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*Research Article*

# Developing and analyzing the Mechanical Properties of industrial Aluminum-Bronze AB-1-RHA metal matrix composite

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***Abstract***

*Tailored material with conjugation of two or more dissimilar materials in order to obtain elevated properties terms as metal matrix composite. Alloy conversion to composites especially gives more independence to fabricate new engineering materials in accordance to basic desire of application where it is used. Degree of applications of composite material grown steadily, penetrating and concurring the new markets. Modern technologies demand unusual combination of properties which cannot be fulfilled by simple metals, ceramics and conventional alloys. In current experimental work industrial AB-1 grade alloy (Cu86Al8.9Fe2.6 as major constituent) was taken as matrix metal and rice husk ash (with main constituent silica) as particulate reinforcement. Rice husk ash was used because it is known for most economical source for obtaining experimental type silica, silica acted as hardening material. Fabrication process involve stir casting method. Percentages of rice husk ash used were 3%, 6%, 9% and 12%. Rods of these compositions produced. Under investigation it was observed that tensile strength maximum at 6% RHA whereas the hardness values increased with increase in RHA composition.*

***Keywords:*** *Particulate, MMC, AB-1, industrial AB-1, RHA.*

## 1. Introduction

In the present scenario composite industry has been recognized for wide scale industrial applications. Now composite materials are not specific to only aerospace industry but now are used almost in every application due to their properties. Thus shift of composite materials from aerospace industry to other industrial application is remarkable. Composite material also finds their application to absorb shocks and vibrations. High performance reinforcement materials such as glass fibres, RHA, SiC, carbon etc. when reinforced with metal alloys or polymer resins innovated a new class of material. These developments created their extensive use in present day scenario. High volume production also reduced their manufacturing cost to greater extent.

Industrial applications whether it may be a simple pin to the production of big ship engines aluminum-bronze materials are being used extensively. Gas vehicles, propellers, fuel cylinders, vehicles bushes, paper making rollers and even industrial drive shafts are few examples of their use. Structural aspects of the aluminum-bronzes are also strong. Composites have the capability to replace the conventional materials. General conventional material which we see for major industrial application is steel, but with the advancement in property of other materials like aluminum-bronzes and its alloys, these aluminum-bronzes and its alloys with reinforcements of high performance materials can create new definitions in industrial applications. Composites showed remarkable achievement in improving the mechanical properties such as tensile strength, hardness, toughness, impact strength together with tribological properties of materials such as wear rate. Many modern technologies demand unusual combination of properties which cannot be fulfilled by simple metals, ceramic, conventional alloys and polymeric materials for example material requirements for transportation, underwater works and space industry. Due to limited properties of general metals the sophistication levels cannot be achieved, there always remains demand of harder, stiffer, tough material for wide applications. Metal matrix composites which involve metal-metal reinforcements can also be subjected to generally used heat treatment processes which further enhance their property. **K. S. Sridhar Raja *et al.* [2014]** carried out experimentation for checking wear behavior on composite formed by reinforcing boron carbide in aluminum A356 fabricated through stir casting technique and the wear test has been performed through pin on disc wear testing machine. Parameters at which variation in wear compared were applied load

