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INVESTIGATION OF THE EFFECTS OF RICE HUSK ASH ADDITION ON THE MECHANICAL PROPERTIES OF Al-Cu-Mg ALLOY COMPOSITE

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ABSTRACT
Investigation of the effects of rice husk addition on the mechanical properties of Al-Cu-Mg composite was carried out. Rice husk ash was added to the Al-Cu-Mg alloy at an interval of 2 weight (%) up to 10 weights (%) using the double stir casting process. The mechanical properties examined include hardness value, ultimate tensile strength, ductility and impact energy. The microstructural examination was done through scanning electron microscopy (SEM), and X-ray diffraction (XRD). The results showed that the addition of rice husk ash to the alloy increased the hardness value, while the impact energy decreased as the weight percent of the rice husk ash increases in the composite. Maximum values of yield strength and ultimate tensile strength was noticed at 8 weight (%) addition. The increase in strength and hardness is as a result of distribution of hard, brittle ceramic phases in the ductile matrix. The results obtained generally show that addition of rice husk ash to the Al-Cu-Mg alloy can improve its properties and could be a potential substitute for certain constituents of Aluminium alloy composite.

Keywords: Rice husk ash, mechanical properties, Composite matrix, Aluminium alloy, Stir casting.

INTRODUCTION
Aluminium alloys are very important alloys which are useful in different engineering applications. They are relatively low cost, light weight and can be easily machined by traditional and non traditional machining process. Aluminium-copper-magnesium based alloys (2xxx series) are widely used in structural applications, in particular alloys with Cu:Mg atomic ratio of one is used extensively in the aerospace sector, and for car body applications[3].

As researchers in the field begins to experience drawback due to economic reasons, difficulty in mass production or further improvement ruled out; a new system takes over in what we called metal matrix technology [3]. Among metal matrix composite, Al-alloy based composite were always on the forefront of research and has remained a potential material for making viable engineering components [2].

The development of low cost metal matrix composites reinforced with low cost, eco-friendly materials has been one of the major innovations in the field of materials in the past few decades. Among the various discontinuous dispersion's used, rice husk ash is one of the most inexpensive, readily available and low density reinforcement available, and as a result of this, low cost quality materials are produced for application in automotive industries for the production of components such as piston, cylinder liners, connecting rods etc [1].It is therefore expected that incorporation of rice husk particles in aluminium alloys would promote yet another use of this low cost waste by-product and thereby, reducing the cost of aluminium products[5].

This research work therefore, will critically examined the effects of rice husk ash addition on the mechanical properties of Al-Cu-Mg composite for use in different engineering applications.

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MATERIALS AND METHOD

Sample Collection and Preparation

Dried rice husks which was obtained from Igbemo-Ekiti, Ekiti State, pure aluminium ingot from NIGALEX Nigerian limited Lagos, magnesium powder and copper wire obtained from Owode local market in Lagos.

The rice husk used were thoroughly washed to remove dirt, sun-dried to eliminate any moisture and then pulverized to micro particles after which sieve analysis was done in order to determine the peak particle size. The pulverized particles were divided into three batches namely A, B and C. Batch A was left uncarbonized,batch B was carbonized at 900ºC for 5 hours while batch C was carbonized at 900ºC for 5hours and then ball-milled for 32hours.

The required quantity of aluminium and copper were sectioned after charge calculation and weighed in readiness for casting. The copper was charged into an oil fired crucible furnace (Thermocraft:VOF-1200-36,36''tall) for melting.Then the weighted aluminium was charged into the molten copper, and heated until the entire charge became molten. This was allowed to cool in the furnace to a semi solid state. The preheated batches of rice husk along with magnesium powder were added and stirred for 3-5 minutes for homogenization. The composite was superheated, stirred manually and cast into a preheated mould cavity.

The cast composite samples were properly fettled, sent to the machine shop for machining to the required dimensions for the tensile, hardness and impact test samples.

