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Study of Mechanical Behaviour of Aluminium Alloy with Alumina and Bamboo Leaf Ash Reinforcement

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***Abstract:* --- Current engineering applications require materials that are stronger, lighter and less expensive. Aluminum Matrix Composites (AMC) are the most versatile of the Metal Matrix Composites because of number of factors which include ease of processing, relatively low cost of Al matrices, good combination of physical and mechanical properties and excellent tribological properties. Literatures reveal that a good number of research work has been carried out on utilising ceramic particulates as reinforcing material compared to agro waste derivatives. In this regard, a number of works has been published on the potentials of the agro waste ashes as complementing reinforcements. K. K. Alaneme and E. O. Adewuyi studied the mechanical behavior of Al-Mg-Si alloy matrix composites reinforced with Alumina and Bamboo Leaf Ash (BLA). Alumina (Al_2O_3) particulates complemented with 0, 2, 3, and 4 %wt. BLA were utilized to prepare 10%wt. of reinforcement in Al-Mg-Si alloy matrix using double stir casting method. As a continuation of their initiation, in this work mechanical behavior studies were conducted on Alumina (Al_2O_3) particulates complemented with 5, 6, and 7 %wt. BLA of total 10 %wt. of reinforcement.**

***Index Terms*− Aluminium, Bamboo Leaf Ash, Hybrid Metal Matrix Composite, Stir Casting**

I. INTRODUCTION

1.1 Aluminium MMC

A Metal Matrix Composite (MMC) is a composite material with atleast two constituent parts, one being a metal necessarily; the other material may be a different material, such as a ceramic or organic compound. MMCs are made by dispersing a reinforcing material into a metal matrix. The common metallic alloys utilized in composites are alloys of light metals (Al, Mg and Ti) however; other metallic alloys like zinc (Zn), copper (Cu) and stainless steel have been used [1, 2] but, Aluminium remains the most utilized metallic alloy as matrix material in the development of MMCs. It is remarkable for the metal's density which is one-third that of steel which is relatively soft, durable, lightweight, ductile and malleable metal. Aluminium is very rare in its free form and is hard to extract it from its ore aluminium oxide (Al_2O_3).

1.2 Reinforcement

The reinforcement is embedded into the metal matrix and does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity [3]. The different reinforcing materials used in the development of AMCs can be classified into three broad groups, which are synthetic ceramic particulates, industrial waste derivatives and agro waste derivatives. The major problem involved in the development of ceramic reinforced aluminium matric composite is the high cost involved and the limited supply of conventional ceramic reinforcing materials. Industrial waste and Agro waste derivatives are some of the alternative reinforcing materials that have been investigated. A new direction in the use of agro waste ashes has been based as complementing reinforcement to either Silicon Carbide or Alumina to develop hybrid composites. A few number of agro waste have been processed into ashes and their suitability for use as reinforcing phase material have been studied. Few such agro waste particulates include Bamboo Leaf Ash (BLA), Rice Husk Ash (RHA), Bagasse Ash (BA), Palm Kernel Shell Ash (PKSA), Maize Stalk Ash (MSA), Corn Cob Ash (CCA) and Bean Shell Waste Ash (BSWA) [4-8].

1.3 HMMC Production

Hybrid Metal Matrix Composites (HMMC) are composites with two reinforcements compared to a single reinforcement. Hybrid reinforced AMCs like the single reinforced AMCs are generally produced via two routes viz.: solid route and liquid route. Solid route involves powder metallurgy techniques while liquid route, which entail compo-casting, squeeze-casting and mostly stir casting

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techniques [9]. Stir Casting is a liquid state method of composite material fabrication, in which a dispersed phase is mixed with a molten matrix metal by means of mechanical stirring. Stir casting technique has remained the most investigated technique for fabricating AMCs owing to its simplicity, flexibility and commercial viability. The stir casting method ensures homogenous distribution of the reinforcement particles. The wettability between the aluminium matrix and reinforcing materials has been improved by reinforcement coatings and wetting agents such as K2TiF6, Borax and Magnesium [10].

