Microstructural Analysis of the Aluminum Metal Matrix Composites Reinforced with Aluminum Oxide and Rice Husk Ash

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***Abstract*- Micro-structural investigation is done on the Al matrix composites reinforced with rice husk ash and aluminum oxide. Aluminum alloy (LM6) is used as the matrix metal. Composites are prepared through stir casting. Rice husk ash and aluminum oxide are reinforced in the 4 and 8 % of the weight of matrix metal. Scanning Electron Microscopy is done to analyze the microstructure of the metal matrix composites. Energy-dispersive X-ray spectroscopy (EDS) is also done to check the chemical composition of the rice husk ash (RHA). Results reveal that the rice husk ash is distributed more uniformly throughout the matrix material as compared to aluminum oxide. EDS of the rice husk ash shows that the rice husk ash contains SiO_2 as its major constituent.**

***Key words*- Metal matrix composites (MMCs), rice husk ash (RHA), aluminum oxide (Al_2O_3), stir casting, Scanning Electron Microscopy, Energy-dispersive X-ray spectroscopy (EDS).**

I. INTRODUCTION

Today is the world of advancements in every field, researchers and engineers are in search of inventing best and advance materials in an economical way. In this context from past few decades composite materials had received good attention throughout the world due to its distinctive combination of properties. Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), Polymer Matrix Composites (PMCs) are some common types of composites. Among them MMCs are very important. Aluminum is widely used as metal matrix among all metals. There are numerous fields in which aluminum alloys are used, some of the critical fields are aircraft, automotive and domestic uses appliances [1-3]. Aluminum metal matrix composites possesses unique combination of light weight, good corrosion resistance and excellent mechanical properties. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus, high hardness, tensile strength and good wear resistance as compared to unreinforced alloys (4-9). Some of the common reinforcements for aluminum-based MMCs are graphite, boron carbide, mica, silica, zircon, alumina, aluminum nitride and silicon carbide (Rohatagi et al. 10). Innovation to develop low cost MMCs reinforcing with some materials which are not harmful to the environment is growing day by day. (Rice husk ash RHA) is one of such reinforcement. The rice husk contains about 75% organic volatile matter and the balance of the weight of the husk is converted into ash during firing process and is known as RHA (S.D. Saravanan et al. 7). It is estimated that about 70 million tons of RHA is produced annually worldwide (Torralba et al 11). This RHA is a great environmental threat, causing damage to land and surrounding area on which it is dumped. Recent research studies reported that the RHA in turn contains more than 85% amorphous silica (Ghassan Abood Habeeb et al.12). Composites can be produced through various techniques. Properties of the composites are affected by processing technique. Liquid method to produce composites is preferable over others due to its simplicity, low cost and favoring condition to mass production. Stir casting is an extensively adopted liquid method for the production of MMCs (13-14). In this experiment main aim is to investigate the microstructure of composites reinforced by aluminum oxide and RHA as most of the researches are carried out to determine the mechanical behavior of the composites. Stir casting technique is adopted to prepare the composites. Energy-dispersive X-ray spectroscopy is done to check the chemical composition of the RHA.