Determination of Tensile Test

The composite test sample which was machined in conformity with American Standard for Testing and Materials (ASTM) test standard, was fastened properly on the grips of the lower and upper cross beam of the universal test machine (Instron 5969). A load was applied on the composite test sample until failure occurs. The values of the load were read off as displayed by the machine while the extension values were determined by combining the two broken pieces of the test sample. The test was carried out on the three samples (A, B, and C) for different percentage weights (ranging from 2 to 10 % weight).

Determination of Impact Test

The impact test was conducted on the test samples using the Charpy Impact Test machine (model: Instron CEAST 9360). The mass of the hammer was 227 kg while the strike velocity was 3.5 m/s. Standard round impact test notched samples measuring 60 mm × 10 mm with notch depth of 2 mm at an angle of 45º was used. The suspended hammer was allowed to hit the fastened, notched test sample while the impact energy was captured from the digital screen.

Determination of Hardness Test

The hardness values of the samples were determined using the Rockwell hardness tester on 'B' scale (Frank well Rockwell hardness tester, model 38506) with 1.56 ball indenter, minor load of 10 kg, major load of 100 kg and hardness value of 101.2 HRB as the standard block. The samples were placed on anvil, which acts as support for the test samples. After indentation the hardness values were read directly from the semi-automatic digital scale. Three indentations were taken and the average represents the hardness values.

X-Ray Diffraction (XRD)

The X-ray diffraction patterns of the carbonized rice husk particles were determined using an X-RAY diffractometer (model: ULTIMA IV) with Cu-K radiation and Ni filter. The analysis was conducted at 40 KV,voltage and 30 µA, current intensity.

SEM Analysis

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The microstructure and chemical compositions of the phases present in the composite were examined using a JOEL JSM 5900 LV scanning electron microscope equipped with an oxford INCA energy dispersive spectroscopy system. The polished samples were firmly held on the sample holder using double carbon tape before insertion to the sample chamber. The SEM was carried out at an accelerating voltage of 15 KV.

RESULTS AND DISCUSSIONS

Particles Size Analysis

From the figure 1 below, it was observed that the weight retained increases as the sieve aperture size increases to a peak before it falls to a lower value for both the non carbonized and carbonized rice husk ash. For the batch A, the highest sieve aperture size retained was 177 µm while 149 µm for batch B.

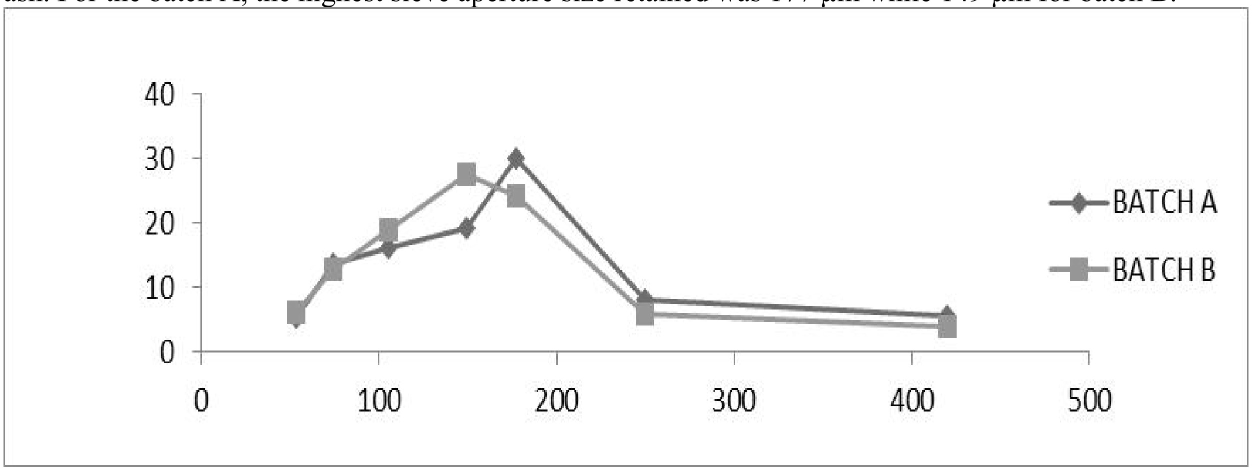

Fig.1 Particle weight retained against sieve aperture for carbonized and uncarbonized rice husk.