1.4 Al HMMC

Table 1: Properties of Aluminium and Bamboo [11, 12]

PROPERTIES	ALUMINIUM	BAMBOO
Modulus of Elasticity (MPa)	69500	16170
Density (kg/m^3)	2700	350
Tensile Strength (MPa)	195 – 215	160
Hardness (VHN)	83	32

II. LITERATURE REVIEW

Alaneme and Adewuyi [13] investigated the influence of BLA as a complementing reinforcement to Al2O3 on the mechanical behaviour of Al-Mg-Si based hybrid composite. BLA constitutes 2, 4 and 6 percent of the entire 10 %wt. of the reinforcing phase. It was reported that the tensile strength, yield strength and specific strength reduces with increasing BLA in the reinforcing phase. However, slight reduction was less than 9% even with 40% replacement of Al2O3 by BLA. This indicates that the introduction of the BLA does not have significant effect on the performance of the hybrid composites. The BLA for the certain mix ratios exhibited improved ductility and resistance to the brittle fracture when used as a complementing reinforcement to synthetic reinforcements (Al2O3 and SiC).

Considering the articles surveyed on hybrid AMCs, it is reasonable to conclude that using agro waste derivatives as a complementing reinforcement in the development of hybrid AMCs can improve the fracture toughness and ductility of AMCs without significant drop in strength. Despite the potentials of agro waste derivatives in the cost reduction and maintaining performance levels in terms of mechanical properties, a few number of researchers were curious about the influence of agro waste derivative reinforcements on the corrosion and wear performances of AMCs. The wear performances of certain mix ratios of reinforcements are usually superior to that of the single reinforced AMCs.

III. EXPERIMENTAL WORK

3.1 BLA Preparation

Since bamboo leaf ash is not commercially available, we had to prepare it on our own. The green leaves were collected from bamboo farm. They were sun-dried, burnt in a perforated metallic vessel and then heated for 2hrs to obtain the bamboo leaf ash. Large clumps of ash were sieved to retain only finer particles and coarse particles were discarded. Finally bamboo leaf ash was utilised for heat treatment.

3.2 Composite Production

Commercial Aluminum alloy (6063) was used for this experiment. Before the start of the melting, Alumina, Bamboo Leaf Ash and Magnesium were measured as per %wt. of Aluminium taken. Aluminium was melted in a crucible by heating it in an induction furnace at 800°C for nearly three hours. The furnace temperature was first raised above the liquidus temperature of Aluminium to about 750°C to melt the Aluminium completely and was then cooled down just below the liquidus to keep the slurry in semi-solid state. The interiors of the metal die were applied with chalk powder. Simultaneously the in the development of hybrid AMCs can improve the fracture toughness and ductility of AMCs without significant drop in strength. Despite the potentials of agro waste derivatives in the cost reduction and maintaining performance levels in terms of mechanical properties, a few number of researchers were curious about the influence of agro waste derivative reinforcements on the corrosion and wear performances of AMCs. The wear performances of certain mix ratios of reinforcements are usually superior to that of the single reinforced AMCs.

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Figure 1: Wrought Aluminium, Alumina, Bamboo Leaf Ash

IV. TESTS AND RESULTS

4.1 Wear Test

The wear test was conducted in pin-on-disc wear testing machine.

