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Experimental Investigation and Analysis of Wear Characteristics of Aluminium A6061 Reinforced with Red Mud

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Abstract: Red mud emerges as the major waste material during production of alumina from bauxite by the Bayer's process. It comprises of oxides of iron, titanium, Aluminium and silica along with some other minor constituents. Based on economics as well as environmental related issues, enormous efforts have been directed worldwide towards red mud management issues i.e. of utilization, storage and disposal.

Different avenues of red mud utilization are more or less known but none of them have so far proved to be economically viable or commercially feasible.

It is generally agreed that resistance to wear of MMCs is created by reinforcement and also the wear properties are improved remarkably by introducing hard Inter metallic compound into the Aluminium matrix. The reinforcing materials are generally SiC, Al2O3, TiB2 etc and are costly.

The present research work has been undertaken with an objective to explore the use of red mud as a reinforcing material as a low-cost option. This is due to the fact that red mud alone contains all these reinforcement elements and is plentifully available.

This work describes Fabrication of composites by different weight percentages (5%,10%,15%) of Red mud reinforced with Aluminium AA6061.

Experiments have been conducted under laboratory condition to assess the wear characteristics of the aluminium red mud composite under different working conditions in pure sliding mode on a pin-on-disc machine.

Keywords: Composite, Aluminium, Red mud, Wear rate, Specific wear rate, Volumetric wear rate, Coefficient of friction.

I. INTRODUCTION

History is often marked by the materials and technology that reflect human capability and understanding. Many times scales begins with the stone age, which led to the Bronze, Iron, Steel, Aluminium and Alloy ages as improvements in refining, smelting took place and science made all these possible to move towards finding more advance materials possible.

A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale. Generally, a composite is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics).

When designed properly, the new combined material exhibits better strength than would each individual material. As defined by Jartiz[3] Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form. Kelly very clearly stresses that the composites should not be regarded simple as a combination of two materials.

In the broader significance; the combination has its own distinctive properties. In terms of strength or resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Many types of classifications of composites are there depending upon type of Matrix material and Reinforcement, Here Aluminium metal matrix composite is taken with Red mud reinforcement.

II. MATERIALS AND METHODS

Aluminium AA6061(Si:08%, Fe:0.15%, Ti:0.001%, V:0.007%, Cu:0.001%, Mn:0.003, Al:99.76%) was bought from Balanagar, Hyderabad, Telangana, India. Red mud is obtained from a private retail shop in Hyderabad. Specimens were fabricated by using Stirr casting method by using the cylindrical and circular dies with appropriate size for testing.

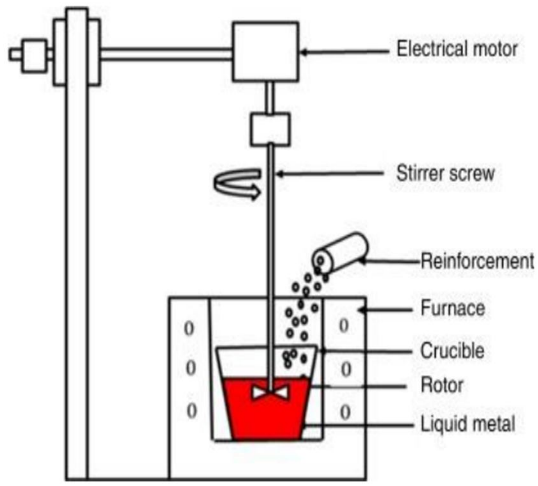

Fig 2.1Stirr casting equipment

A. Mechanical Testing

Physical tests were conducted for Yield strength, ultimate strength and Hardness. The values obtained were listed below:

Specimen	Yield Stress (Mpa)	Ultimate Stress (Mpa)	Modulus of Elasticity (Gpa)	Percentage Elongation	Hardness (VHN)
Pure Al	24.3	66	73	25	40.7
95% Al + 5% Red mud	23.82	6.1	29.7	8.7	40.7
90% Al+ 10% Red mud	23.47	6.75	34.9.	9.25	52.78
85%Al+ 15% Red mud	25.83	5.88	41.0	14.17	56.33

B. Wear Testing

Wear tests were conducted for pure aluminium and aluminium with red mud (different weight percentages) at different rpms and different loading conditions. Plots are drawn for wear rate, specific wear rate and volumetric wear rate using the obtained data.