Chemical Composition of the Alloy

(The chemical composition of the Al-Cu-Mg Alloy (control) was obtained with the aid of SPARKMET optical spectrometer as shown below).

Table 1:÷ Chemical composition of Aluminum alloy (control)

Elements	Al	Cu	Mg	Si	Fe	Mn	Zn
Chemical Composition(%)	92.5	3.92	1.20	0.84	0.51	0.071	0.55

This analysis shows the key elements of the matrix which includes aluminium, copper and magnesium which is a 2xxxseries alloy.

X-Ray Diffraction (XRD)

The chemical composition and the XRD pattern of the rice husk ash is shown below.

Table 2: Chemical composition and constituents of Rice Husk Ash

Constituent	Wt%
Silica	91.17
Carbon	4.3
Calcium oxide	1.98
Magnesium oxide	0.83
Potassium oxide	0.59
Ferric oxide	0.31
Titanium oxide	0.20

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The XRD pattern of the rice husk ash is shown below in plate 1 below. The peaks observed include silicon dioxide, carbon, calcium oxide and magnesium oxide. Chemical reactions between the rice husk particles and molten aluminium alloy during synthesis of the composite was as a result of the chemical composition, high reactivity of rice husk ash particles. The reaction between rice husk reinforcement containing silica and liquid aluminium alloy leads to the formation of alumina and silicon.

Plate 1: XRD pattern of the rice husk.

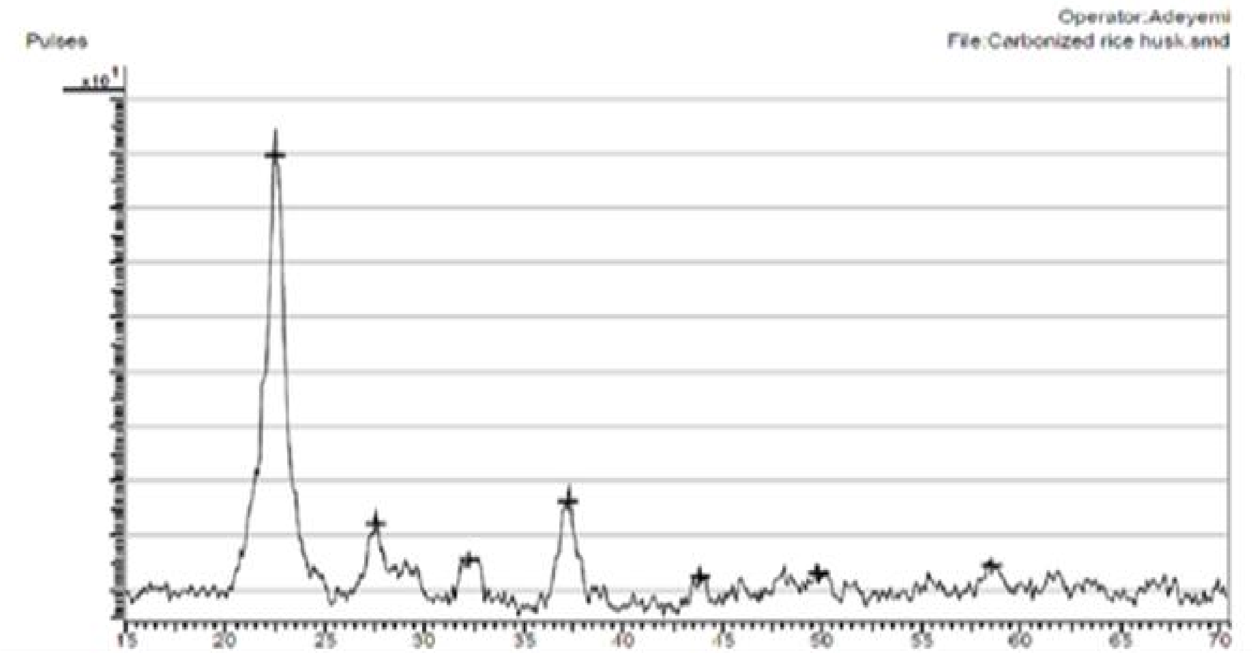

Plate 2 to 4 Shows the SEM micrograph of the unreinforced and reinforced Al-Cu-Mg alloy. The unreinforced alloy shows clearly homogeneity of the base matrix with all the elements present. In the reinforced matrix, it was observed that there was a good dispersion of the rice husk particulates in the aluminium alloy matrix with little particles clusters. There was no significant challenge of segregation which often occurs during solidification of metal matrix composites having components with different densities and wet-ability characteristics.