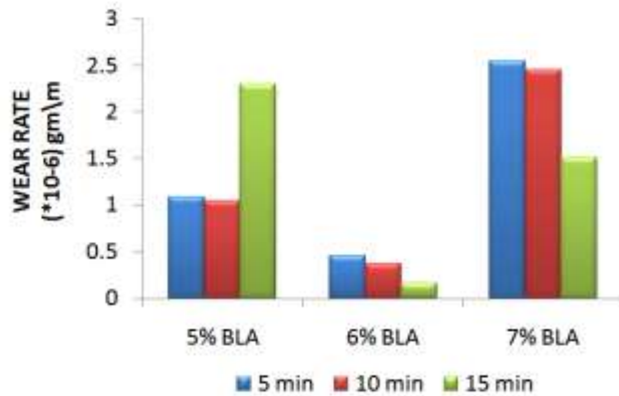

Figure 2: For 1 kg load

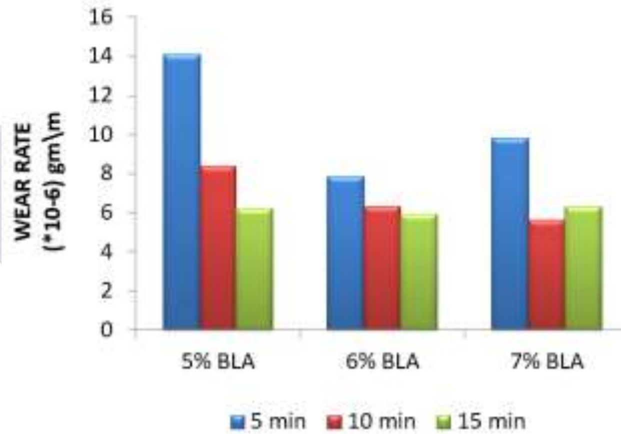

Figure 3: For 2 kg load

4.2 Hardness Test

The hardness test was conducted in Vickers Hardness Testing Machine for a load of 5kg with dwell time of 20s.

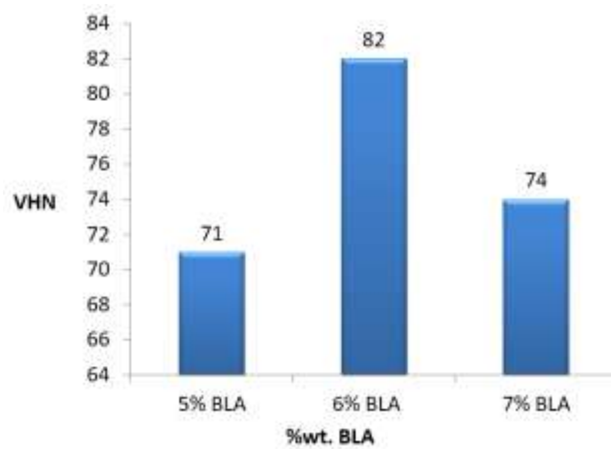

Figure 4: VHN v/s Composition

4.3 Tensile Test

The tensile test was conducted in a Tensometer.