2.2 Pin on Disc wear testing

C. Wear Testing for Heat Treated Composites

The specimens with 15% red mud were taken because of their sudden increase in wear rate. This composition is taken as optimum weight percentage. These specimens were heat treated and tested for wear characteristic. Different heat treatment temperatures were taken at different loads using different quenching media (Air, Water with oil) at 200 rpm of pin-on disc test equipment. Different plots are drawn for wear rate, specific wear rate, volumetric wear rate and coefficient of friction.

III. ANALYSIS OF WEAR CHARACTERISTICS USING ARTIFICIAL NEURAL NETWORKS

An artificial neural network is a parallel distributed information processing system. ANN (Artificial Neural Network) is developed in the model of human brain. Many types of networks are there. An artificial neuron can carry out a simple mathematical operation and or can compare two values. The path connecting two neurons is associated with a certain variable weight which represents the synaptic strength of the connection. The input to a neuron from another neuron is obtained by multiplying the output of the connected neuron by the synaptic strength of the connection between them. The artificial neuron then sums up all the weighted inputs coming to it.

Each neuron is associated with a threshold value and a squashing function. The squashing function is used to compare the weighted sum of inputs and the threshold value of that neuron. If the threshold value is exceeded by the weighted sum the neuron goes to a higher state, i.e. the output of the neuron becomes high. Different squashing functions are used in different applications. In the present work a back-propagation learning algorithm has been used. Feed forward neural network is used for this analysis.

From the original process data two neural networks were tested with twenty-seven data sets. Different process parameters were used for this analysis. Neural network-1 was used for air & water-cooled samples whereas network II was used for water with oil cooled at 25°C respectively. Each data set contained inputs such as normal load, sliding distance, heat treated temperatures and an output values (wear rate, volumetric wear rate and specific wear rate) were returned by the prediction neural network.

In this work, a neural network is designed to predict the volumetric, specific, and wear rate of the particle reinforced aluminium matrix composite according to given volume percent of red mud particles. This study has shown the capability of ANN to predict the wear properties of aluminium red mud composite. It can be concluded that ANN is a good analytical tool that has potential used in the field of tribology if properly used. The well-trained neural network provides more useful data from relatively small experimental data base and also can be used to know the results of the critical and large operating conditions.

IV. RESULTS AND DISCUSSION

A. Results Of Specimens Without Heat Treatment

From the plots it is clear that at pure Aluminium the wear rate is maximum for all the speeds. But after that the wear rate is low to increase for different percentage of Red mud and at last it is reduced.

The specific wear rate decreases with increase in filler volume fraction and after attaining a minimum value within 10-15%it again increases. Thus there exists an optimum filler volume fraction, which gives maximum wear resistance to the composite.

The specific wear rate of the composite increases with increase in sliding velocity. From the figure it is also clear that rate of increase of wear rate is initially high and decreases as the load increases. For 15% volume of red mud this is somewhat deviating in all cases i.e. the wear rate increases to a very high value in comparison to other.

B. Results Of Specimens With Heat Treatment

Table 4.1 Physical test of specimens with heat treatment

Heat treated temperature(°c)	Air cooling hardness (VHN)	Water With oil quenching hardness (VHN)
350	60.13	62
400	71.9	74.1
500	82.3	78.02

It is observed that the specific wear rate first increases and then almost remains same for the entire test period for all cases.

The composite at some loads showing increase in the value of coefficient of friction and there is a decrease in the value of coefficient of friction for some other cases. But almost remains constant throughout the experiment.

Table 4.2 Comparison of wear rate with air cooling and water cooling at 400 temperature with load of 10N

	Air cooling	Temperature	Load (N)	Water+oil cooling	Temperature	Load(N)
Wear rate	0.0396	400°c	10	0.0338	400°c	10
Volumetric wear rate	1.6734	400°c	10	1.3271	400°c	10
Specific wear rate	1.357	400°c	10	0.9031	400°c	10

V. CONCLUSIONS

A. It is concluded that coefficient of friction decreases.

B. At higher speed specific wear rate decreases with increase in Red mud content

C. Wear resistance of the composite increase due to addition of red mud particles. However there exists an optimum filler volume fraction which gives maximum wear of the Aluminium Re mud composite.

D. The conclusions of heat treatment drawn from the present investigation are as follows:

E. Red mud, the waste generated from alumina plant can be successfully used as a material to produce Metal-Matrix Composite (MMC) component in aluminium matrix to be used in wear. It can be successfully used in place of conventional aluminium intensive material, there by a saving of about 15percent matrix material could be achieved.

F. There is good dispersibility of red mud particles in aluminium matrix which improves the hardness of the matrix material and also the wear behaviour of the composite. The effect is increase in interfacial area between the matrix material and the red mud particles leading to increase in strength appreciably.

