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Production and mechanical properties of Fly ash and Basalt ash reinforced Al 6061 composites

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ABSTRACT

This paper presents the characterization of Al 6061 metal matrix composite (MMC) reinforced with fly ash and basalt ash produced by stir casting method. Basalt is a natural material that is found in volcanic rocks. Three sets of hybrid MMC were prepared by varying the weight fraction of the reinforcements (2.5% basalt ash + 7.5% fly ash, 5% basalt ash + 5% fly ash, 7.5% basalt ash + 2.5% fly ash). The effect of reinforcements on the mechanical properties of the hybrid composites such as hardness, tensile strength and impact strength were studied. The result reveals that tensile strength and impact strength are increased with increasing weight fraction of fly ash, whereas the hardness is increased with increasing weight fraction of the basalt ash. Scanning electron microscopic images of the microstructures reveals the dispersion of the reinforcements in the matrix.

Key words: MMC, Al6061, Fly ash, Basalt ash, Stir casting, SEM.

1. INTRODUCTION

Aluminium metal matrix composites are the most expert material in the industrial world. For the past few years, researchers finding alternate material to meet the better properties and production methods by adding various reinforcements. Among the various reinforcements, fly ash is one of the cheapest available reinforcement and it enhances the tensile strength [1]. Fly ash and e-glass fiber can be effectively implemented to fabricate hybrid composite using stir casting method. The tensile, compressive and hardness increased with increase in wt. % of fly ash [2-5]. While decreasing the particle s Aluminium metal matrix composites are the most expert material in the industrial world and in the past few years, researchers finding alternate material to meet the better properties and production methods by adding various reinforcements. Among the various reinforcements, fly ash is one of the cheapest available reinforcement and it enhances the tensile strength [1]. Fly ash and e-glass fiber can be effectively implemented to fabricate hybrid composite using stir casting method. The tensile, compressive and hardness increased with increase in wt. % of fly ash [2-5], while decreasing the particle size of fly ash increases the mechanical properties [3]. The density of the composites decreased with increasing fly ash content. Hence these lightweight composite can be used where weight plays major role like space and aeronautical industries [4-6]. Hybrid matrix composites could be considered as an excellent material than singe reinforcement material where enhanced properties are needed [5]. Size of the fly ash increases the mechanical properties [3]. The density of the composites decreased with increasing fly ash content, hence these lightweight composite can be used where weight plays major role like space and aeronautical industries [4-6]. Hybrid matrix composites could be considered as an excellent material than single reinforcement material where enhanced properties are needed [5]. By adding alumina (Al2O3) and fly ash with aluminium increases the mechanical properties like tensile and hardness, on the other hand ductility and impact strength decreases [7]. The micro hardness and tensile strength of the aluminium matrix composites are increased by the addition of fly ash [8]. The stir casting method is found to be a cost effective and conventional route to fabricate the hybrid metal matrix composites [9, 10]. Almost all the properties like tensile, compression, hardness, etc. enhanced with increasing fly ash content and it should be applied in the commercial production of composites as it use for the production can turn industrial waste into industrial fortune [11].

The present investigation is an attempt to study the mechanical and physical properties of Al 6061/basalt fiber ash/fly ash with various percentage of reinforcements. The hybrid MMCs were fabricated using the stir casting method. Mechanical properties like tensile, hardness, impact strength were investigated and microstructure of hybrid MMCs is also studied.

2. EXPERIMENTAL PROCEDURE

2.1. Materials

In this investigation, Aluminium Alloy (Al-6061) is used as a matrix material while basalt fiber ash and fly ash are used as reinforcement material for the preparation of composite specimen. The chemical compositions of the matrix and reinforcement materials are shown in Table 1, Table 2 & 3 respectively.

Table 1 The chemical composition of Al-6061

Elements	%
Si	0.43
Fe	0.7
Cu	0.24
Mn	0.139
Ni	0.05
Pb	0.24
Zn	0.25
Ti	0.15
Sn	0.001
Mg	0.802
Cr	0.25
Al	96.75

Table 2 The chemical composition of basalt fiber ash

Elements	%
O	30.6
Na	2.54
Mg	3.59
Al	6.8
Si	26.09
K	0.51
Ca	6.94
Ti	1.35
Fe	12.14
Br	3.31

Table 3 The chemical composition of fly ash

Elements	%
SiO_2	35.4
Al_2O_3	17.5
Fe_2O_3	5.3
SO_3	2.8
MgO	4.6
CaO	26.1
Moisture	0.1
LOI	0.4

2.2. Fabrication

Basalt fiber ash and fly ash reinforced aluminium alloy (Al 6061) composites, processed by stir casting technique (Liquid metallurgy route) was used in this work. There are three composition are taken for the casting process such as 90% Al + 2.5% Basalt fiber ash + 7.5% Fly ash, 90% Al + 5% Basalt fiber ash + 5% Fly ash, 90% Al + 7.5% Basalt fiber ash + 2.5% Fly ash were taken according to the weight ratio of the composition.