II. EXPERIMENTAL PROCEDURE

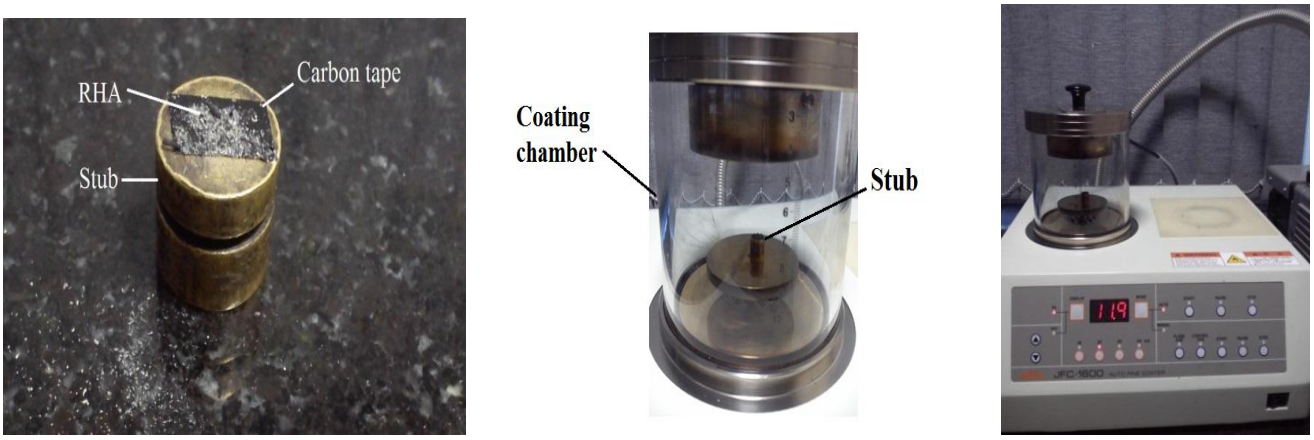
In this experiment aluminum alloy LM6 is used as the matrix material. Table 1 shows the chemical composition of the aluminum alloy LM6. For the investigation RHA and aluminum oxide reinforced composites are required. To prepare RHA the rice husk was collected from a local rice mill at Ambala, Haryana. The collected rice husk was washed with water in order to remove the impurities and subsequently dried in sunlight for 30h. The dried rice husk was placed in a container and carburized. The carburized ash was heated for 2hrs and the color of the ash changes from black to grayish. The composites are prepared through stir casting. Stir casting is an economical method. It is very suitable from the engineering point of view in terms of production capacity. The aluminum alloy ingots were put in the crucible and heated until the ingots were melted. After melting the matrix metal, the reinforcements RHA and aluminum oxide were added gradually from the top in the molten metal. Four straight blade steel stirrer was used to generate a vortex in order to disperse

the reinforcement uniformly in the molten metal. Steering was done for 5 minutes at a speed of 300rev/min. After mixing the reinforcements the molten metal was poured in the sand mould. Metal is then allowed to get cool in air.

Table-I Chemical composition of LM6

Chemical composition, %	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti	Al
	0.1 max	0.1 max	10.0-13.0	0.6 max	0.5 max	0.1 max	0.1 max	0.1 max	0.05 max	0.2 max	Balance

From the cast, specimens (20×20 ×10 mm) for the SEM were prepared. Specimens were polished by the use of standard metallographic technique and etched with Keller's reagent. SEM gives the information regarding the microstructure of the test specimen. SEM uses a beam of electrons to scan the test specimen. It gives the information like crystalline structure and their orientation and also the texture of the material. Data was collected from a specified area of the specimen. For the Energy-dispersive X-ray spectroscopy of RHA it was important to make the rice husk ash a conductive material. For that purpose coating is done on the rice husk ash. For the coating a stub is used then a carbon tape is used on the surface of the stub and rice husk ash was placed on that stub. The devices used for this coating are shown in the Figure 1. Stub was then placed in the SEM machine. Energy-dispersive X-ray machine was combined with the SEM equipment because it also uses the high energy carrying electrons to analyze the chemical composition of the tested specimen.



(a) (b) (c)

Fig. 1 (a) Rice husk ash over stub (b) Stub in the coating chamber (c) Coating machine

