

Preparation & Analysis of Mechanical and Microstructural Properties of Aluminium Based Metal Matrix Composite Reinforced with Bagasse Fly Ash

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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. However the methods used to produce these composites are constantly evolving particularly in getting rid of non-uniform distribution of the reinforcement. Stir casting is the most commonly used method for production of particulate reinforced cast metal matrix composites. Stir casting has been used in the present investigation to produce aluminum matrix composites reinforced with fly ash. The composites are prepared by adding the fly ash 6%, 10% and 14% by weight than the mechanical properties are compared by pure aluminium. The tensile properties of the resulting composites are measured. The improvements in the tensile properties are appreciable.

KEYWORDS: BA-Bagasse Ash, Al- Aluminium, MMC- Metal Matrix Composite

I. INTRODUCTION

The importance of composites as engineering materials is reflected by the fact that out of over 1600 engineering materials available in the market today more than 200 are composites. These composites initially replaced Cast Iron and Bronze alloys but owing to their poor wear and seizure resistance, they were subjected to many experiments and the wear behaviour of these composites were explored to a maximum extent and were reported by number of research scholars for the past 25 years [1].

Bagasse is a by-product from the sugar industry and it is usually burnt at the mill to provide process power or steam that provides energy for process machineries. The use of sugar cane bagasse as a source of energy, because of its appreciable calorific value, leads to production of ash as waste which has no specific economic application. The aim of this work is to utilize abundant bagasse ash as agricultural wastes as reinforcement in the production of aluminium matrix composites so as to reduce the environmental impact of the solid wastes to the society and improve economic utilization of bagasse waste and aluminium matrix composites.

II. RELATED WORK

To prepare MMC of aluminium and fly ash there are number of casting techniques which can be used but the stir casting technique is most economical and less time consuming[5].

In this research the researcher prepare MMC of aluminium with Sic with different mesh size and different weight. He uses reinforced particles size of SiC as 220 mesh, 300 mesh, 400 mesh respectively and mix it to aluminium by weight of 5%, 10%, 15%, and 20%. Then he calculate mechanical properties of the sample and find the best one [6].

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In this research the researcher uses Sugar Cane- Bagasse Ash, which contains aluminium ion and silica, in concrete with cement by weight of 0%, 5%, 10%, 15%, 20% and 25%. By this he is used to minimize the industrial waste and also used to minimize the use of cement in concrete by replacing it to bagasse ash [8].

In this research the researcher uses Rice Husk fly ash to prepare MMC of aluminium. He uses Rice Husk because it has a high silica content which helps him to increase the mechanical properties of aluminium and reduce the industrial waste which is harmful to the environment. He incorporate 0- 30% of fly ash in aluminium and find the best MMC among them [1].

III. EXPERIMENTAL DETAILS

A. Matrix material

Aluminium Alloy is greatly influence the engineering industrial applications Where most necessary areas of stress. And which can be accommodating thin sections and can able to cast varying cross sections. Cast alloy can also heat treated to improve the mechanical properties and also LM4 has the high static loads are anticipated and creep extinction at the elevated higher temperature. LM4 is general-purpose sand or gravity casting alloy which conforms to BS 1490 1988 standards and is suitable for the manufacture of a wide range of Aluminium casting applications and can be very good formability, machinability [2].

Element	%	Element	%
Si	.36	V	.01
Fe	.25	Ti	0.09
Mn	.12	Cr	0.07
Mg	.11	Ni	0.03
Cu	.02	Al	Remainder

Table.1.Chemical Composition of Aluminium (LM4)

Sl. No	Property	Value
1	Density	2.75g / cm ³
2	Elastic Modulus	71 Gpa
3	Shear Modulus	28 Gpa
4	Tensile Strength	140MPa
5	% of Elongation	2-8%

Table.2.Properties of Aluminium (LM4)

B. Particulate Material

The BAGGESS ASH is used as particulate material in aluminium to improve its mechanical and microstructural properties.

Content	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	Na ₂ O	K ₂ O	MnO	TiO ₂	BaO	P ₂ O ₅
%	78.34	8.55	3.61	2.15	0.12	3.46	0.13	0.50	<0.16	1.07

Table.3.Chemical Composition of Baggasse Ash

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IV. SPECIMEN PREPARATION

Tensile Test: The sample for tensile test was prepared on lathe machine by turning operation as ASTM E8 standards. The tensile testing of the composite was done on UTM. Standard specimens with 100mm gauge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite materials was made with the commercially pure aluminium.

Impact Test

IZOD Test: The specimens for the IZOD test were prepared on shaper machine. The IZOD test specimen was 75mm long with 10×10 mm² cross section, having a standard 45° notch 2mm deep.

