition of discrete soft phase constituents like cadmium (Cd), indium (In), tin (Sn), lead (Pb), and bismuth (Bi). Among these materials, both Pb and Sn offer most attractive combinations of engineering properties, cost and availability. On account of this reason, both these materials are widely employed in the plain bearings. When compared to Sn, Pb is soft and has low modulus of elasticity and this confers better embed ability and conformability as a constituent of bearing alloy. Also, Pb is cheaper than Sn. This is the reason for selecting Pb as an alloying element in the aluminum matrix material. If the Al-Pb/fly-ash composites are produced by the casting methods, these are likely to exhibit segregation and non-uniform distribution of particles. The reasons are: (i) wide difference in densities between Al, Pb and fly-ash particles, (ii) poor wet ability between the fly-ash particles and Al-Pb matrix, and (iii) immiscibility between Al and Pb. On the other hand, the powder metallurgy method is capable of producing aluminum alloy matrix composites with improved uniform distribution of reinforcement particles. Hence, in the present work, the powder metallurgy method has been adapted to prepare the Al-Pb/fly-ash composites. Aluminum matrix composites (AMCs) are the competent material in the industrial world. Due to its excellent mechanical properties, it is widely used in aerospace automobiles, marine etc.

2. METHODOLOGY

2.1 Sample preparation

The simplest and the most cost effective method of liquid state fabrication is stir casting. So, for fabrication process stir casting process is used. A stir casting setup consists of pre-heater, electric furnace with stirrer assembly. Three-phase electrical resistance type 10 KW capacity furnace is used. The temperature range of the furnace is 1000˚ C. The temperature range of pre-heater is about 800˚C. The melting range of aluminum and lead in 700˚C - 800˚C. When setting up the stir caster before an experiment the rotor was first lowered into the crucible. Its height was accurately adjusted to form a partial seal at the exit such that it was held concentrically during stirring. Only a partial sealing of the outlet was allowed to ensure that torque pick-up from the rotor-crucible interaction was negligible. An external plug attached to the batch casting trolley provided a full seal at the exit. After the caster set-up, metal melted in an induction furnace was transferred to a resistance holding furnace where it was stabilised at a temperature 20 °C above the liquids temperature. The melt was then poured into the stir caster furnace which had been preheated to 570 °C to 595 °C for Aluminum Metal Matrix Composites.

Fig 1 Stir Casting

The stirrer was rotated up to 600 – 700 rpm. The depth of immersion of the impeller was approximately one third of the height of the molten metal, from the bottom of the crucible. Stirring was continued until interface interactions between the particles and the matrix promoted wetting. After few minutes of stirring the melt is poured in to the preheated die. The dies were pre heated and coated additives to ease the process of removing the castings. After solidification the required casts are obtained.

The different Elemental compositions of fly-ash weight percentage given below in the table 1

Table 1 Elemental composition of FLY-ASH

S.No	Constituents	Value
1	Loss on Ignition (LOI) %	0.52
2	Silica as SiO2 %	61.75
3	Iron Oxide as Fe2O3 %	01.06
4	Aluminum as Al2O3%	27.79
5	Titanium oxide as TiO2 %	0.95
6	6 Manganese as MnO %	0.14
7	Calcium oxide CaO %	4.36
8	Magnesium oxide MgO%	0.73
9	Sodium oxide Na2O %	0.15
10	Potassium oxide K2O %	0.64
11	Phosphorus as P2O5 %	0.83
12	Sulphate as SO4 %	0.98

The weight percentage of aluminum constituents are mentioned in the table 2

Table 2 Specification of Al

S.No	Constituents	% Percent
1	Manganese(Mn)	1.00
2	Iron(Fe)	0.50
3	Magnesium(Mg)	1.20
4	Silicon(Si)	1.30
5	Copper(Cu)	0.10
6	Zinc(Zn)	0.20
7	Titanium(Ti)	0.10
8	Chromium(Cr)	0.25
9	Aluminium	Balance

The weight percentage of Lead constituents are mentioned in the table 3

Table 3 Specification of Lead

S.No	Constituents	value
1	Purity	99.5%
2	Atomicweight	207.20
3	Mesh size	325
4	Melting point	327°C

Table 4 Constituents of samples

Sample	Composite specimen (wt.%)
Sample 1	Al - 85% Pb-15% Fly ash- 0%
Sample 2	Al - 85% Pb-10% Fly ash- 5%
Sample 3	Al - 85% Pb-5% Fly ash- 10%

The final casted AMC samples were then made into specific specimen sizes. The varying weight percentage of reinforcements of samples is shown in Table 4.

3. RESULT AND DISCUSSION

3.1 SEM Result

The SEM instrument is made up of two main components, the electronic console and the electron column. The electronic console provides control knobs and switches that allow for instrument adjustments such as filament current, accelerating voltage, focus, magnification, brightness and contrast.

