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Characterization of Aluminium Hybrid Composite Reinforced with Rice Husk Ash and Molybdenum Disulfide Processed through Compo Casting

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Abstract:
The focus of the current study is lies on the development of high performance self lubricating aluminium composite material with low cost reinforcements. The base material selected for the composite development is Aluminium 6061 whereas the rice husk ash (RHA) and molybdenum disulfide are chosen as primary and secondary reinforcements. The fabrication methodology selected to process this novel composite is compo casting in which the amount of rice husk ash in aluminium matrix is varied from 0 to 15% with constant increment of 5% and the amount of solid lubricant is fixed as 3%. The developed composite is analyzed for its density, hardness, tensile and wear properties. The results reveals that the developed composite is lighter than the base material and it posses high hardness and tensile strength also. The wear resistance capability of the aluminium is also considerably decreases with RHA addition.

***Keywords**: Aluminium; rice husk ash; compo casting; hardness; wear.*

I. INTRODUCTION

In the view of addressing rising industry challenges, focus of the present era materials research community around the globeis on developing novel materials. One important category of material among these novel materials is metal matrix composites (MMCs). Metal matrix composites can be utilized to numerous advanced applications when compared to monolithic materials.These materials are currently in demand for various aerospace, automobile and defense purposes due to their superior ability to resistcreep, conduct the heat, dimensional stability,specific stiffnessand strength [1, 2].Great physical and mechanical properties, superior thermal capabilities with excellent tribological properties are offered by the aluminium based composites when compared to other matrix materials. Numerous researchers were committed to number of research works to study and understand the effect of reinforcements on aluminium matrix composite (AMC) properties. The researchers attempted to study the effect of various reinforcements such as Al_2O_3 [1], SiC [2] and TiC [3] etc., on the properties of AMC. But some other studies utilizes the cost effective options such as reinforcements derived from industrial and agro waste products in the view of reducing the cost of these advanced materials. Greater availability at zero cost, ability to process at lost and possibility of enabling cleaner environment are the advantageous factors that supports the utilization of these waste byproducts/materials as reinforcements. Even though considerable studies were performed in this waste based reinforcement area, only minimal works are reported that involves these waste materials as hybrid reinforcements along other

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solid lubricant materials such as molybdenum disulfide, boron nitride and graphite etc.

Some researchers have tried these waste byproducts/materials as reinforcing materials in hybrid reinforcedAMCs with the focus of developing cost effective AMCs [4,5]. These type of hybrid composites are often termed as cost effective high performance composite as because the addition of these low cost reinforcements not only decreases the cost but also improves the properties of the base material. The most commonly used such agro and industrial waste reinforcements are coal fly ash (FA), redmud,rice husk ash (RHA), bamboo leaf ash (BLA) and bagasse ash [6-8]. The added advantage of these materials is lower density (BLA-0.36 g/cm^{3}and RHA-0.31 g/cm^3)when compared to commonly used reinforcements (silicon carbide-3.18 g/cm^{3}and alumina-3.96 g/cm^3). So these materials can be utilized for developing cost effective composites.

II. MATERIALS AND METHODS

The method selected for fabricating the novel cost effective high performance hybrid composite is compo casting which is also called as multi step stir casting. The setup utilized for fabricating the composite materials is shown in figure 1. The measure quantity of rice husk ash and MoS_2 particles were preheated separately in a muffle furnace at 250°C in the view of eliminating the moisture content and increasing the wettability with base molten alloy. The amount (weight %) of RHA particles in aluminium matrix is varied as 0, 5, 10 and 15 in order to identify the effect of RHA on the performance of Al MMC wherein the secondary reinforcement (MoS_2 solid lubricant) percentage is fixed as 3. The amount of secondary reinforcement is kept as minimal as because of its soft nature which will deduce the properties of AMC when added more.

A measured quantity of base aluminium material is kept in the furnace and the temperature is raised to 610°C which makes the material semi solid. The preheated RHA and MoS_2particles were added into the molten metal in multiple steps and temperatures. Then the molten mixture is stirred with the aid of a motorized stainless steel stirrer to get uniform distribution of reinforcements in the matrix. Then the mixture is poured into the preheated die and allowed to cool. Similarly other compositions with different RHA percentage are fabricated and the samples were prepared for further testing.

Figure 1. Experimental setup for MMC processing

The developed samples are analyzed for density, hardness, tensile behaviour and wear properties. Archimedes principle is followed to calculate the density of the developed samples with the help of an electronic weighing balance of 5 digit accuracy. The hardness of samples is measured through Vickers method using Matzuwa (Japan) instrument while the tensile strength is obtained through Universal Testing Machine. Then the wear rate of the samples is measured through pin on disc wear test under environmental conditions.