CHARPY Test: The specimens for the CHARPY test were prepared on shaper machine. The IZOD test specimen was 55mm long with 10×10 mm² cross section, having a standard 45° notch 2mm deep.

Hardness Test: The samples for the bending test were prepared on lathe machine. The samples were prepared according to ASTM E10. The dimensions for samples were 10mm diameter and 15mm length. After this, with the help of microscope, indent caused by the ball indenter is measured, a inbuilt micrometer scale is present in the microscope, which is adjustable according to the position of indent we can adjust it to measure the diameter of indent.

Micro structural Characterization

Scanning Electron Microscopy (SEM): Microstructural characterization studies were conducted to examine distribution of reinforcement throughout the matrix. This is accomplished by using scanning electron microscope. The composite samples were metallographically polished prior to examination. Characterization is done in etched conditions. Etching was accomplished using Keller's reagent. The SEM micrographs of composites were obtained using the scanning electron microscope. The images were taken in secondary electron (SE) mode. This analysis was done by a LEO scanning electron microscope (SEM) equipped with an energy dispersive X-ray (EDX) detector of Oxford data reference system.

V. RESULT & DISCUSSION

TENSILE STRENGTH MEASUREMENT

Tensile test was performed on universal testing machine. The specimens were prepared according to ASTM E8 standard. The composites are prepared by adding the sugarcane bagasse fly ash. First specimen was prepared by adding 6% fly ash by weight, second was prepared by adding 10% fly ash by weight and the last was prepared by adding 14% fly ash by weight. The result of these three composites is compared with the result of pure Al specimen.

S No	Composite Samples	Tensile Strength (Mpa)			
		Sample 1	Sample 2	Sample 3	Average of Sample 1,2 and 3
1	Pure Al	141	139	142	140.67
2	Al-6% Fly ash	149	150	149	149.3
3	Al-10% Fly ash	163	161	161	161.67
4	Al-14% Fly ash	176	176	179	177

Table 4: Tensile Strength of Pure Al and its Composites

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Table 4 describe the result of tensile test of all samples. We prepare three samples of pure Al, Al with 6% fly ash, Al with 10% fly ash and Al with 14% fly ash and then we calculate the average of all three samples find Al with 14% fly ash sample best.

IMPACT STRENGTH MEASUREMENT

IZOD TEST

A comparative account of Izod impact strength of MMC fabricated at different concentration of sugarcane Bagesse fly ash has been provided in Table 5. It is clear from the data that the Izod impact strength is decreased by increasing the percentage fly ash, and by the results we can say that the Al-6% fly ash composite has the best property as compared to pure Al and Al-14% fly ash composite has the worst property as compared to pure Al.

S No	Composite Samples	Impact Strength (Joules)			
		Sample 1	Sample 2	Sample 3	Average of Sample 1,2 and 3
1	Pure Al	12	11	12	11.67
2	Al-6% Fly ash	9	10	9	9.33
3	Al-10% Fly ash	7	7	6	6.67
4	Al-14% Fly ash	7	6	6	6.63

Table 5: Impact Strength (IZOD) of Pure Al and its Composite

Table 5 describe the result of IZOD test of all samples. We prepare three samples of pure Al, Al with 6% fly ash, Al with 10% fly ash and Al with 14% fly ash and then we calculate the average of all three samples and find pure Al sample best.

CHARPY TEST

A comparative account of Charpy impact strength of MMC fabricated at different concentration of sugarcane Bagasse fly ash has been provided in Table 6. It is clear from the data that the Charpy impact strength is decreased by increasing the percentage fly ash, and by the results we can say that the Al-6% fly ash composite has the best property as compared to pure Al and Al-14% fly ash composite has the worst property as compared to pure Al.

S No	Composite Samples	Impact Strength (Joules)			
		Sample 1	Sample 2	Sample 3	Average of Sample 1,2 and 3
1	Pure Al	15	14	14	14.33
2	Al-6% Fly ash	14	13	13	13.33
3	Al-10% Fly ash	12	11	11	11.33
4	Al-14% Fly ash	9	7	9	8.33

Table 6: Impact Strength (CHARPY) of Pure Al and its Composites

Table 6 describe the result of CHARPY test of all samples. We prepare three samples of pure Al, Al with 6% fly ash, Al with 10% fly ash and Al with 14% fly ash and then we calculate the average of all three samples and find pure Al sample best.

HARDNESS MEASUREMENT

The Hardness test was performed on Brinell hardness testing machine. A comparative account of Brinell hardness number of MMC fabricated at different concentration of sugarcane bagasse fly ash has been provided in Table 7. It is

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clear from the results that the BHN has increased by increasing the percentage fly ash in the composite i.e. BHN is maximum in Al-14% fly ash composite and minimum in Al-6% fly ash composite as compared to pure Al.

