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Corrosion Characterization of Aluminium 6061 / Red Mud Metal Matrix Composites in Sea Water

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Abstract: *The present investigation aims to evaluate the corrosion properties of red mud particulate reinforced aluminium 6061 metal matrix composites. Red mud particulates reinforced varying from two to six percent by weight in steps of two percent under dry conditions. Composites are prepared by liquid melt metallurgy techniques using vortex method. Castings are cut, turned and shaped into the required size to prepare the specimens for evaluation of the corrosion properties. Corrosion tests were conducted at room temperature (23^0 C) using conventional weight loss method according to ASTM G69-80. The corrodent used for the tests was Arabian Sea water collected from Malpe beach, Udupi District, Karnataka. Weighed specimens dipped in sea water. Specimens were taken out at every 24 hours interval up to 96 hours. Four specimens for each condition and time were immersed corrodent solutions. In all 16 specimens of matrix and composites were immersed in corrodent. Corrosion rates were calculated using the formula 534DAT/W. In each case the corrosion rate in sea water decreases with increase in exposure time for matrix and metal matrix composites due to passivation induced by aluminium.*

Keywords: *Vortex, Al6061, Zircon, Passivation*

1. Introduction

Metal Matrix Composites (MMCs) are being extensively used in automotive, aerospace and mining engineering, etc. as they are reported to possess high strength–to-weight ratio at elevated temperatures, improved shock-resistance properties, relatively higher wear resistance, toughness, etc.[1] Corrosion can affect the metal matrix composite in a variety of ways which depend on its nature and the environmental conditions prevailing. Studying corrosion resistance of Al-based materials is important especially for automotive and aircraft applications where the parts are prone to corrosive media like salt water solutions, acidic and alkaline media. The major advantages of AMMCs compared to unreinforced materials are as follows: greater strength, improved stiffness, reduced density, good corrosion resistance, improved high temperature properties, controlled thermal expansion coefficient, thermal/heat management, improved wear resistance and improved damping capabilities.[2] Aluminum and its alloys show corrosion resistance in almost all corrosive mediums due to passivation. Therefore, studying the corrosion behavior of aluminum alloys and their composites in the sea water medium is of prime importance. Sea water is highly alkaline containing more than forty percent of dissolved salts. Extensive literature survey reveal that many researchers have worked on corrosion characteristics of particulate reinforced metal matrix composites but no concrete investigation has been made on red mud particulate reinforced with aluminum alloy 6061 metal matrix composites. The present work deals with corrosion characterization of Alluminium 6061 reinforced with red mud particulates metal matrix composites.

2. Experimental Procedure

2.1. Material Selection

In the present study the matrix alloy used is Al6061, which exhibits excellent casting properties and reasonable strength. The chemical compositions of the Al6061 alloy are given in Table I.

TableI. *Chemical Composition of Al6061alloy*

Mg	Si	Fe	CU	Ti	Pb	Zn	Mn	Sn	Ni	Al
0.8-1.5	10-12	1	0.7-1.5	0.2	0.1	0.5	0.5	0.1	1.5	Bal

The reinforcement used is red mud particulates. Red mud is a waste obtained after the removal of aluminium from its ore. Its EDS analysis reveals the presence of oxides of iron, silicon, titanium, zirconium etc. it behaves as a ceramic material. It is obtained from HINDALCO, Renikoot district, UP. 50-80 μm size particulates of red mud are used in this study.

The corrosion medium used to characterize the composites is Arabian Sea Water, collected from malpe Beach, Udupi District, Karnataka.

