

Evaluation of Wear Behaviour of Al-8011 Alloy Reinforced with Red Mud.

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ABSTRACT: The interacting surfaces in the relative motion of mechanical components will be subjected to the frictional force causing progressive removal of surface material called to wear. Particulate reinforced metal matrix composites are found to exhibit good wear resistance. In this research work, Al-8011/Red mud particulate (RMP) composites were synthesized by the conventional stir casting route. The weight percentage of red mud was varied from 4% to 12% in steps of 4%. Preheated red mud particles were slowly introduced into the vortex of the liquid metal. Optical micrographs of the casting confirm the uniform distribution of red mud particles in the Aluminum matrix. The micro-hardness of the composite was found to increase from 21.3 BHN of the base alloy to 31.1 BHN with 12 wt. % of reinforcement to alloy. Wear studies on the prepared composites at chosen load, speed and time indicate that 12wt. % RMP reinforced composite exhibits maximum wear resistance in comparison to other composites.

KEYWORDS: Red Mud, Stir casting, Graphite, Dry slide wear.

I. INTRODUCTION

There is an increased demand for low-cost materials with excellent tribological performance in aircraft and automobile sector. Aluminum matrix composite has gained much attention to fulfill this demand [2]. The combination of wear-resistant ceramic particles with ductile material has found great applications in the field of tribology [3]. Ceramic reinforced AMC's exhibit considerable wear resistance towards tribological application. Wear resistance of composite material will vary according to the hardness of the reinforcement and percentage of reinforcement used. Al₂O₃, TiB₂, B₄C, TiC, SiC are the most widely used reinforcements because of their good hardness and ease of availability. The ever-increasing demand for low-cost reinforcement stimulated the interest in the utilization of red mud. Red mud is hazardous waste generated in the Bayer process while production of alumina (Al₂O₃) from bauxite ore which contains high levels of toxic heavy metal and residual alkalinity [4]. Since the generation of red mud exceeds 60 million tons annually throughout the world [5] it is quite difficult to store, dispose, and to recycle. Red mud in the dry and wet form will cause many ill effects on human health. In this connection, many researchers have found many possible ways to find the proper application of red mud such as geotechnical material in civil construction, metallurgical applications, low-cost building material-bricks, foundation clay, wastewater treatment, etc. The fabrication procedure like stir casting, powder metallurgy, spray deposition, and others plays a vital role in uniform distribution of reinforcement in the matrix material and also in the improvement of tribological and mechanical properties of the composites. Whether or not wear constitutes failure of these components depends upon whether the wear deleteriously affects the ability of the components to function. In the present research work, stir casting is employed to prepare the composite. Wear behavior of prepared composite is tested in pin-on-disc wear tester as per the ASTM-G99-95 standard.

II. MATERIAL SELECTION

Aluminum-8011 wrought alloy is chosen for the present investigation. The red mud is collected from the Belgaum unit of Hindalco, located in Karnataka, India in the form of granules and ball milled to get the required grain size. The average size of 90 microns of red mud powder is selected. The chemical composition of the matrix is Al 97.3- 98.9%, Fe 0.60 – 1%, Si 0.50 - 0.90%, Mn ≤ 0.20%, Zn ≤ 0.10%, Cu ≤ 0.10%, Ti ≤ 0.08%, Cr ≤ 0.050%, Mg ≤ 0.050 % and

thereinforcement is Al₂O₃-18.34, Fe₂O₃- 45.93, SiO₂- 7.23, TiO₂- 9.56, Na₂O-3.42, CaO-1.0015, LOI- 8.00145 respectively.

III. COMPOSITE PREPARATION

Liquid metallurgy route using a single-stage stir casting process was employed to prepare Al-8011/ RMp composite by varying weight percentage of reinforcement from 4% to 12% with an increment of 4%. The base alloy was melted in electrical resistance furnace and the preheated reinforcement to 400±500C was charged into the melt followed by the manual stirring using Zr coated steel rod for 10 to 12 min to obtain the proper distribution in the matrix material. To improve the wettability of the reinforcement a small amount of magnesium was added to the melt. The composed melt was then poured to the preheated cast iron mold.