Plate 2: SEM spectrum of unreinforced Al-Cu-Mg alloy

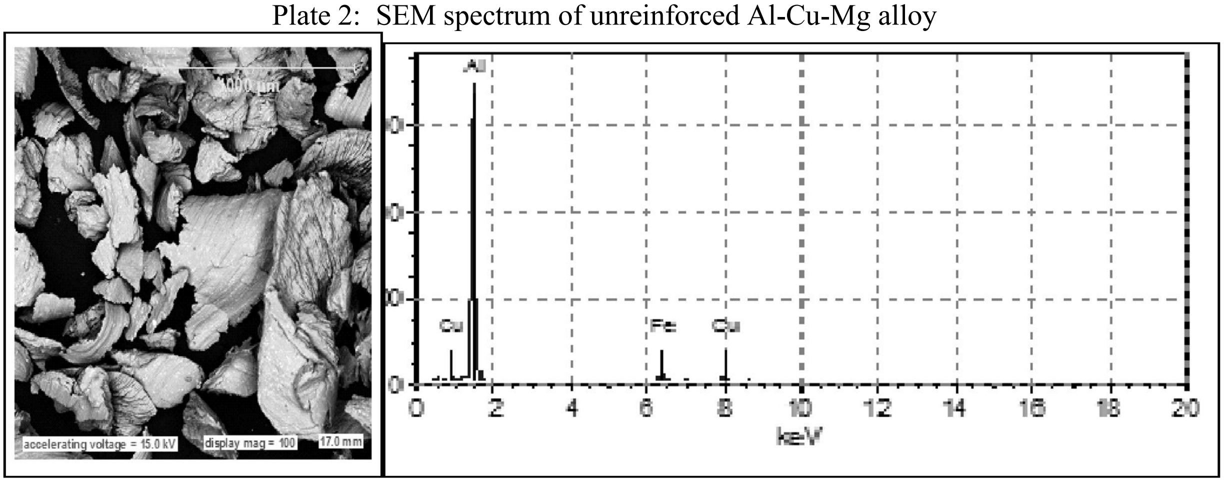

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Plate 3: SEM spectrum of Al-Cu-Mg alloy reinforced with carbonized 8% rice husk