III. RESULT AND DISCUSSION

A. Results and discussion for SEM

Many mechanical properties of the material depend largely on the micro structure. Development of the structure in the composites depends on many factors like cooling condition, size of the reinforcement, densities of base metal and reinforcements [prasad15]. Figure 2 shows the microstructure of the aluminum oxide reinforced composites whereas the figure 3 shows the microstructure of the RHA reinforced composites. Presence of the aluminum oxide and the RHA particles can be recognized clearly. From the Figure 2(a) it can be seen that the aluminum oxide are distributed more uniformly in the base metal but from the figure 2 (b) clustering of the aluminum oxide particle can be seen clearly. This may be due to density difference between the base metal and the reinforcement (density of LM 6 is 2.65 gm/cm^3 and density of aluminum oxide is 3.95 gm/ cm$^{3)}$. To disperse the reinforcement having higher density high vortex is required which can be produced at high steering speed so may be the steering speed was not sufficient enough to produce the required vortex [16-17]. However from the figure 3 (a) & (b) uniformly distribution of the RHA particles in both the case this is due to the fact that RHA has density 2.70gm/cm^3) very close to the base metal. Moreover RHA makes good bonding with matrix metal [Gladston 18]. Figure 4 shows the SEM of the RHA. From the figure irregular shapes of the RHA particles can be seen clearly.