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and sliding speed. Volume percentage of boron carbide taken was 3%, 6%, 9%, 12%. Out of all composites, wear has been seen increasing at 9% boron carbide reinforced with 91% A356 and at 12% boron carbide reinforcement the wear rate decreased in comparison. It has also been found that wear rate and wear volume increased linearly as load increased. **M. Singh *et al*. [2002]** has conducted two body wear experiment, first material taken for the study was alloy aluminum and other composite material was Al alloy-10 wt% particle of Sillimanite. The abrasive size varied to 25 μm, 100 μm and 200 μm. Practical conducted at varying loads of 1N, 3N, 5N and 7N also sliding distance varied for all different loads. Minimum wear rate was observed with composite of 25 μm abrasive particles in comparison to 100 μm and 200 μm abrasive particles. Wear rate seen decreasing as sliding distance increased individually for different loads. **T. Luangvaranunt *et al*. [2010]** demonstrated the fabrication of Aluminum-4mass% Cu/$Al_2O_3$ composite. The powders used were of copper, rice husk ash silica and aluminum for the fabrication of composite through powder metallurgy method, it involved sintering at 650˚C, then hot forged the sintered material at 600˚C and at pressure 660 MPa, heat treatment done then-after. Plastic deformation of matrix was induced by hot forging it also fractured porous silica thus creating two phase contact, alumina produced by chemical reaction between RHA silica and matrix aluminum. Copper addition hardened the phase further. Hardness 44 HRA observed at 15 volumetric percent of RHA silica. **G. B. Veeresh Kumar *et al*. [2010]** has fabricated composites Al6061-SiC and Al7075-$Al_2O_3$. They showed that plastic forming capacity was higher with particle reinforcement compared to fiber or whisker reinforcements. They considered these composites for hardness, wear and TS properties. Composite preparation technique was liquid metallurgy method. Composite of 2-6 wt% prepared, followed by machining of cast and base specimen material. It resulted in higher hardness when SiC and $Al_2O_3$ wt % increased. Tensile strength also resulted in an increment as SiC in Al6061 dispersed and similar pattern for $Al_2O_3$ in Al7075 was observed.
**D. Siva Prasad and A. Rama Krishna [2012]** has fabricated the matrix mixture of A356.2/RHA composite. In fabrication vortex was created by mechanical stirrer during mixing reinforcements in matrix. Temperature of molten mixture was maintained to 800˚C-850˚C. Experimental apparatus taken under consideration for wear testing was pin on disc. Condition under which wear tested was dry and the disc slided against pin of chromium steel at room temperature. Weight loss observed higher as normal load increased for various RHA compositions, resulted in high wear rate as load increased. With RHA 8 wt % wear observed minimum compared to unreinforced aluminum alloy. Wear resistance shown decreasing trend. **F. Uchenna [2011]** has fabricated the polymer composite with epoxy as base material and RHA as its reinforcement. Carbonization of RHA done at temperature 850, 900 and 950˚C and these samples individually reinforced with epoxy resin. Compositions of 10%, 20%, 30%, 40% RHA were prepared. Method used for fabrication was manual stirring. Wear tested for each composition and apparatus used for the purpose was pin on disc and condition for testing wear rate was dry in nature. Carbonized ash at 950˚C shown steady wear compared to other compositions and wear rate $1.03\times10^{-5}$ N/m for 30% carbonized ash at 950˚C at 5N load. The bonded structure of silica resulted lower wear rate at 950˚C carbonization process. **O. I. Sekunowo *et al*. [2013]** has fabricated composite of aluminum-bronze and added to it iron granules as reinforcements and variation range of iron granules was 2-10 wt%. These composites compared with unreinforced aluminum-bronze sample. Properties evaluated were charpy impact, tensile and micro-hardness. The UTS observed maximum at 4 wt% iron granules and hardness value observed was 88.7 HRB at same composition. Impact energy was also seen maximum at 4 wt% of iron granules addition.

## 2 Materials

### *2.1 Industrial Aluminum-Bronze AB-1*

Composite fabrication carried out with use of industrial aluminum-bronze as the matrix material. The density of aluminum-bronze grade AB-1 is 8.29 gm/cm³. Table-1 describes the elemental composition of aluminum-bronze AB-1.

**Table-1** Elemental composition of industrial aluminum-bronze AB-1

| | |
|---|---|
| Zn | .40 |
| Sn | .087 |
| Pb | .042 |
| Ni | .82 |
| Mg | .98 |
| Fe | 2.67 |
| Al | 8.921 |
| Cu | Remainder |

### *2.2 RHA*

RHA is used in the experiment which is considered as most economical source of industrially used silica. For producing RHA rice husk (RH) taken and washed thoroughly with water for purpose of removing unwanted particles like dust and rock impurities and then dried at room temperature for one day. Dried RH is then heated at 200°C for two hours for purpose of removing organic matter and remaining moisture. At this stage the color of RH turned from dark yellow to black. Black matter then heated to 1100°C for 24 h for removing carbonaceous matter. In this process black matter turned to grayish color. For purpose of producing RHA 11.5 Kg of RH was taken and finally 2.2 Kg of ash was produced resulting in approximately 81% loss of matter.