2.2. Preparation of Composites

The liquid metallurgy route using vortex technique used by Krupakara et al[3] is employed to prepare the composites. A mechanical stirrer was used to create the vortex. The weight percentage of red mud used was 2-6 in steps 2%. Red mud is added in to molten Aluminium 6061 alloy melt by creating a vortex in the melt using a mechanical stainless steel stirrer coated with aluminite (to prevent migration of ferrous ions from the stirrer material to the zinc alloy). The stirrer was rotated at a speed of 450 rpm in order to create the necessary vortex. The red mud particles were pre heated to 400°C and added in to the vortex of liquid melt at a rate of 100 g/m. The composite melt was thoroughly stirred and subsequently degassed by adding degasifying tablets made up of hexa chloro ethane to the melt. Castings were produced in permanent moulds in the form of cylindrical rods. [Diameter 30mm and length 150mm] The material was cut into 20x20mm pieces using an abrasive cutting wheel. The matrix alloy was also casted under identical conditions for comparison

2.3. Specimen Preparation

The samples were successively ground using 240, 320, 400 and 600 SiC paper and were polished according to standard metallographic techniques and dipped in acetone and dried. The samples are subjected to microstructural studies by scanning electron microscope. The samples were weighed to fourth decimal place using electronic balance and the specimen dimensions were noted down using Vernier gauge.

2.4. Corrosion Test

The corrosion behaviour of Aluminium 6061 alloy was studied by immersion test. The Samples were suspended in the 200 cm^3 of sea water for different time intervals up to 96 hours in steps of 24 hours. After the specified time the samples were cleaned mechanically by using a brush in order to remove the heavy corrosion deposits on the surface washed with distilled water and acetone. Then air dried. The corresponding changes in the weights were noted. Corrosion rates were computed using the equation Corrosion rate = 534 W/DAT mpy.[4] Where W is the weight loss in gm, D is density of the specimen in gm/cc, A is the area of the specimen ($inch^2$) and T is the exposure time in hours.

3. RESULTS AND DISCUSSION

3.1. EDAX Analysis of Red Mud

Figure 1 shows the energy dispersive X-ray spectroscopic analysis of red mud. It shows that red mud contains oxides of iron, aluminium, titanium, calcium, zirconium, sodium, vanadium etc.

