Realization of agro waste fiber-particulate for low cost aluminium based metal matrix composite: A review

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Abstract. The utilization of agro waste fiber particulate from various industries and agricultural sector has elicited research interest in recent years. Presently, high demand has been placed on the use of agro discarded by product to manufacture engineering components to control environmental threats. Agricultural and industrial by-product is selected to ceramic oxide like SiC and Al₂O₃ as a result of low cost and world-wide acceptance. The production of cheaper aluminium based metal matrix composites involves using cheaper environmental friendly waste products like rice husk ash as reinforcing material in aluminium alloy. The review paper concentrates on the usage of rice husk ash as reinforcing material to manufacture inexpensive aluminium metal matrix composites. The results of the researches carried out by various authors’ shows that inclusion of rice husk ash as reinforcing agent improves the mechanical characteristics of the composites.

Keywords: Aluminium matrix, stir casting, rice husk ash, reinforcement, composite

1. Introduction
The advancement in the use of inexpensive materials to produce aluminium matrix composite with improved mechanical and structural properties has been the aspiration of many engineers and researchers [1-2]. Currently, the challenge of the world is how to resolve the extinction of natural resources and the utilization of agro and industrial waste for industrial application. Researches have been carried out in the last few decades to realize the objective of the industrial sector [3-4]. The matrix phase of aluminium matrix composites is pure aluminium while non-metallic ceramic like SiC, Al₂O₃, SiO₂, B₄C, Al-N are used as reinforcements. Aluminium alloys are frequently used due to better corrosion resistance, great damping capacity, low density and good electrical and thermal conductivities. Aluminium matrix composites are utilized in various engineering fields encompassing serviceable and structural applications because of difference in mechanical characteristics anchoring on the percentages of strengthening and chemical composition of aluminium matrix.

The limitation of manufacturing aluminium matrix composites is cost of production and of the fortifying materials. The use of modern processing stir casting techniques has drastically reduced the fabrication cost and ease of operation [5-6]. The aluminium matrix composites is a type of MMC that retains properties such as low density, super stiffness, higher wear resistance, higher fatigue resistance and better firmness at elevated temperature. Composites are utilized for the fabrication of a several mechanisms for advanced applications [7]. Aluminium matrix composites were produced to enhance the operation of existing aluminium alloys which cannot measure up to standard modern engineering products. Rice husk ash is among the cheapest and low-density reinforcement that comprise of SiC,
Al₂O₃ etc. which is obtainable in great amounts as solidified waste product. Therefore, its effective usage is immediately required to reduce environmental hazard. Rice husk is obtained from agriculture by product in the milling of the rice. A large quantity of rice husk ash (RHA) is manufactured yearly across the globe. The proper use of this agriculture leftover will safeguard the environment from degradation. Currently, aluminium is generally applied in the design, domestic use like windows and door frame, automotive industry, electronic apparatus, and other devices [8]. This paper presents a detailed review of agro waste fiber particulate from various industries and agricultural sector to enhance mechanical and tribological properties.

2. Effect of RHA on the mechanical properties of aluminium composites

2.1 Microstructure

The homogenous dispersal of reinforcing agent in the metal matrix is the proper method of building a good microstructure. The process of forming solid state, fluidity, kind of reinforcement, and technique of integration are the factors affecting the dispersal of particles. It is essential to have particulate to be homogeneously distributed during the course of the casting for proper composite processing [10]. Hossain et al., (2017) examined the microstructure of A356 reinforced with RHA particulate using optical microscopes. The authors noticed that the percentages of RHA are equally distributed in the surface morphology of the aluminium A356 matrix. The inclusion of RHA shows slight micro porosity in the casting and the visibility of RHA in the matrix. Furthermore, it has decent interaction between metal matrix and RHA that shows excellent bonding strength [8]. According to Ahamed et al., (2016), fabricated aluminium alloy/ RHA particle composites formed by stir casting techniques. The surface morphology analysis using SEM shows the distribution of reinforcement which reveals fruitful production of the composites [9]. Siddharth and Rao (2017) examined the microstructure of A7075/ RHA composites. The authors observed the presence of white (α) primary grains and a dark eutectic Zinc. It was known that there was presence of RHA particulates in A-7075 alloy matrix fine structure in the base matrix of Al- 7075 alloy [11].