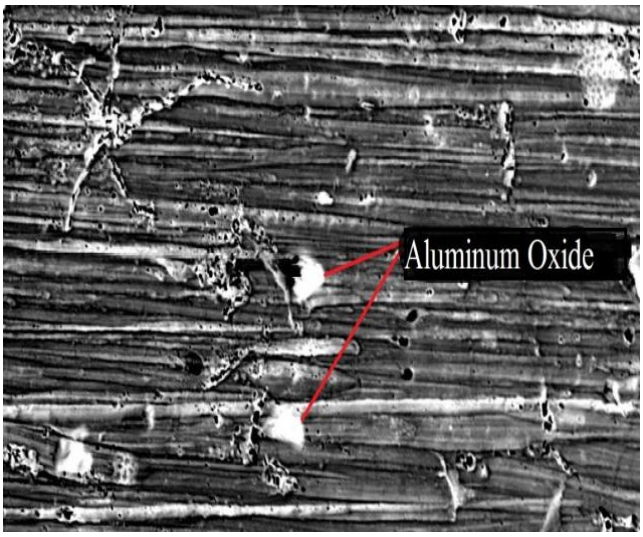


Fig. 2 (a) Composite with 4% aluminum oxide

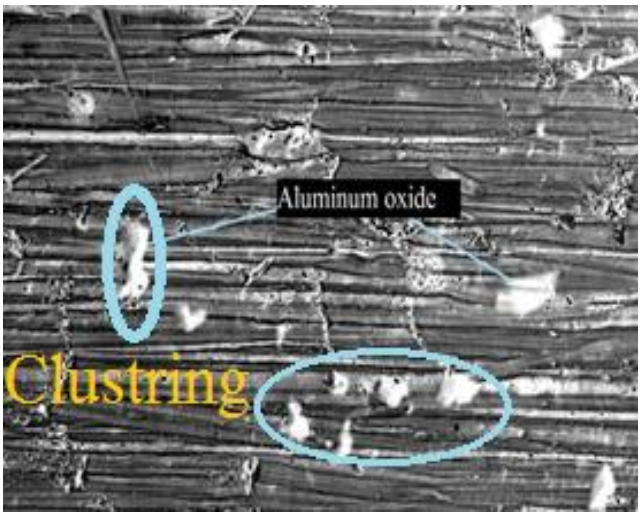


Fig. 2 (b) Composite with 8% Aluminium Oxide

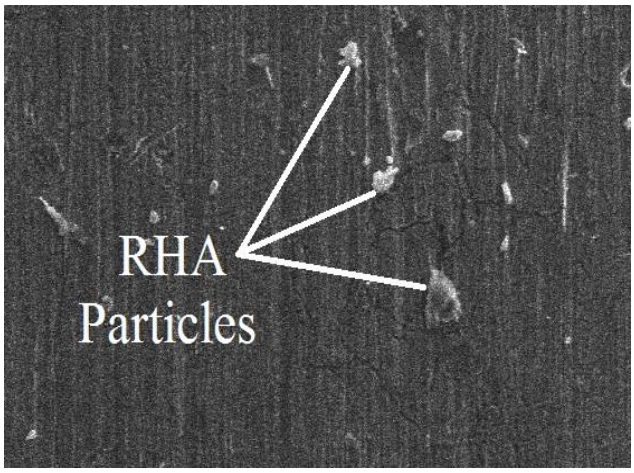


Fig. 3 (a) Composite with 4% RHA

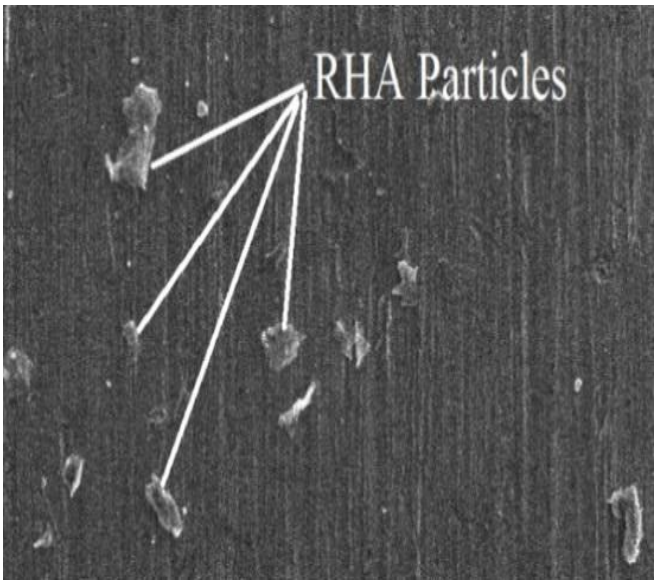


Fig. 3 (b) Composite with 8% RHA

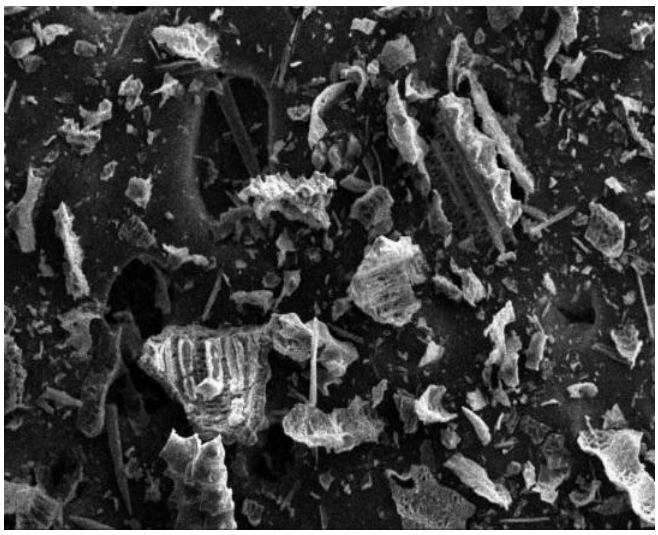


Fig. 4 SEM of RHA

B. Results and discussion for EDS

Figure 5 shows the various spectrums taken on the RHA in order to check the chemical composition of RHA through EDS. From the Figures high peaks of the Si and O can be seen clearly. Presence of the oxygen confirms the oxidation processes in the RHA. Silicon (Si) and oxygen (O) particles are present in the form of SiO_2. Apart from these two, small peaks of the potassium, carbon, magnesium, sodium and copper can also be seen.