The aluminium alloy (Al 6061) was preheated at a temperature of 700°C for 1hr and melted at the temperature of 900°C. The basalt fiber ash and fly ash particles were preheated at a temperature of 300°C for 30 minutes then added at a constant feed rate into the molten aluminium and stirred with the speed of 340 rpm for 30 seconds. During the process the degassing agent and the skum powder were added to the mixture to avoid the excess gas formation and to remove the slags from the mixture. Then the mixture is poured into the die and it gets solidified. After 10 minutes the casted materials were removed from the die and cooled at room temperature.

2.3. Testing

The tensile test was carried out using the testing machine UTE-40 as per the ASTM standard IS 160P-2005 for the prepared specimen with the gauge length of 50mm and diameter of 10mm. As per the ASTM standard E384-11e1 the Vickers hardness test has been carried out by indenting the test material with a indenter subjected to 10 kgf load for 10 to 15 seconds. The impact test was conducted as per the ASTM standard D7136 according to the standard size of 10mm×10mm×55mm with 5mm depth at the center of the specimen using Charpy test apparatus.

3. RESULT AND DISCUSSION

3.1. Tensile test

The tensile testing of Aluminium, basalt fiber ash and fly ash composite material with the various percentage of reinforcement has been conducted in universal testing machine as per the specification. The comparison of tensile strength of various compositions is shown in graph. From the figure 1, it shows that tensile strength of first composition (90%Al+2.5% Basalt Ash +7.5 % Fly Ash) is

higher than the other two compositions.

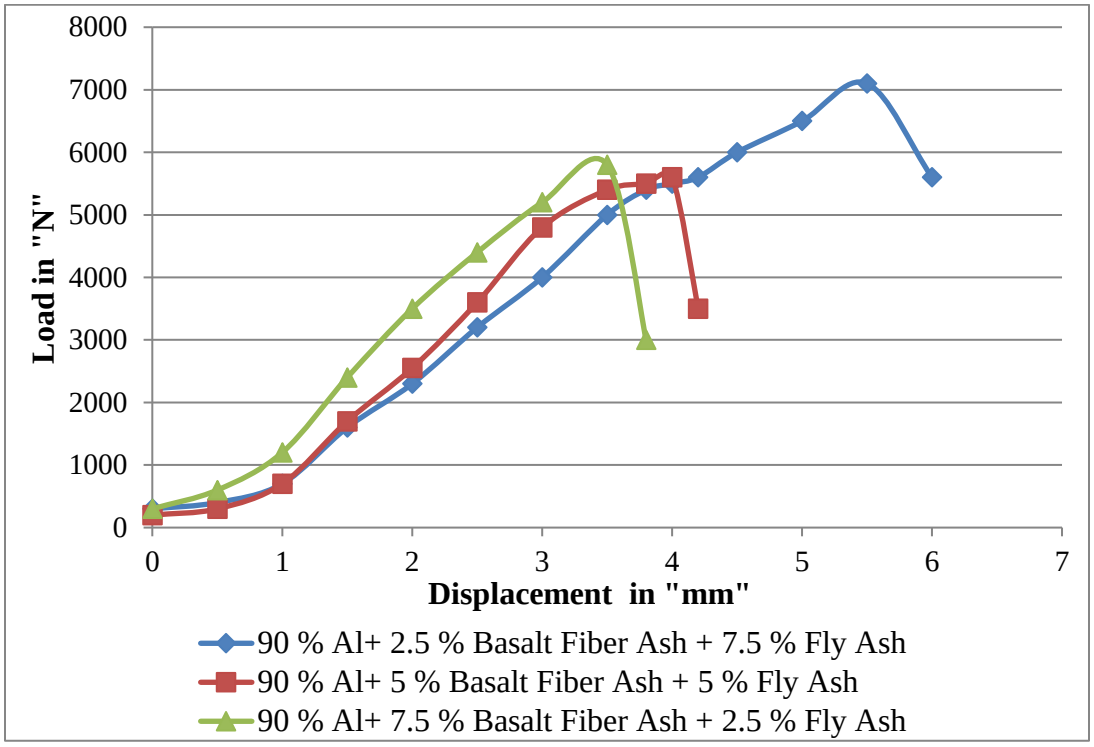


Figure 1 Effect of variation of basalt fiber ash and fly ash on the tensile strength of composite material