The FEI Quanta 200 is a state of the art electron microscope that uses a computer system in conjunction with the electronic console making it unnecessary to have bulky console that houses control knobs, CRTs, and an image capture device. All of the primary controls are accessed through the computer system using the mouse and keyboard. The user need only be familiar with the GUI or software that controls the instrument rather than control knobs and switches typically found on older style scanning electron microscopes. The image that is produced by the SEM is usually viewed on CRTs located on the electronic console but, instead with FEI the image can be seen on the computer monitor. Images that are captured can be saved in digital format or printed directly.

Aluminum composites from the figures it can be observed that, the distributions of reinforcements in the respective matrix are fairly uniform. Further these figures reveal the homogeneity of the cast composites. The microphotograph also clearly reveals the increased filler contents in the composites. Cracks are also seen in the microstructure. Figures 2, 3, 4 are presented with the microphotographs of Casting of Al, Pb and Fly-ash.

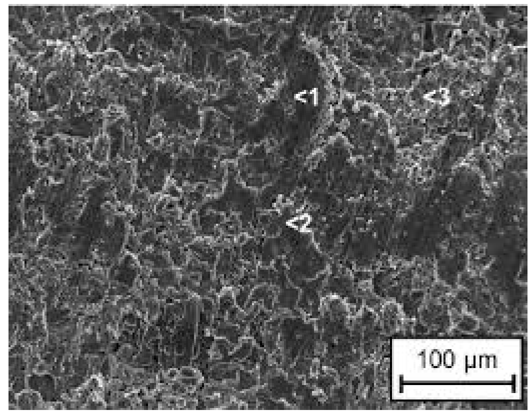

Fig 2 SEM image of Al+15wt%Pb

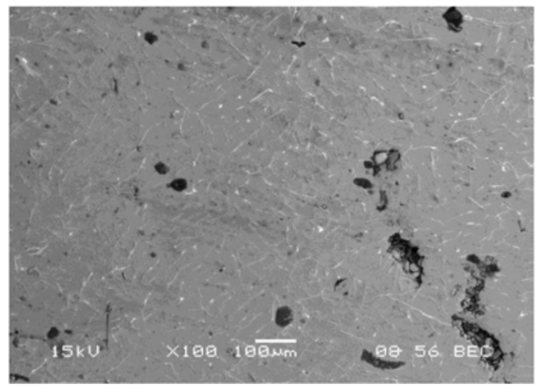

Fig 3 SEM image of Al+10wt%Pb+5wt%Flyash

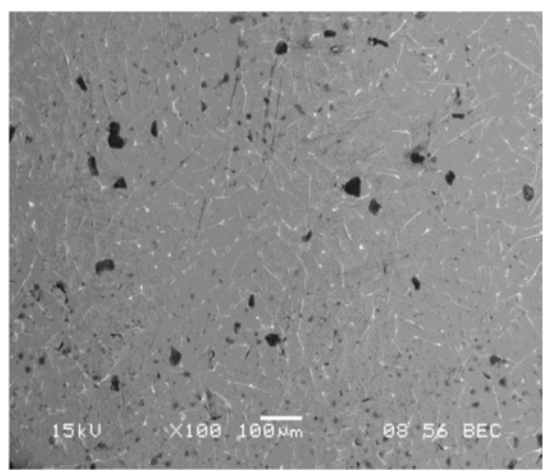

Fig 4 SEM image of Al+5wt%Pb+10wt%Flyash

3.2 Hardness Test

The harness test result for various combinations of matrix and reinforcement materials in weight percentage is shown in the table 5. The complete ranges of hardness are calculated. The hardness test shows a marginal increase in hardness with the increase in the addition of Pb and Flyash. The hardness test shows a greater increase with stir casting process.The hardness property of Aluminum matrix composite is increased by addition of Pb and Fly-ash. The table 5 shows the hardness of reinforcement particulates of fabricated AMCs. The hardness of the composite is augmented from 70 HV to 75 HV.

The increase in hardness with the increase in percentage of particle fraction is due to the increase in the availability of specific surfaces of the particulates in the composites.