III. RESULT AND DISCUSSION

III.1. Density

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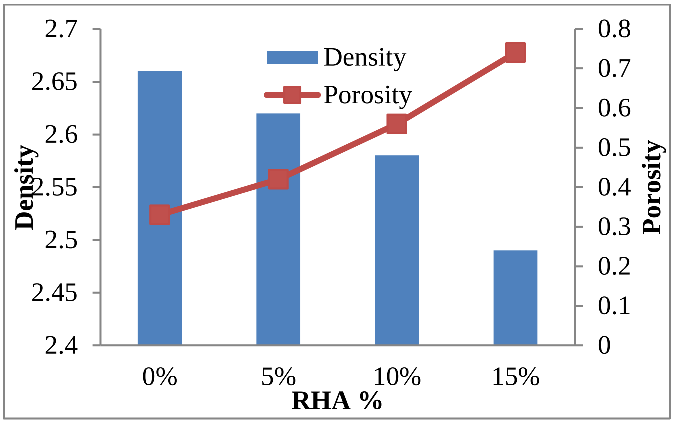

Figure 2. RHA percentage vs density

Density of the developed composite along with porosity level with respect to reinforcement percentage is illustrated in the figure 2. As a result of lower density of reinforced rice husk ash particle the developed composites are lighted than the base material which can be clearly identified from the figure 2. The porosity of the developed AMC is found increasing with every increase in rice hush ash percentage which is also minimal. This decrease in density is a huge advantage for the developed AMCs as because the advanced applications such as aerospace require materials with lower densities.

III.2. Hardness

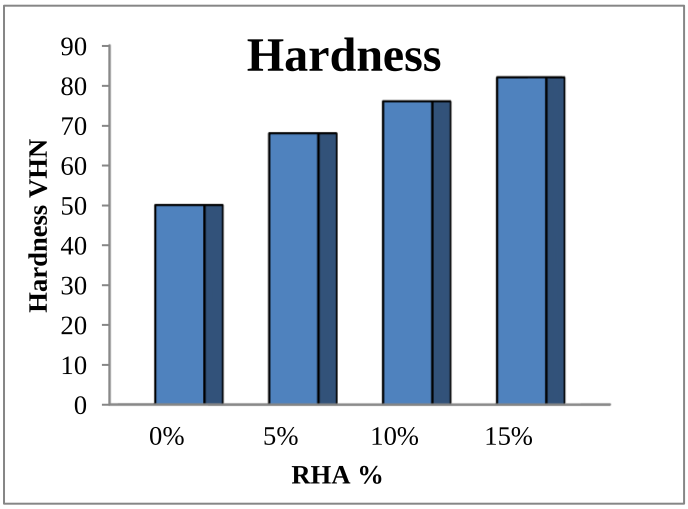

Figure 3. RHA percentage vs micro hardness

The influence of rice husk ash particle on the micro hardness of the aluminium is presented in figure 3. It can be clearly noted from the figure that the addition of rice husk ash particle in aluminium matrix yields positive results i.e. hardness is found increasing. Since the rice husk ash abundant amount of silicon dioxide, alumina and other constituents, it helps to increase the hardness of the base material. Since the reinforced particles are in micro size, its surface area is high which tends to increase the hardness of the aluminium base material. These reinforced rice husk ash particle and molybdenum disulphide particles helps to hinder the dislocation motion when the load is applied on the surface and hence the load required for plastically deform the material is high i.e. hardness increases.

III.3. Tensile Properties

The influence of rice husk ash and secondary reinforcement particles on ultimate tensile strength of the fabricatedcost effective hybrid metal matrix composite is given in figure 4. It is clearly visible from the tensile strength plot that the addition of rice husk ash particles on aluminium results in improved tensile strength. This increased strength of aluminium is attributed to the strengthening mechanism offered by added rice husk particles in which the RHA particles deviates the slip plane during plastic deformation while external load is applied.This increased ultimate strength is also attributed to the load transfer capability of the reinforced particle which transfers the applied load. Further, the dislocation density in the composite is also increases as a result of higher difference in the thermal expansion co-efficient between the base material and reinforced RHA and molybdenum disulfide.