3.2. Hardness test

The Vickers hardness test has been conducted for the three different composition of composite material by using the sample specimen. The experimental data shown in figure 2 indicates the Vickers hardness value for the composition of 90% Al+7.5% Basalt Ash +2.5 % Fly Ash is higher than the other two compositions.

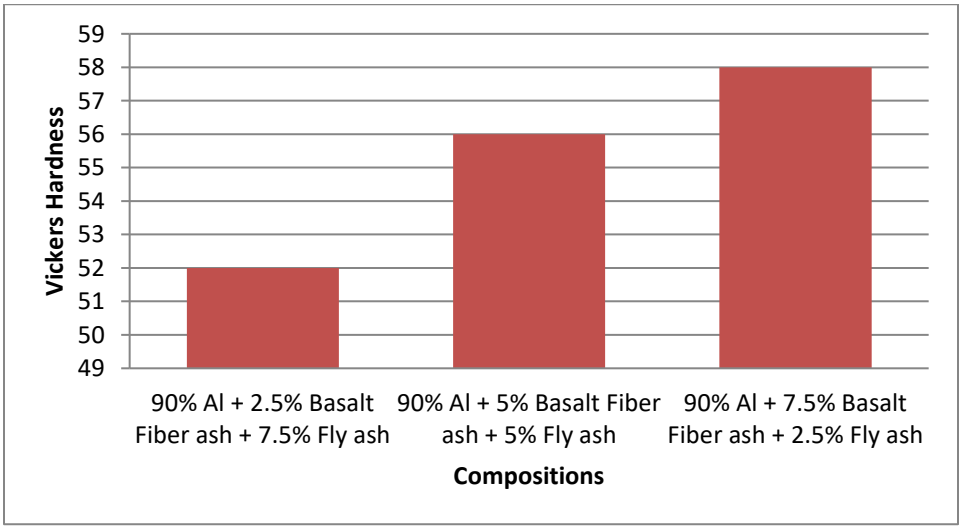


Figure 2 Effect of variation of basalt fiber ash and fly ash on hardness strength of composite material

3.3. Impact test

For the samples of various compositions the impact Charpy testing has been conducted. The sample dimension for the experiment is taken as 10 mm x 10 mm x 55 mm, the result obtained from the impact test has been tabulated and compared. From the figure 3 it is clear that the impact value of first composition (90%Al+2.5% Basalt Ash +7.5 % Fly Ash) is higher than other compositions.