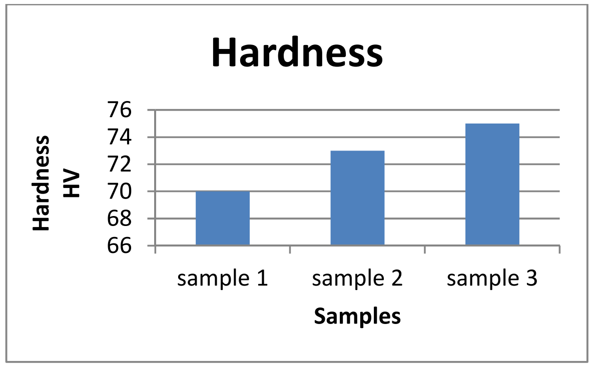

Fig 5 Hardness Test graph for various samples

Table 5 Hardness Test Result

Sample	Composition	Hardness Test Trial			Average value (HV)
		Trial 1	Trial 2	Trial 3	
1	Al +Pb-15%	72	70	71	70
2	Al+10%Pb+5%Fly ash	73	74	72	73
3	Al+5%Pb+10%Fly ash	75	76	74	75

Table 6 Tensile Test Result

Sample	Composition of samples	UTS (N/mm2)	Elongation (%)
1	Al +Pb-15%	157.28	10.35
2	Al +10%Pb+5%Fly ash	154.75	11.29
3	Al +5%Pb+10%Fly ash	148.90	12.58

Table 7 Impact Test Result

Samples	Composition of samples	Impact Test			Absorbed Energy (Nm)
		Trial 1	Trial 2	Trial 3	
1	Al +Pb-15%	6.2	6.5	6.6	6.43
2	Al +10%Pb+5%Fly ash	7.8	8.2	8.5	8.17
3	Al +5%Pb+10%Fly ash	9	9.1	8.8	8.97

3.3 Tensile Test

From the test result the tensile strength of the three different wt.% composite sample is increased gradually and addition of Pb and fly ash sample is to get higher tensile strength 157.28 N/mm^2 compared with other samples. The percentage of elongation of the composite of Pb and fly ash sample was to get higher elongation 12.58%.

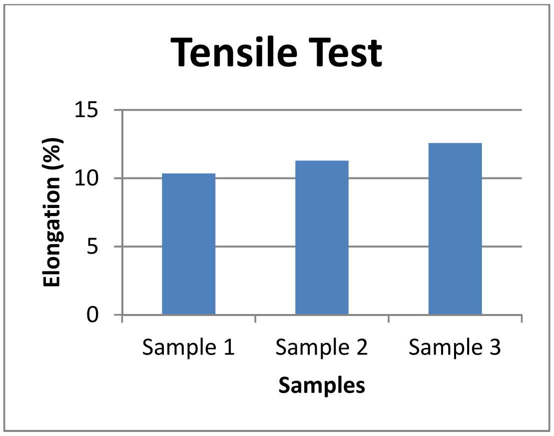

Fig 6 Tensile Result for various samples

3.4 Impact Test

The Charpy impact test, also known as the Charpy v-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness the composites are given in Table-7.

The absorbed energy of Aluminum matrix composite is increased by addition of Pb and Fly-ash. The table 7 shows the impact of reinforcement particulates of fabricated AMCs. The absorbed energy of the composite is augmented from 6.43Nm to 8.97 Nm.

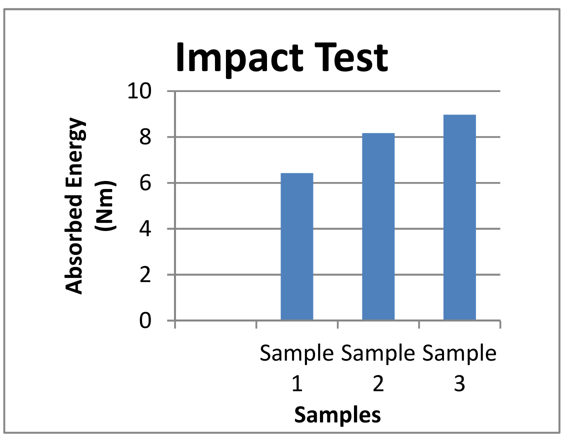

Fig 7 Impact Test Result for various samples

4. CONCLUSIONS

Al –Pb/ Fly ash metal matrix composites were produced by modified stir cast route with different weight percentage of reinforcement and the mechanical properties such as Hardness Test, SEM analysis, Tensile strength, Impact Test were evaluated.

From this study, the following conclusions are derived.

The hardness of the composites was increased from 70 HV to 75 HV with respect to addition of weight percentage of Fly-ash. Hardness is an important property of a component which is subjected to heavy load. The reinforcement of particles has enhanced the hardness of aluminum matrix composites.

The microstructure of 10% Pb and 5% Fly-ash confirms the presence of major elements like copper, zinc, iron and Fly-ash particlespresented in the composite and these particles are reasonably well distributed within the MMC.

There was an improvement in Tensile Strength of MMC increased with increase in Fly ash with lead and percentage elongation is more with increase in Fly ash.

The absorbed energy on impact test was increased from 6.43 Nm to 8.97 Nm with respect to change of fly-ash and lead percentage.

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