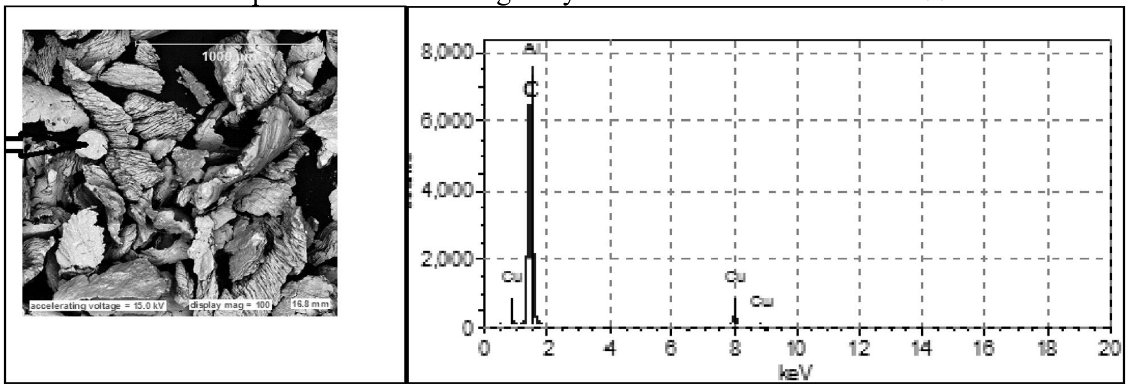
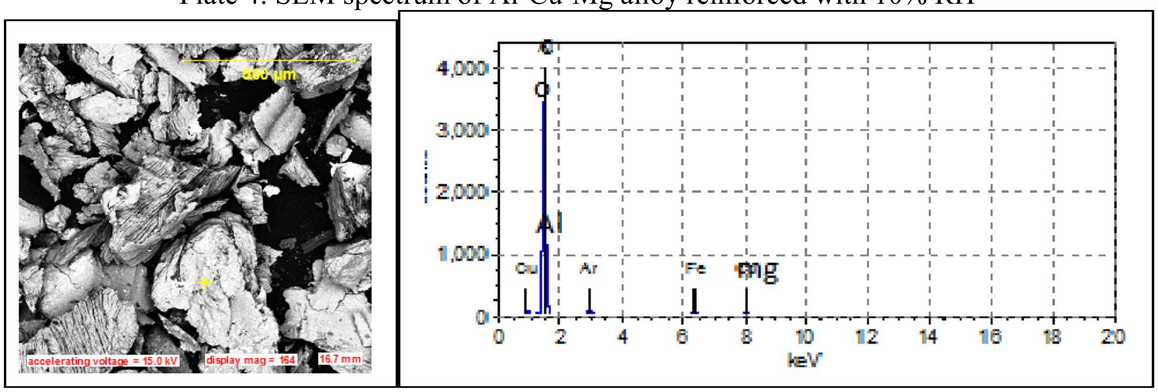


Plate 4: SEM spectrum of Al-Cu-Mg alloy reinforced with 10% RH



Ultimate tensile strength (UTS)

The ultimate tensile strength obtained during the tensile test is shown in fig 2 below. It was observed that addition of rice husk particles has a significant effect on the tensile strength, that is, addition of rice husk particles increases the ultimate tensile strength (UTS) of the material. For batch C, the UTS is higher than the other two batches which shows that reduction in the particle size of the rice husk improves the strength of the composite considerably.

It has been well reported [1,2,4] that particle reinforced aluminium matrix composites achieve improved strength due to load transfer from the matrix to the particles and creation of more dislocation which serve as a constraint to plastic dislocation.

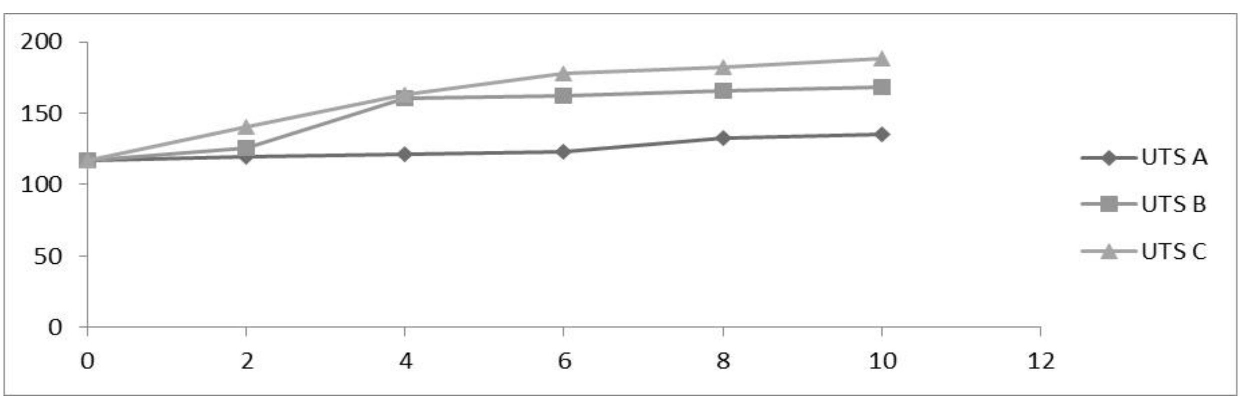


Fig. 2: percentage weight of Rice husk and its ultimate tensile strength impact on Al-Alloy

Ductility

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The effect of percentage reinforcement of rice husk on percentage elongation of composite was presented in the figure 3 below. It was observed that ductility of the composite decreases with the increase in weight fraction of the rice husk. For the carbonized ball milled rice husk (batch C), the % elongation is lesser when compared to the other batches. This is due to the more finely carbonized particles which impede dislocation movement. Similar observations were made [7,8] for various weight percent of fly ash reinforcement.