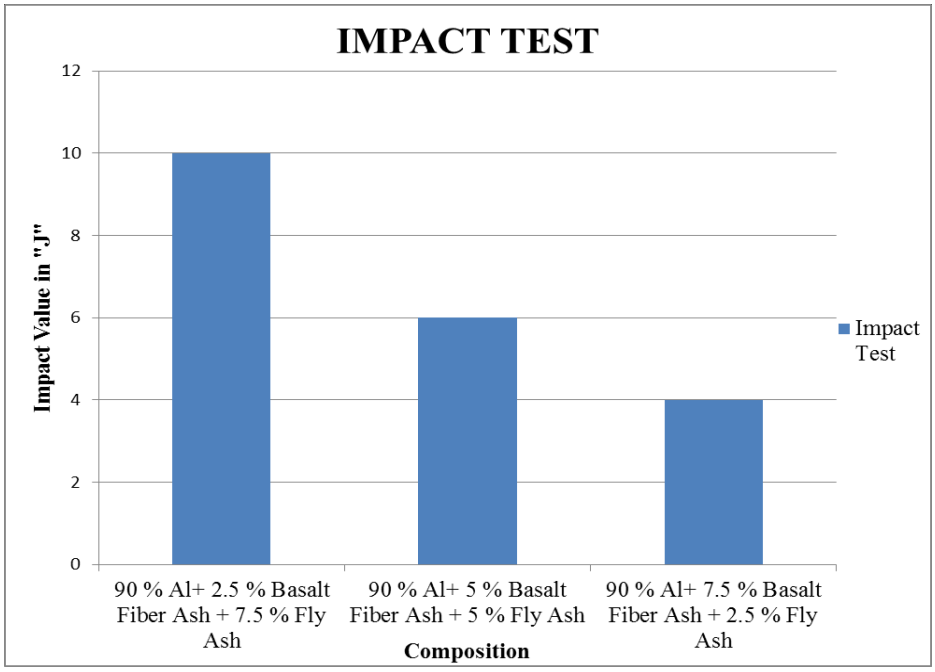
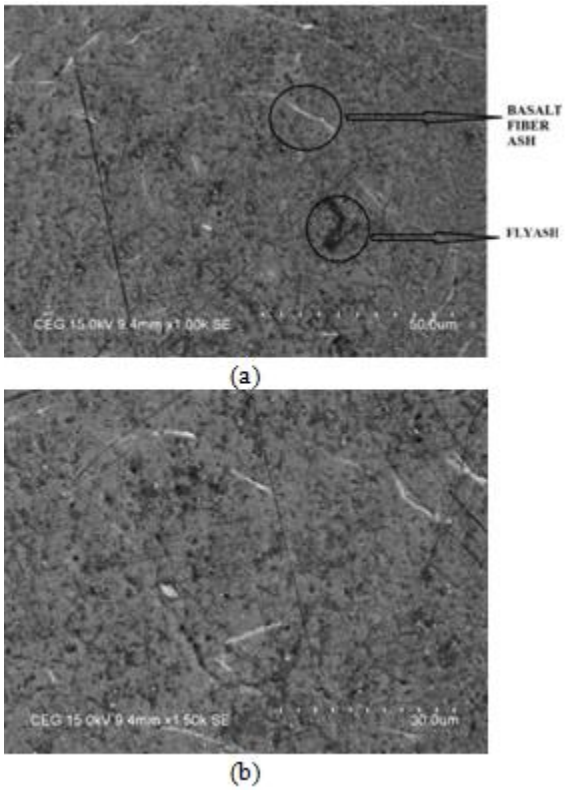
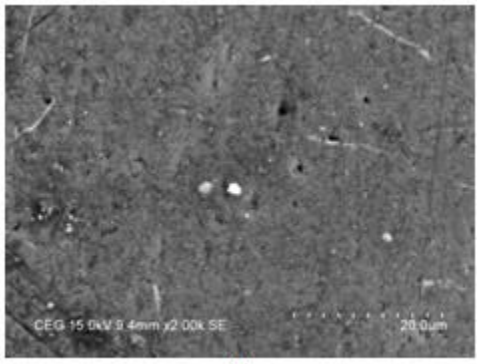


Figure 3 Effect of variation of basalt fiber ash and fly ash on impact strength of composite material

3.4. SEM Micrographs

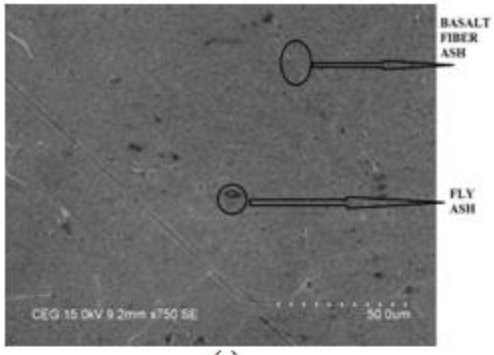
The SEM micrographs of aluminium composites with various percentages of reinforcement are shown in figure.4, figure.5 and figure.6. The SEM images are shown with various magnifications as 50 and 30 and 20 microns for the three compositions. The SEM image reveals the presence of reinforcements basalt fiber ash and fly ash in the matrix material aluminium. This indicates that the stir casting technique is efficient for the production of composites.