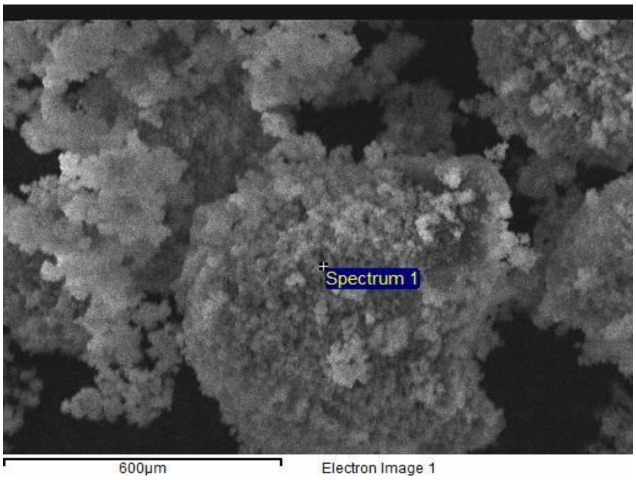


**Figure 1** RHA EDX spectrum

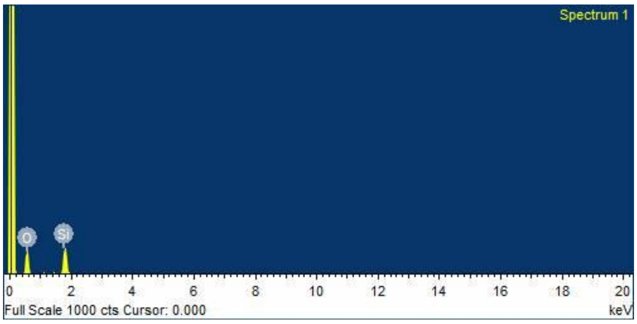


**Figure 2** RHA EDX spectrum

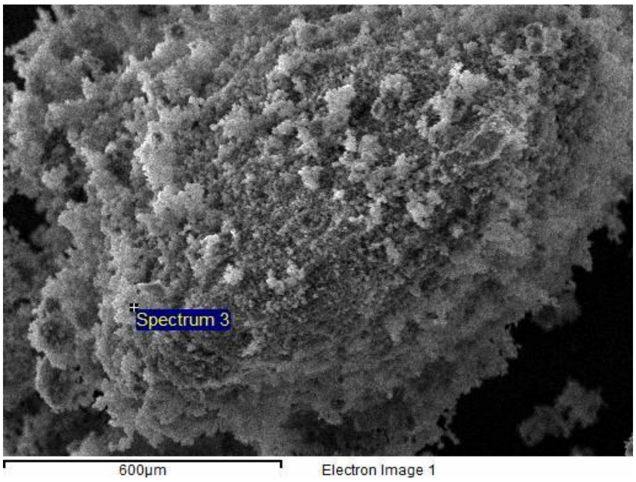


**Figure 3** RHA EDX spectrum on iteration

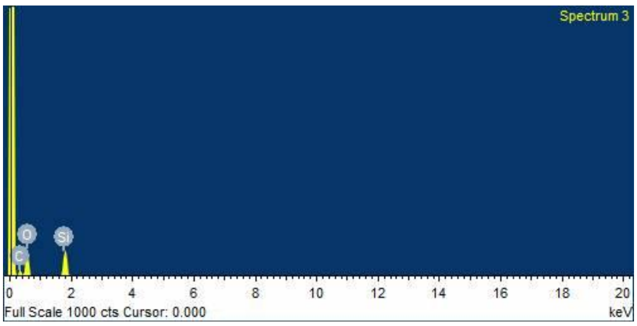


**Figure 4** RHA EDX spectrum on iteration

**Table-2** Average elemental composition of RHA on thirteen iterations

| | |
|---|---|
| O | 71.016 |
| Si | 27.007 |
| C | 1.977 |
| N | ------- |
| Fe | ------- |
| Al | -------- |