The Formula used for calculation of BHN.

$$BHN = \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})}$$

S No	Composite Samples	Hardness(BHN)			
		Sample 1	Sample 2	Sample 3	Average of Sample 1,2 and 3
1	Pure Al	46.31	47.51	46.92	46.91
2	Al-6% Fly ash	51.87	51.30	51.87	51.68
3	Al-10% Fly ash	62.41	62.41	62.37	62.39
4	Al-14% Fly ash	76.25	75.89	76.10	76.08

Table 7: Hardness of Pure Al and its Composites

Table 7 describe the result of hardness test of all samples. We prepare three samples of pure Al, Al with 6% fly ash, Al with 10% fly ash and Al with 14% fly ash and then we calculate the average of all three samples and find Al with 14% fly ash sample best.

SEM MICROGRAPH ANALYSIS

The Scanning Electron Microscopy (SEM) was done to analyse the microstructure of pure Al, Al with 6% Bagasse fly ash, Al with 10% Bagasse fly ash and Al with 14% Bagasse fly ash. The SEM micrographs of these specimens are shown in Figure 1 to Figure 16. Figure 1 to Figure 4 shows the micrograph of pure Al at different resolutions. Figure 5 to Figure 8 shows the micrograph of Al with 6% Bagasse fly ash at different resolutions. Figure 9 to Figure 12 shows the micrograph of Al with 10% Bagasse fly ash at different resolutions. Figure 13 to Figure 16 shows the micrograph of Al with 14% Bagasse fly ash at different resolutions.

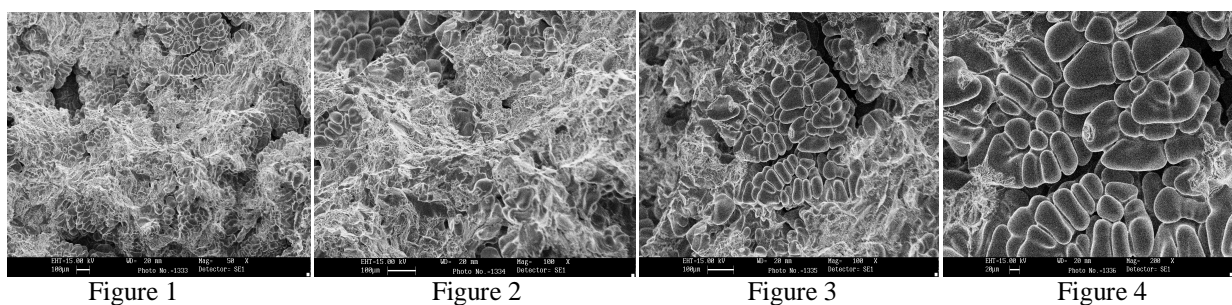


Figure 1 to Figure 4 shows the SEM micrograph of pure Al at different resolutions. Figure 1 shows the micrograph of pure Al at 50X magnification. Figure 2 and Figure 3 shows the micrograph of pure Al at 100X magnification. Figure 4 shows the micrograph of pure Al at 200X magnification. These micrographs are used as reference which is used to compare the micrographs of MMC.

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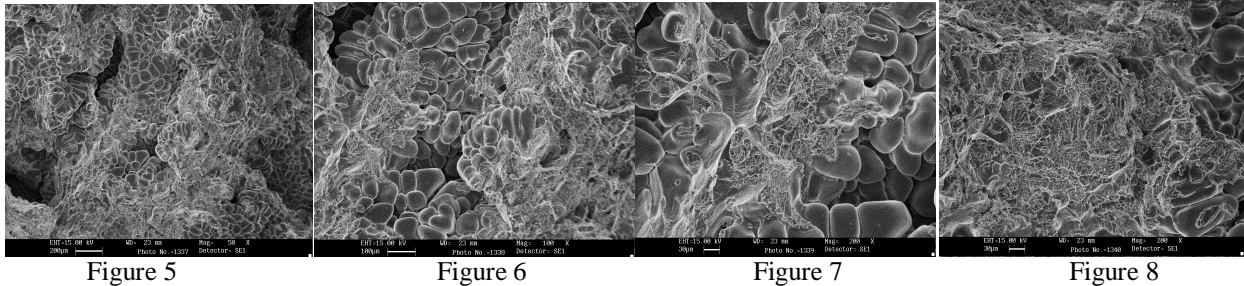


Figure 5 to Figure 8 shows the SEM micrograph of MMC of Al with 6% fly ash at different resolutions. Figure 5 shows the micrograph of MMC of Al with 6% fly ash at 50X magnification. Figure 2 shows the micrograph of MMC of Al with 6% fly ash at 100X magnification. Figure 3 and Figure 4 shows the micrograph of MMC of Al with 6% fly ash at 200X magnification. By these micrographs we see that the fly ash is mixed with aluminium and give us better properties than aluminium.