G. The specific wear rate of the composite decreases with addition of filler volume fraction, and after attaining a minimum value (10-15%) it again increases. Thus, there exists an optimum filler volume fraction which gives maximum wear resistance to the composite.

H. The results indicate that quenching of heat-treated samples in water gives better wear resistance than that achieved by air cooling. This is due to higher cooling rates attained in 65 water with oil quenching which induces more strain in the samples when compared to those induced by air cooling.

I. The heat treatment temperatures concerned are low. So, the occurrence of chemical reaction between the phases present is approximately nil. However, there is the chance of mutual dissolution among the phases present and the phases formed to increase the wear resistance by heat treatment.

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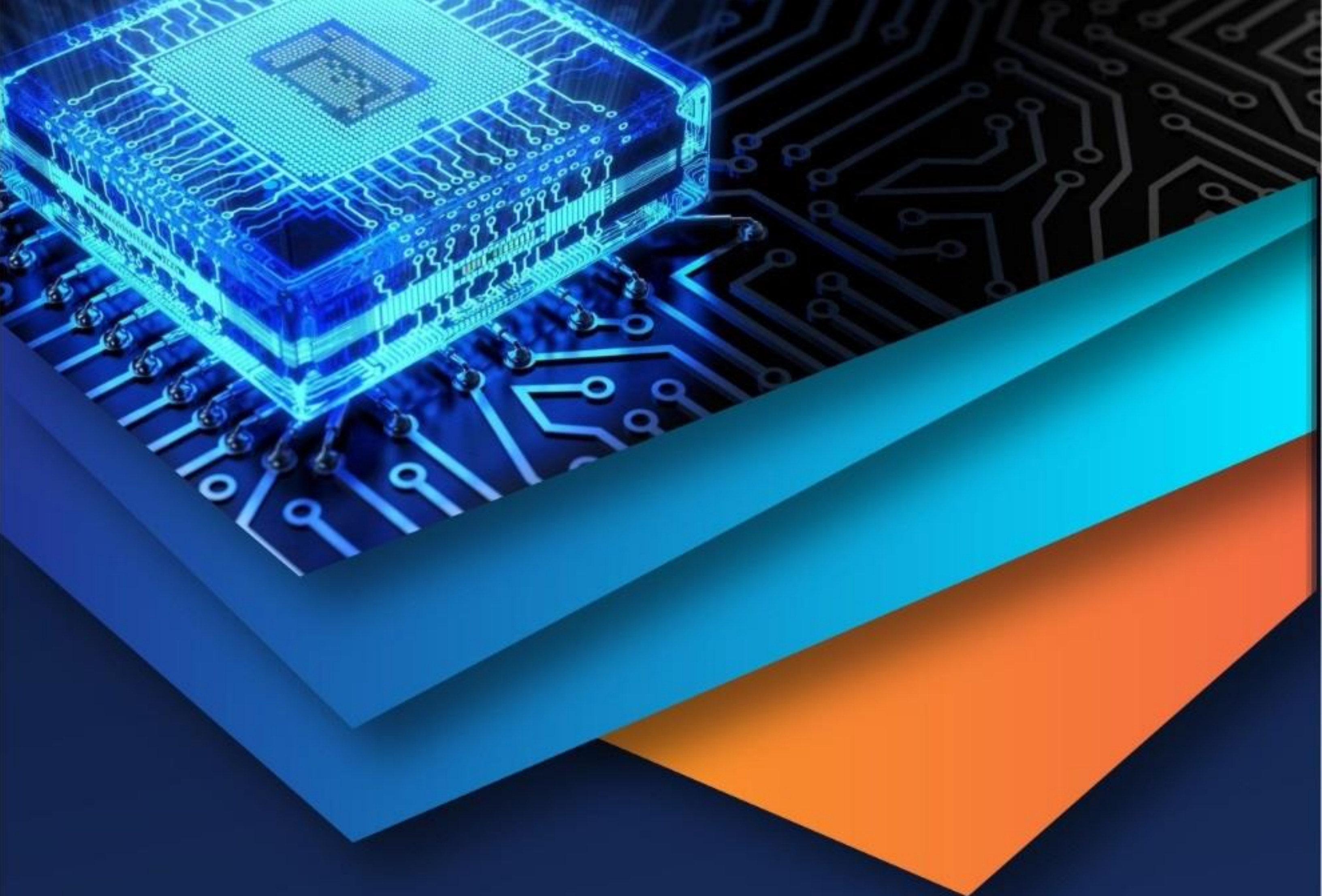

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