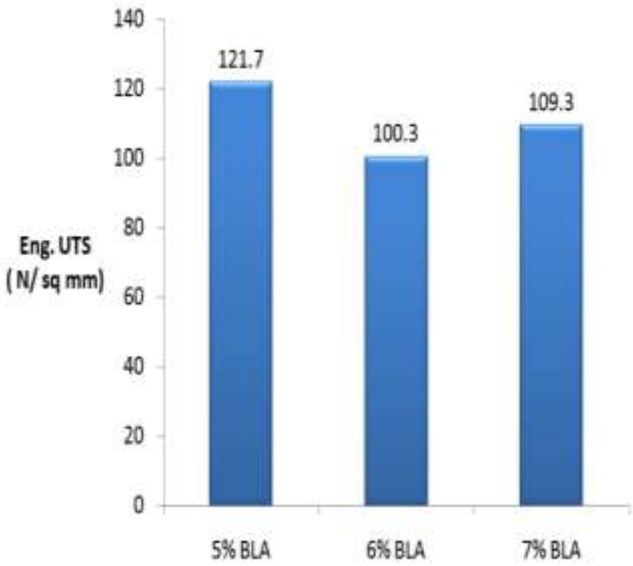

Figure 5: Tensile Strength v/s Composition

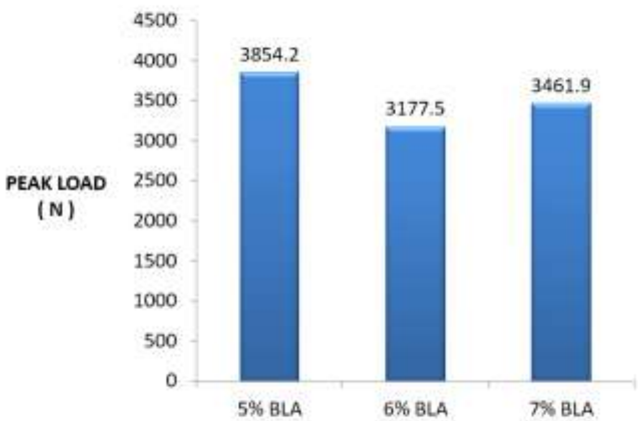

Figure 6: Peak load v/s Composition

V. CONCLUSION

- The 6% BLA composite has produced promising results in wear test and hardness tests.
- It is clear that the wear rate for 6% BLA is the least compared to 5% and 7% BLA composites for both 1kg and 2kg load.
- The comparative test results of Vickers Hardness Number from ***K. K. Alaneme* and *E. O. Adewuyi*** and our test results are as follows:

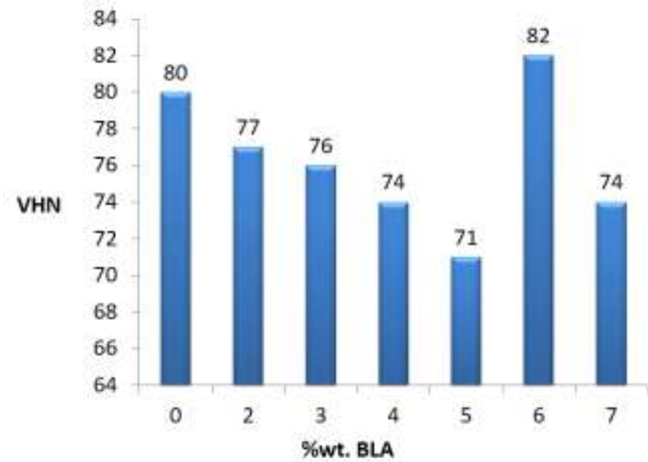

Figure 7: VHN v/s Composition

- From the graph it is clear that the hardness number decreases with increase in BLA composition but 6% BLA shows the highest Hardness value.
- The comparative test results of tensile strength from ***K. K. Alaneme* and *E. O. Adewuyi*** and our test results are as follows:

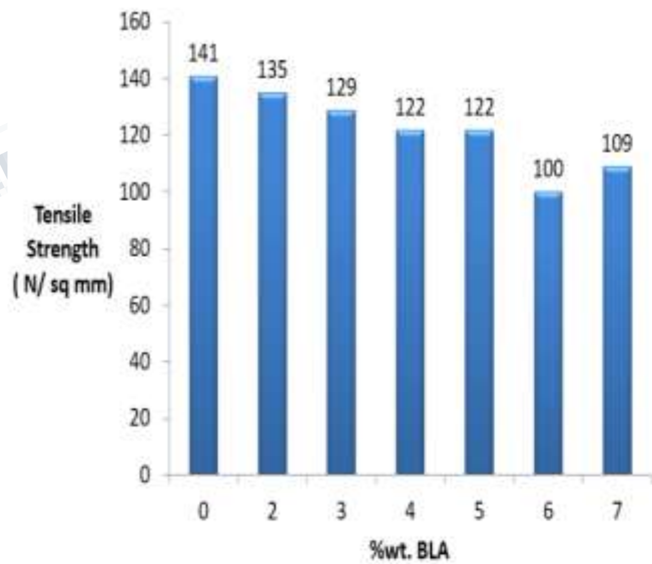

Figure 8: Tensile Strength v/s Composition

- The tensile strength decreases with increase in BLA composition though there is a slight increase in 7% BLA.

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VI. SCOPE FOR FUTURE WORK

- Though stir casting is a less expensive method of producing composites, powder metallurgy techniques can provide better results owing to the homogenous distribution of the reinforcement particulates.
- A study on different binding agents that could bind Aluminium and Bamboo Leaf Ash particles can decrease the slag formation during the stirring process.

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