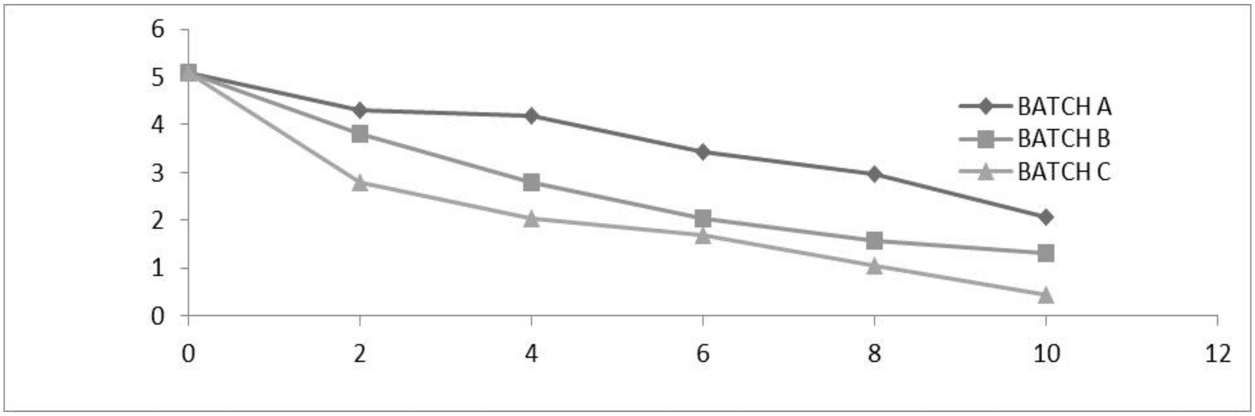

Fig. 3. *percentage weight of rice husk and its impact on ductility.*

Hardness Values

The hardness values increased with an increasing percentage of rice husk additions (figure 4). This is largely due to the presence of a hard ceramic phase of the rice husk ash in the ductile matrix. The 10% of (Batch C) rice husk addition in the matrix yielded the highest hardness value as a result of finer particle size of the ball milled rice husk. As far as the hardening behaviour of the composite was concerned, particle addition in the matrix alloy increases the strain energy in the periphery of the particles in the matrix, and it could be attributed to the formation of dislocation at the boundary of the ceramic particles. Similar results were obtained [6] for silicon carbide reinforcements.