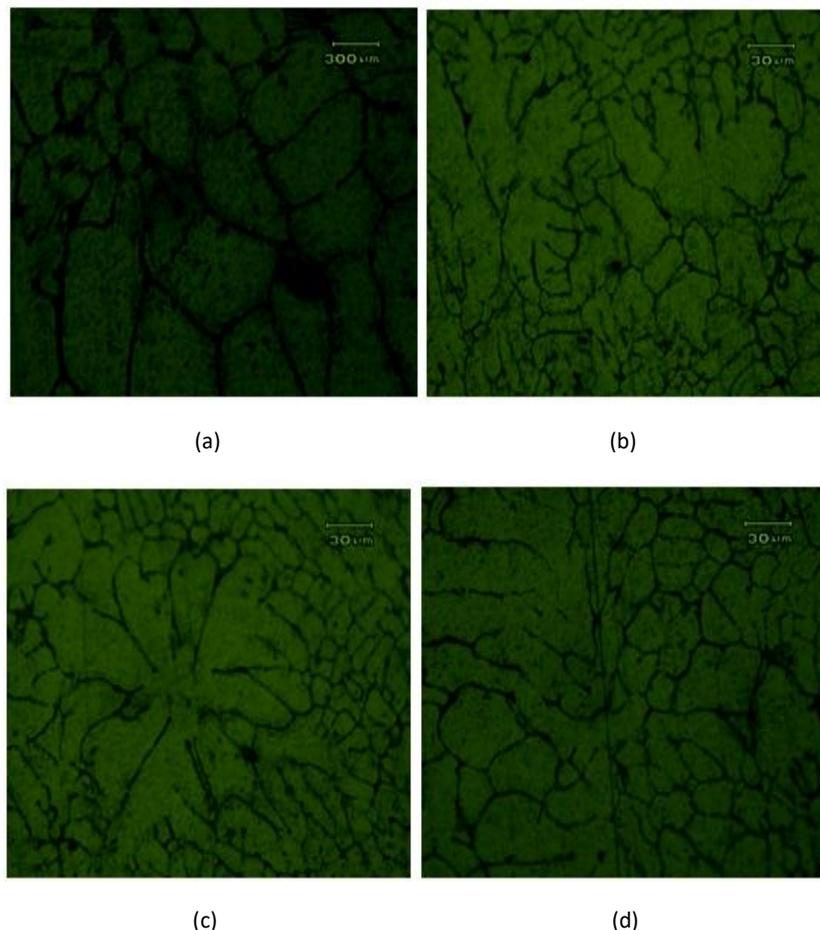


Fig. 1. Optical micrographs (a) Al-8011; (b) Al-4%RMp; (c) Al-8%RMp; (d) Al-12%RMp

IV. CHARACTERIZATION

The specimens were polished as per the metallographic procedure and etched with Keller's reagent (2.5% HNO₃+1.5% HCl+1% Hf+95% H₂O). The microstructure was captured at different locations of the polished specimen using an optical microscope (Olympus Microscope). The hardness of as-cast composite was tested using Brinell hardness tester as

per the ASTM-E10-93 at different locations of the surface and average results is taken and tabulated. Pin-on-disc tribometer with rotating EN-31 steel disc with hardness of 60HRC and surface roughness of 1.6Ra is used for testing the tribological behavior of composite. Speed-100/200/300Rpm, Load-1/1.5/2 Kg, Time-5/10/15min were used as three prime parameters for the dry slide wear test.