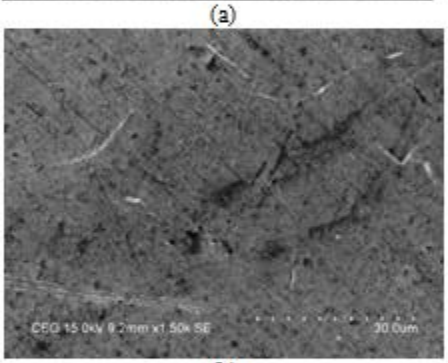


(c)

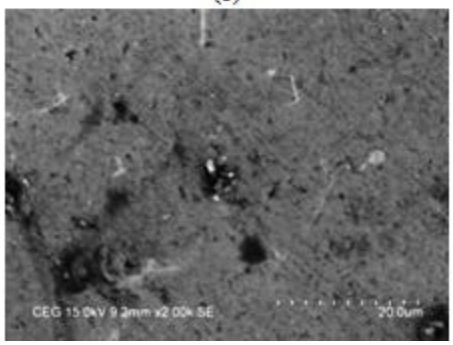
Figure 4 SEM images of Al 6061 with 2.5% basalt fiber ash and 7.5% fly ash magnification (a) 50 µm (b) 30 µm (c) 20 µm



(a)



(b)



(c)

Figure 5 SEM images of Al 6061 with 5% basalt fiber ash and 5% fly ash magnification (a) 50 µm (b) 30 µm (c) 20 µm (a)

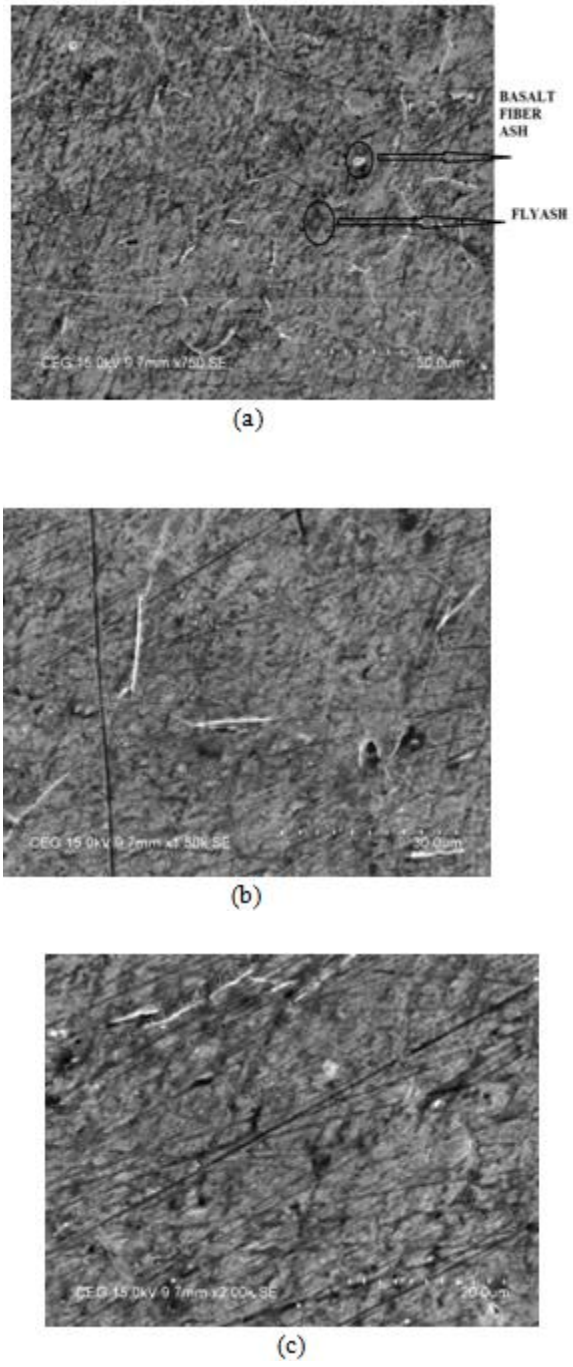


Figure 6 SEM images of Al 6061 with 7.5% basalt fiber ash and 2.5% fly ash magnification (a) 50 µm (b) 30 µm (c) 20 µm

5. CONCLUSION

There are three compositions were taken for the tensile test, hardness and the impact test. The following results were revealed from the test results on the hybrid composite material. The Fly ash has enhanced the tensile strength and impact strength of aluminium matrix in the first composition (90%Al-6061+2.5% Basalt Ash +7.5 % Fly Ash). The third composition (90%Al-6061+7.5% Basalt Ash +2.5 % Fly Ash) enhanced the hardness value of the hybrid composite. This is because of the presence of Basalt fiber ash. The increase of basalt fiber ash helps to increase the hardness value of the material. The SEM micrographs revealed the presence of Basalt Fiber Ash and Fly Ash particles in the composite with homogeneous dispersion.

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Conflicts of Interest: The authors declare no conflict of interest.

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