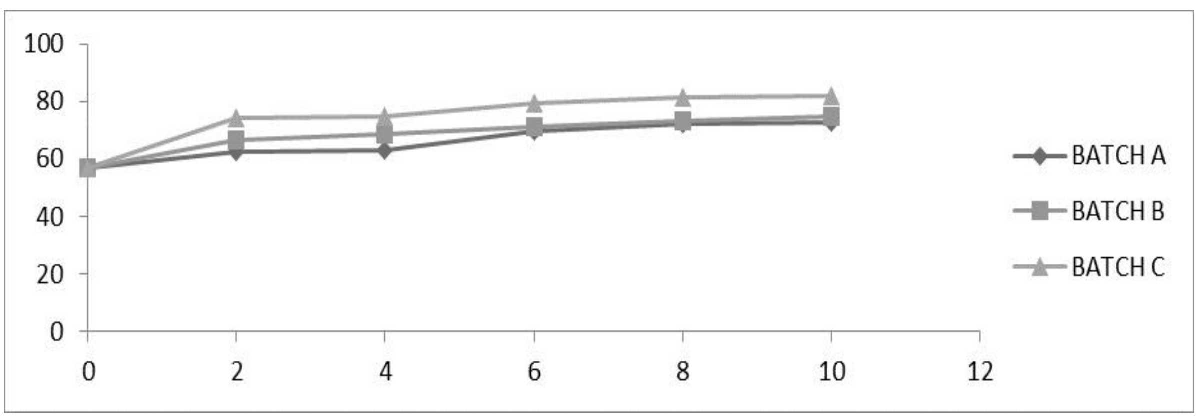

Fig. 4: percentage weight of rice husk and its impact on hardness value

Impact Energy

From the graph obtained under the impact energy (figure 5), it was clearly seen that the impact energy of the samples decreased as the percentage of rice husk ash increases in the matrix. The brittle nature of the reinforcing material aids in degrading the impact energy of the composite. This could be evidently noticed in the unreinforced alloy having the highest impact energy, indicating that they are the toughest of them all. This agrees with the earliest observation of [1].

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Table 3: matrices of the percentage composition of Rice Husk Ash with respect to impact energy.

Wt of rice Husk ash (%)	*Batch A Impact. Energy(J)*	*Batch B Impact. Energy(J)*	*Batch C impact. Energy(J)*
0%	*11*	*11*	*11*
2%	*5.9*	*6.8*	*9.9*
4%	*5.7*	*6.4*	*8.5*
6%	*5.4*	*6.0*	*7.8*
8%	*4.8*	*5.6*	*7.2*
10%	*4.4*	*4.9*	*6.7*

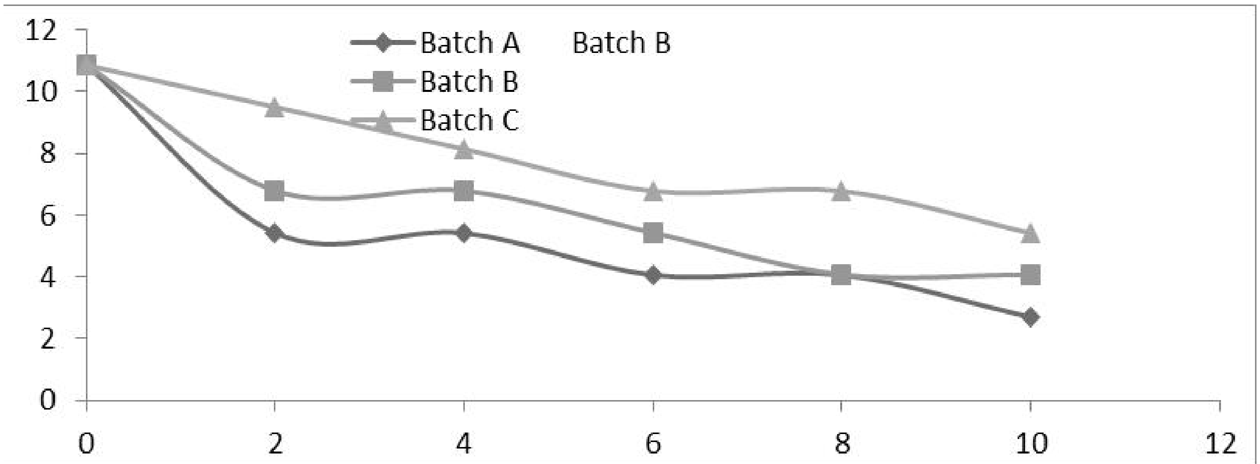

Fig. 5: percentage weight of rice husk and its impact energy on Al-Alloy

CONCLUSIONS

A huge success was recorded in the synthesis of rice husk ash addition to Aluminium Alloy. Rice husk, a well known agricultural waste could be successfully used as reinforcement in metal matrix technology. Hardness, which is a very important mechanical property, improves with the addition of rice husk ash due to good dispersion of rice husk in the parent matrix. Also, where light weight materials are needed, rice husk ash composite will serve satisfactorily. With the application of rice husk ash addition, this agricultural waste could be significantly utilized without recourse to burning.

RECOMMENDATION

We strongly recommend that efforts be made in establishing other mechanical or physical properties like corrosion resistant, wear resistant, fatigue strength not covered in this research work. This will be good development to engineering research knowledge.

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