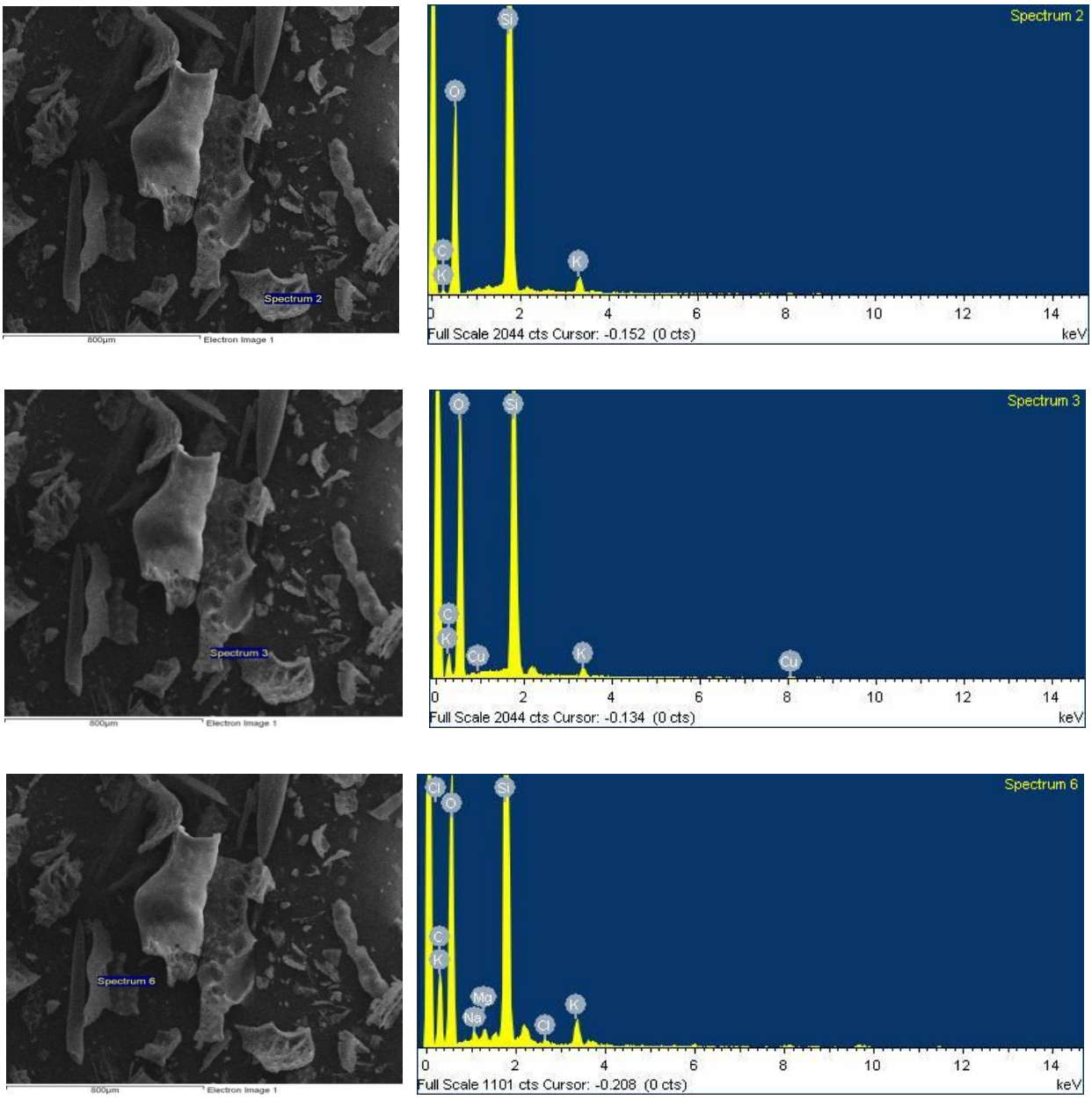


Fig. 5 EDS of RHA

IV. CONCLUSIONS

Microstructures of the LM6 based metal matrix composites reinforced with aluminum oxide and rice husk ash has been investigated. Composites were prepared by reinforcing both the reinforcements in 4 and 8 % of the weight of the matrix metal. Investigation reveals that:

- RHA is distributed uniformly throughout the matrix metal whereas in the case of aluminum oxide reinforced composites it is evaluated that aluminum oxide is not dispersed uniformly over the matrix metal , clustering of the aluminum oxide particles take place when the aluminum oxide is reinforced in high quantity.
- EDS of the RHA shows that it contains SiO_2 as its major constituent. Apart from SiO_2, presence of potassium, carbon, magnesium, sodium and copper in RHA is also confirmed through the EDS.

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