V. RESULTS AND DISCUSSION

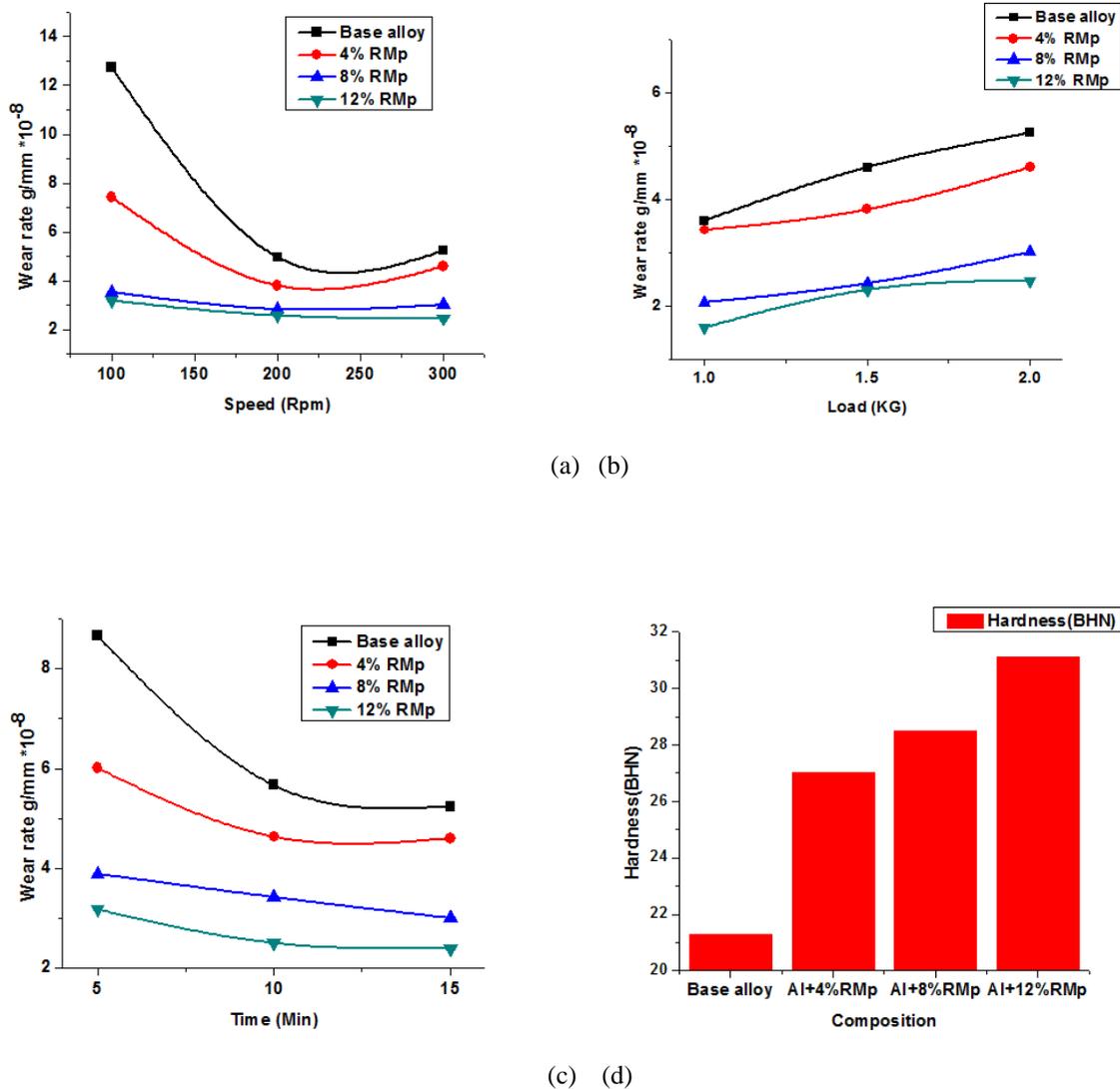


Fig. 2. Wear rate of composites (a) varying speed; (b) varying load; (c) varying time; (d) Hardness value of base alloy and composite.

Figure 1 shows the optical images of base alloy and composite. The higher density of red mud particles compared to Al alloy causes the particle to sink in the melt resulting in uniform distribution. The cluster of the red mud particles found in a certain zone is because of improper mixing. The hardness value of alloy and composite is shown in figure 2(d). It is observed that hardness value increased by 46% with the addition of reinforcement of 12%. The increase in hardness has reflected as an increase in wear resistance of the composites. The wear rate of all composites is presented in figure 2.

The graphs indicate that the wear rate decreases with the addition of reinforcement. It indicates that the wear resistance increases with the increase in red mud particulate addition.

Figure 2 (a) reveals that when the speed of the rotating disc increases the wear rate decreases. Al-8%RMp and Al-12%RMp composite exhibit good wear resistance. Figure 2(b) shows that the wear resistance decreases with an increase in load which is due to high frictional forces. Figure 2(c) shows the variation in wear rate when the contact time is increased. The wear rate of Al-8011 alloy decreases with the increase in time whereas the wear rate of the composites does not show any significant variation.

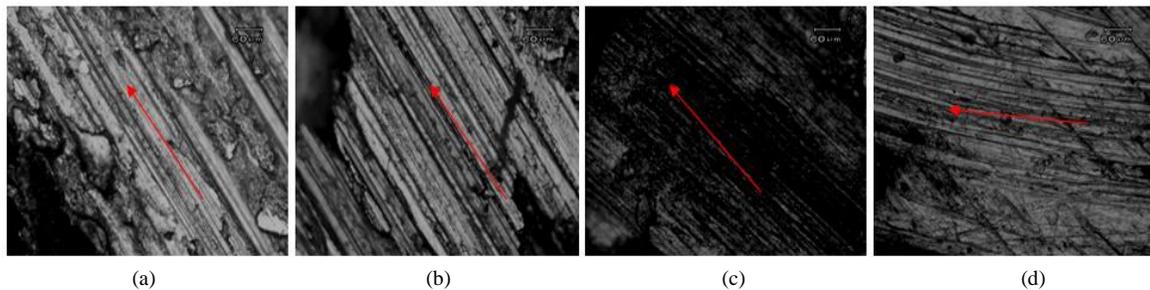


Fig. 3. Worn surface micrographs (a) Al-8011; (b) Al-4%RMp; (c) Al-8%RMp; (d) Al-12%RMp.

Worn surface micrographs in figure 3 show the wear tracks on base alloy and the composite caused by the rubbing action between the hard steel disc and the surface of the specimen. The depth and width of the grooves depend on the testing parameters like load, speed, time, sliding distance, and also the percentage of reinforcements. The mechanism of material removal during sliding motion was observed to be plowing and plastic deformation. The reinforcement particle hardness and the composition were observed to be the reason for the superior wear resistance of the composites.

VI. CONCLUSIONS

From this experimental study the following conclusions are drawn:

The addition of red mud particulates to the alloy can provide good mechanical and tribological properties for many applications. The stir casting procedure adopted for the preparation of the composites leads to the proper and uniform distribution of RMp in the base alloy. Prepared MMC's provide excellent hardness and improvement in the tribological performance. It is observed that the wear resistance increases with the increase in the percentage of reinforcement. Further, it is noticed that the wear rate slightly increases as the load increases.

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