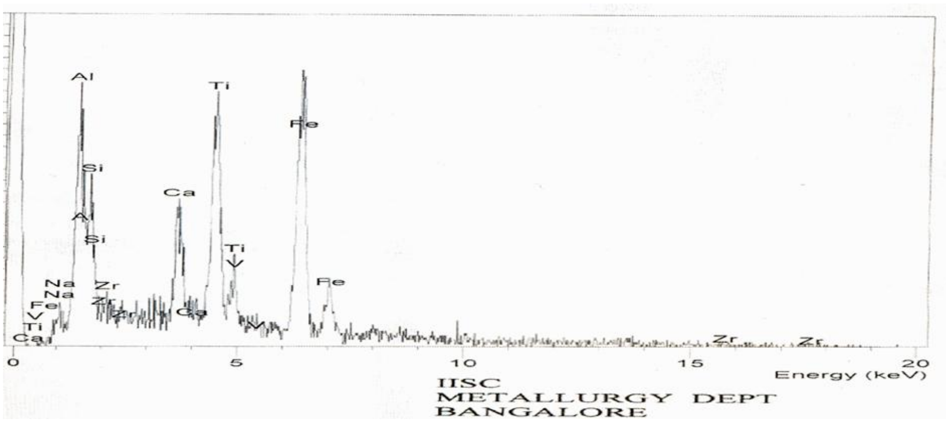

Figure1. *EDAX analysis spectrum of red mud particulates*

Microstructures of alloy and composites

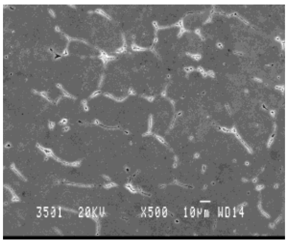

Fig2. *SEM of alloy*

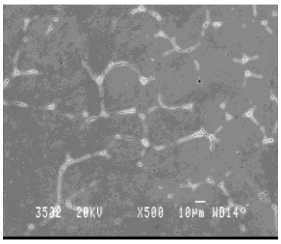

Fig3. *SEM of 2% MMC*

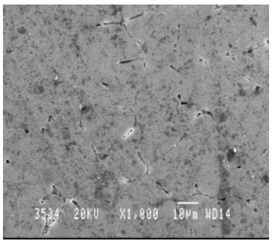

Fig4. *SEM of 4% MMC*

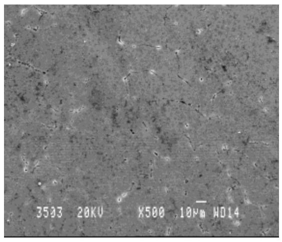

Fig5. *SEM of 6% MMC*

Figures 2 to 5 show the microstructures of aluminium 6061 alloy and its red mud composites taken using scanning electron microscope. Uniform distribution of red mud particulates is observed in composites.

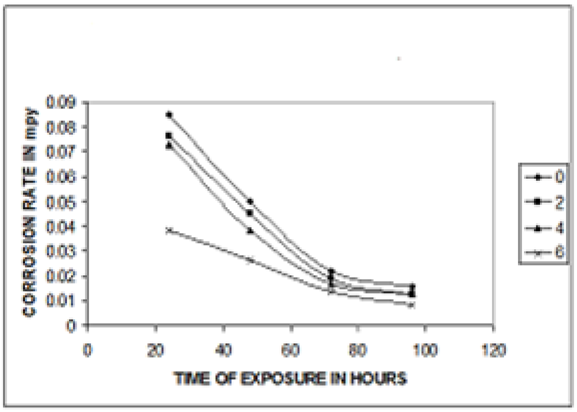

Fig6. *Weight loss corrosion in Sea water*

Figure 6 shows the results obtained for the static eight loss corrosion of Aluminium 6061 / Red mud composites in comparison with matrix alloy for the exposure time from 24 hours to 96 hours.

3.2. Effect of Test Duration

The corrosion rate measurement as a function of exposure time in the static immersion test is shown in figure 6. The trend shows decrease in corrosion with increase in test duration. It is clear from the graph that the resistance of the composite to corrosion increases as the exposure time increases. The gradually decreasing corrosion rate indicates the possible passivation of the matrix alloy.

3.3. Effect of Red Mud Content

From figure 6 it can be clearly seen that for both as cast and composite, corrosion rate decreases monotonically with increase in red mud content. The weight loss in case of unreinforced alloy is higher than in the case of composites. Red mud being a ceramic remains inert and is hardly affected by sea water during the test and is not expected to affect the corrosion of the composite. The results indicate an improvement in corrosion resistance as the percentage of red mud particulates increased in the composite, which shows that the red mud particulates directly or indirectly influence the corrosion property of the composites. This is also due to decrease in porosity of composites.[5] A particulate acts as physical barrier to the initiation and development of corrosion pits and also modifies the microstructure of the matrix material and hence reduces the rate of corrosion. Various researchers[6-7] found that MMCs show decreased susceptibility to pitting attack when compared to non-reinforced alloys voids at the matrix/reinforcement interface. In particulate reinforced composites, increasing reinforcement volume could result in the decreases. S.R.Arun (188) obtained similar results in short glass fiber reinforced 6061aluminium alloy composites, and observed that the corrosion resistance increased with increase in reinforcement content. Better corrosion resistance of the MMCs is probably due to the reinforcement network interfering with the reaction between the acid and the metallic matrix (153).

4. CONCLUSION

The red mud content in aluminium 6061 alloy plays a significant role in the corrosion resistance of the material. Increase in the percentage of red mud will be advantageous to reduce the density and increase in the strength of the alloy and the corrosion resistance is significantly increased. Aluminium 6061 MMCs reinforced with red mud particulates of weight percentage from 0 to 6 percent could be successfully produced by liquid melt metallurgy technique. The rate of corrosion of both the alloy and composite decreased with increase in time duration in Sea water. The corrosion rate of the composites was lower than that of the corresponding matrix alloy in Sea water. The Composite materials are more suitable in marine environments than matrix alloy.

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