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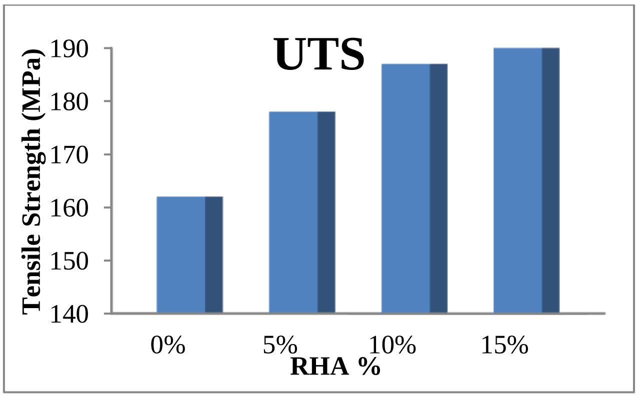

Figure 4. RHA percentage vs tensile strength

The figure 5 depicts the effect of RHA particles on ductility of the aluminium i.e. elongation. The elongation percentage decreases considerably with every addition of RHA particles as a result of increased brittleness. Since the reinforced particles are brittle in nature, the ductility of the aluminium i.e. elongation while loading decreases with every addition of briitle phase in it. And hence the brittleness of the aluminium increases with RHA addition i.e. elongation decreases.

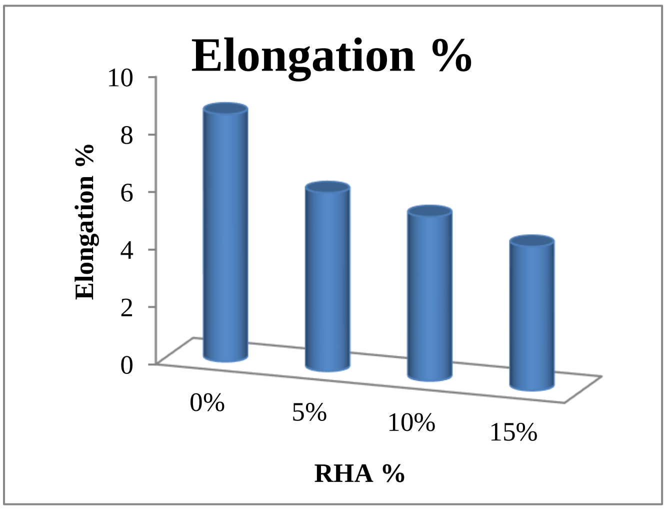

Figure 5. RHA percentage vs elongation %

III.4. Wear Behaviour

Influence of rice husk ash and MoS_2 particles addition on wear loss of aluminium MMC while tested under dry testing conditions in pin on disc setup is shown in figure 6. The loss of wear decreases greatly when the percentage addition of rice husk ash particles increased from 0% to 15% when tested under same conditions. This decrease in wear loss of the developed AMC is due to increased hardness of the composite i.e. the AMC with higher rice husk ash % posses higher hardness and concurrently less wear. This is due to the well known fact that the harder material always gives higher resistance to wear than the softer materials. And so the harder material which has 15% RHA particle exposes higher wear resistance whereas the unreinforced base matrix has less tendency to resist wear. Further, the addition of MoS_2 solid lubricant particles creates lubrication layer between the sliding parts that ends in less wear loss [9].

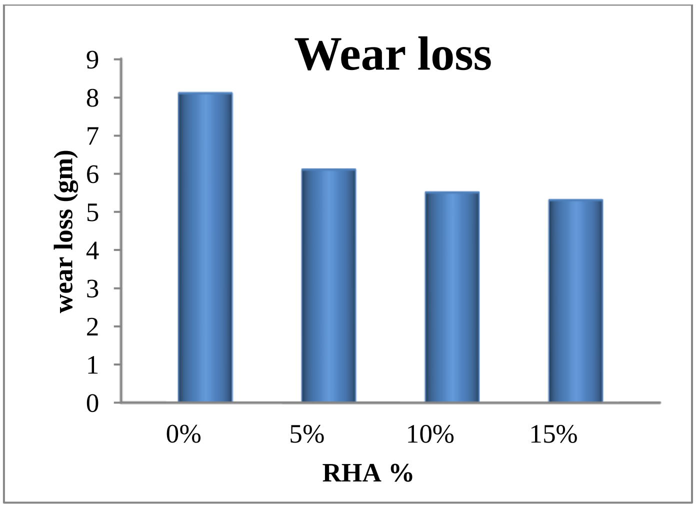

Figure 5. RHA percentage vs wear loss

IV. Conclusion

The novel high performance self lubricating hybrid economic composite was successfully developed through compo casting route and tested for density, hardness, tensile behaviour and wear properties. The following conclusions were made from the study

- The developed composite is lighter than the base material.
- The novel AMC possess high hardness and tensile strength than the base aluminium material.

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- The wear resistance capability of the aluminium is also considerably decreases with RHA addition.

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