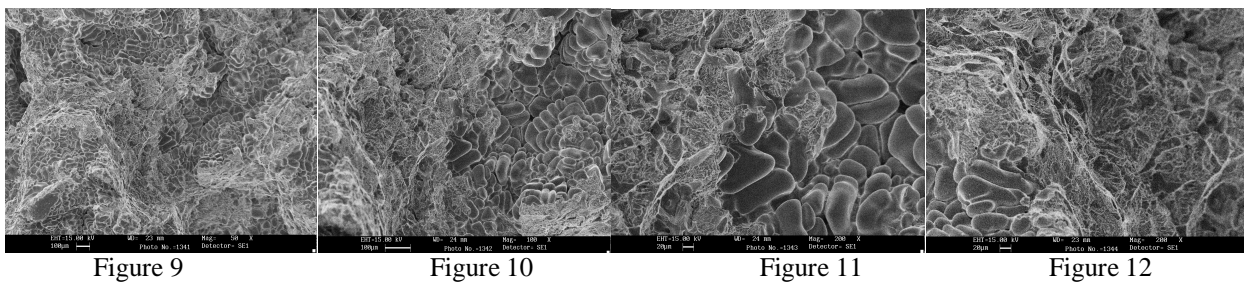


Figure 9 to Figure 12 shows the SEM micrograph of MMC of Al with 10% fly ash at different resolutions. Figure 9 shows the micrograph of MMC of Al with 10% fly ash at 50X magnification. Figure 10 shows the micrograph of MMC of Al with 10% fly ash at 100X magnification. Figure 3 and Figure 4 shows the micrograph of MMC of Al with 10% fly ash at 200X magnification. The fly ash is evenly mixed with the aluminium and helps to increase the mechanical properties of aluminium as compared to pure aluminium.

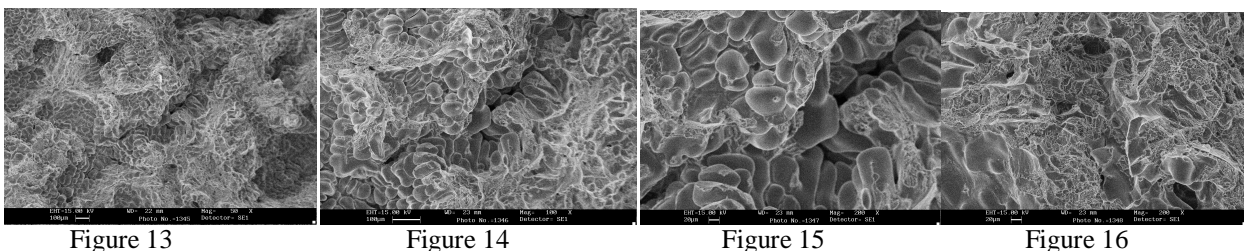


Figure 13 to Figure 16 shows the SEM micrograph of MMC of Al with 14% fly ash at different resolutions. Figure 13 shows the micrograph of MMC of Al with 14% fly ash at 50X magnification. Figure 14 shows the micrograph of MMC of Al with 14% fly ash at 100X magnification. Figure 15 and Figure 16 shows the micrograph of MMC of Al with 14% fly ash at 200X magnification. It is clear from these figures that the fly ash is evenly distributed and by this the molecules of aluminium gets closer and we got the best properties as compared to the rest three.

The SEM micrograph study was done to analyse the distribution of fly ash in the matrix and to analyze how fly ash improve the structure of aluminium. For this we compare the SEM micrograph of pure Al with the SEM micrographs of Al with fly ash.

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By the comparative study we concluded that the fly ash of bagasse is evenly mixed with Al Successfully. The SEM micrograph shows that the Al microstructure will become dense when we added fly ash in it and it helps it to improve in the mechanical properties.

VI. CONCLUSIONS

1. BA Fly ash up to 14% by weight can be successfully added to Al by stir casting to produce composites.
2. The Impact Strength of Al-Bagasse fly ash composites have decreased with increase in addition of fly ash.
3. The Tensile Strength of Al-Bagasse fly ash composites have increased with increase in addition of fly ash.
4. With the help of micrographs we can say that the Bagasse fly ash is evenly mixed in the aluminium.
5. With the help of micrographs we can say that when we added the Bagasse fly ash and increases the quantity of fly ash than the molecules of aluminium gets closer and that's why the mechanical properties increases.

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