Prasad and Krishna (2011) examined the surface morphology of A356.2 /RHA metal matrix composites. SEM equipped with EDX analyzer was used for surface morphology characterization. The authors depicts that RHA particles are uniformly dispersed in the aluminum matrix for all weight percentages (4%, 6%, and 8%). The results also show good retaining of RHA particulate in the produced composites [12]. Mishra et al., (2018) reported on the surface morphology of aluminium alloy (LM6) fortified with RHA using stir casting techniques. The result of the SEM analysis confirms decent bonding between the RHA particulate and LM6 alloy matrix as a result of the heat treatment [13]. Saravanan and Kumar (2013) examined the microstructure of aluminium alloy (AlSi10Mg) reinforced with RHA particles using SEM. The authors observed a uniform dispersal of RHA particulates deprived of voids and discontinuities alongside better bonding of matrix material and RHA particulates [14].

2.2 Mechanical behavior

2.2.1 Hardness

According to Usman et al., (2014) The rise in the quantity of RHA in aluminium matrix using Rockwell hardness value increases its hardness to 25% reinforcements and decreases to 30% volume of RHA. This reveals that all the reinforcement specimens had greater HRV that the unreinforced specimen which indicates that the composites have improved hardness value [15]. Ahamed et al., (2016), measured the hardness of the produced composites utilizing Brinell hardness machine by the application of 4.9KN load and steel diameter of 10mm. The authors stated that the hardness of the composites escalates gradually by
increment in the weight of reinforcement [9]. Prasad and Krishna (2011) measured the hardness of the A356.2 fortified with RHA applying Brinell hardness tester as per ASTM E10 standards. The authors applied a load of 500Kg on the samples for 30sec. It was noticed that the hardness improves with increment in quantity of the reinforcement [12]. Hossain et al., (2017) stated that escalation in the percentage of RHA in A356 advances the hardness of the composites utilizing Brinell hardness testing machine. The authors observed that the peak hardness is obtained at 6% rice husk ash reinforcements [4]. Mishra et al., (2018) reported that the hardness of the composite improves with rise in aging temperature value to 175°C and diminishes on further upsurge in aging temperature [13]. Saravanan and Kumar (2013) confirmed that the hardness of the composite improves with the maximizing the percentage of the RHA particulates using Brinell hardness machine [14].

2.2.2 Tensile behavior
Usman et al., (2014) investigated the variation of UTS and % elongation of composite with RHA addition The authors depicts that increasing the ash percentage above 10% in the alloy will decrease the strength thereby introducing more rice husk ash in the system and hence more location for crack introduction and thus minimizing the load bearing capacity of the composites leading to reduction in the tensile strength [15]. Ahamed et al., (2016) utilized the ultimate tensile machine to study the yield and UTS of the composites and confirmed that adding more of the RHA particulate will improve the yield strength and UTS of the composites [9]. Prasad and Krishna (2011) evaluated A356.2 fortified with RHA particulates and confirmed that inclusion of RHA will modify the UTS of the composites [12]. Hossain et al., (2017) discovered that the ultimate tensile strength increment was due to the increase in the percentage of RHA in aluminium alloy [4]. Saravanan and Kumar (2013) carried out tensile test experiment on the sample using a universal testing machine. The authors detected that the tensile strength improved with the addition of the percentage of RHA in the aluminium matrix [14].

2.3 Wear study
Gladston et al., (2017) examined the wear characteristics of A6061/ RHA composites manufactured using compocasting and investigation was done through pin-on-disc equipment at room temperature. The authors observed that the wear rate diminishes as percentage of reinforcement rises in the sample at any given load. The absorption of RHA particles is advantageous to the improvement of wear resistance. The wear rate rises with increased applied load for a constant volume percentage of RHA particulates [16]. Gupta and Takhi (2015) examined the effects of RHA on the mechanical and wear properties of the aluminum metal composite fortify with aluminum oxide performed on the pin-on-disc equipment. The wear performance of the metal matrix (MMCs) is appraised at load of 9.8N, Sliding distance of 1000m and velocity of 1.5m/s. The result revealed that increasing the percentage of the reinforcement leads to maximizing the tribological properties of the composites [17]. Figure 1 depicts the diagram of pin on disc wear equipment for the study of wear analysis.
Conclusions
Rice husk ash is a potential agro waste fiber-particulate for low cost aluminium based metal matrix composite. The present study demonstrates that enormous research has been done to enhance the mechanical characteristics of aluminium alloy. The aluminium alloy has being reinforced with agro industrial waste products materials in form of rice husk ash. Most of the authors used stir casting method to create composite materials. To conclude, rice husk ash is a perfect reinforcing agent to boost the performance of aluminium matrix composites. The review also shows tribological behavior of aluminum alloy /RHA composites manufactured using stir casting techniques. However, the coefficient of friction with time for each grade of composite was not considered. The result of the study recommends collaborative work and attention on the use of RHA as reinforcing agent in aluminium alloy to reduce environment hazard of the material.

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