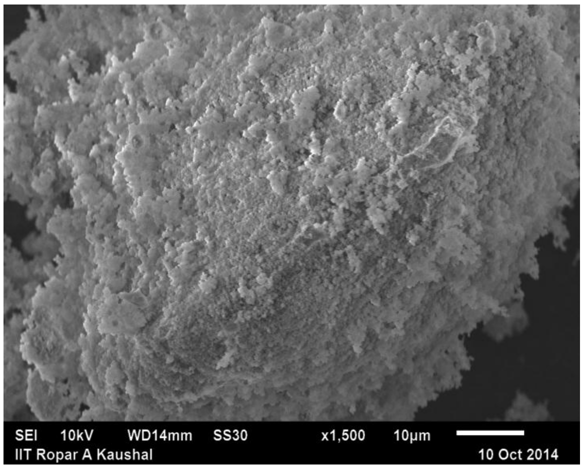


**Figure 5** RHA SEM at x1500

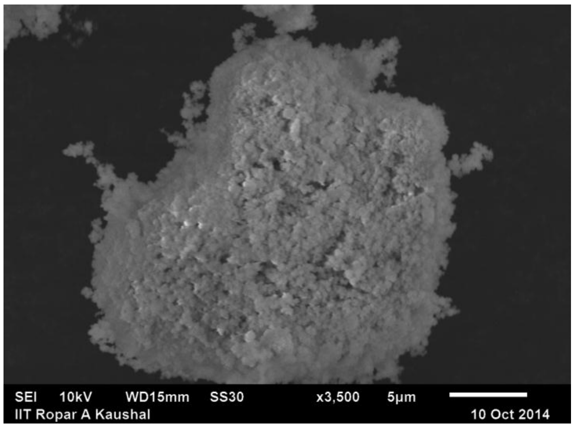


**Figure 6** RHA SEM at x3500

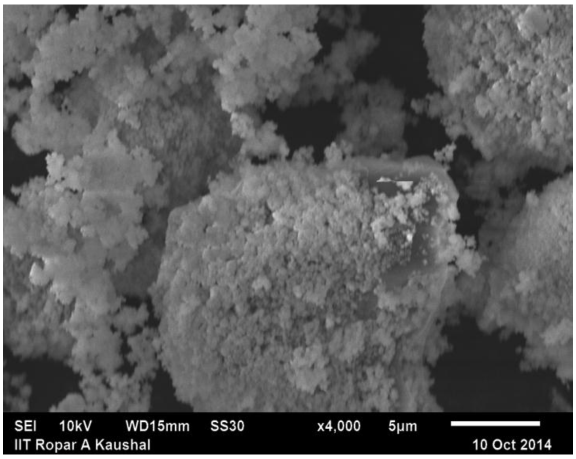


**Figure 7** RHA SEM at x4000

## 3 Specimen Preparations

Firstly the crucible made of graphite was heated up, then aluminum-bronze ingots were charged in. at pasty condition of aluminum-bronze (around 650°C-750°C) albral casting flux was sprinkled over the pasty metal. Albral was added around .5% to increase the fluidity of aluminum-bronze.

**Figure 8** Furnace

**Figure 9** Preheater


**Figure 10** Prepared specimens

The temperature of furnace raised to 1150°C for melting of aluminum-bronze. With help of steel stirrer molten metal stirred till vortex created and at this stage rice husk ash preheated at 1100°C was reinforced to the molten metal at slower rate. The stirring of molten metal and ash was at rate of around 550 RPM for streamlined dispersion of reinforced particles in matrix metal. The mixture was then poured in preheated mould (1100°C) to facilitate uniform solidification. The mould inner was made coated with graphite to avoid sticking of metal to mould surface. This process was followed for compositions of RHA vol% 3, 6, 9, 12.

## 4. Result and Discussion

### *4.1 Tensile Strength measurement*

Tensile strength test carried at machine UTE 100, Capacity 100 KN, Resolution 0.01 KN, Make- FIE at 'CITCO' of as-cast samples and Tensile strength of different sample compositions given against them in Table-3.

**Table-3** Tensile strength results of different compositions

| Sample Number | Composition | Tensile Strength ($KN/mm^2$) |
|---|---|---|
| Sample 1 | AB1 100%+RHA0% | 0.212 |
| Sample 2 | AB1 97%+RHA3% | 0.223 |
| Sample 3 | AB1 94%+RHA6% | 0.231 |
| Sample 4 | AB1 91%+RHA9% | 0.208 |
| Sample 5 | AB1 88%+RHA12% | 0.199 |

### *4.2 Hardness measurement*

Hardness of as-cast samples tested on Vicker hardness tester, Make- FIE at 'CITCO'. Table-4 shows hardness values of different sample compositions.

**Table-4** Hardness values

| Sample Number | Composition | Hardness (HV) |
|---|---|---|
| Sample 1 | AB1 100%+RHA0% | 129 |
| Sample 2 | AB1 97%+RHA3% | 134 |
| Sample 3 | AB1 94%+RHA6% | 142 |
| Sample 4 | AB1 91%+RHA9% | 149 |
| Sample 5 | AB1 88%+RHA12% | 155 |

## Conclusion

1 Rice husk ash reinforced aluminum-bronze AB-1 composite with RHA volume% 3, 6, 9, 12 fabricated by use of stir casting method.
2 Tensile strength increased till 6 volume% RHA reinforcement. The increase in tensile strength is approximately 9% from the unreinforced composite.

3 Hardness values increased linearly with the increase in reinforcement percentage of RHA in aluminum-bronze AB-1.

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