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Weight Loss Corrosion Studies of Al6061 / Quartz Metal Matrix Composites in Sea Water

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Abstract:
This paper deals with the corrosion characterization of Al6061- quartz particulate metal matrix composites (MMCs). Al6061 alloy is used as matrix. Commercially available alloy is used. Quartz is the wastage obtained after the removal of aluminium from its ore and contains silica, alumina, titanium dioxide and ferric oxide. Being ceramic material quartz remains inert and is hardly affected by the corrosion medium. Quartz particles of size 50-80 microns are used as reinforcement. Experiments were conducted to determine the corrosion rate of the samples in sea water procured from Arabian Sea in Malpe, Udupi District, Karnataka. MMC's are prepared according to ASTM standards by liquid melt metallurgy technique using vortex method. Composites containing 2, 4, 6% by weight of Quartz and unreinforced matrix were tested using Arabian sea water at room temperature. Specimens are taken in the form of 20mm x 20mm cylinders. They were exposed to sea water for different intervals of time. Corrosion rates of all samples were calculated using the formula 534W/DAT mpy. The results were computerised and simulation curves were obtained. The composite was found to be more corrosive resistant than matrix alloy. In each test the corrosion resistance of both alloy composites was found to decrease with the exposure time. The decrease in the corrosion rates of composites when compared to that of matrix alloy is due to the physical barrier created by Quartz particles.

Key words: *Composites, vortex, particulates, red mud*

1. Introduction

Metal matrix composites (MMCs) offer designers many added benefits as they are particularly suited for applications requiring good strength at high temperature, good structural rigidity, dimensional stability and light weight.[1-5] The trend is towards safe usage of the MMC parts in the automobile engines, which works particularly at high temperature and pressure environments.[6-7] Particles reinforced MMCs has been the most popular over the last three decades. Among the MMCs ceramic reinforces aluminium MMCs have most popular families. Although incorporation of the second phase into matrix material can enhance the physical and mechanical properties of the base metal, it could also significantly change the corrosion behaviour.

Particle reinforced aluminium MMCs find potential application in several thermal, environmental, automobile engines especially drive shafts, cylinders, pistons and break rotors. MMCs used at high temperature should have good mechanical properties and resistance to chemical degradation [8] in air and acidic environments. For high temperature applications it is essential to have a thorough understanding of the corrosion behviour of the aluminium composites. Some published data[9-11] indicate that the addition of SiC particulate do not appear to affect corrosion substantially on some aluminium alloys because, pits were found to be more numerous on the composite, although they were comparatively smaller and shallower than those on reinforced alloy. Gonzalez et. al [12] have reported that the SiC particles do not give rise to significant galvanic corrosion and no active phases are formed at the matrix/particle interphase.

The objective of the present investigation is to develop simplified methodology and approach to study the weight loss corrosion behaviour of aluminium 6061 alloy reinforced with quartz particulates at room temperature using sea water as corrosion medium. The microstructure of the MMCs before and after corrosion and EDAX studies of Al6061 were conducted

2. Experimental procedure

2.1. Material Selection

The matrix alloy selected is Al6061and its composition is given in Table1

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

Table 1: Composition of Al6061

Quartz is used as reinforcement in the form of particulates. It has got a layered structure. It has a specific gravity of 2.55, with hardness of 6.0 on the Mohr's scale.
The testing corroding medium selected is 0.035, 0.35 and 3.5% solutions of sodium chloride.
The corrosion medium is sea water procured from Arabian Sea from the Malpe beach in Udupi district of Karnataka.

2.2. Composite Preparation

The MMCs are prepared by liquid melt metallurgy technique using vortex method.[13] Matrix alloy is heated to its liquidus temperature and a mechanical impeller coated with alumina is dipped and a vortex is created. Alumina coating on impeller is necessary in order to prevent the migration of ferrous ions from the impeller into the melt. Pre heated but uncoated quartz particles are added in to the melt. The melt is thoroughly stirred and degasified by adding degasifying tablets made up of hexachloro ethylene and poured into pre heated split type moulds.[14] Composites containing 2, 4 and 6% of quartz are prepared.

2.3. Specimen Preparation

The cylindrical bar castings of matrix alloy and composites are made and cut in to 20 x 20 mm size cylindrical specimens by standard metallographic techniques. The specimens are finely ground with silicon carbide paper 1000 grit and washed with water and acetone, then dried and weighed using electronic balance up to fourth decimal place. The specimens for microstructure studies before corrosion are finely polished in steps of 1.5 to 3 μm with diamond paste to obtain fine surface finish

2.4. Corrosion Studies

Weight loss corrosion studies are conducted for the specimens prepared as mentioned above in the sea water collected from Arabian Sea at room temperature using conventional weight loss method according to ASTM 69-80. The tests are conducted up to 96 hours in steps of 24 hours. [13] Sixteen numbers of 250cm^3 glass beakers are taken all are filled with 200cm^3 of sea water. The dimension like diameter and height of the specimens are measured with respect to vernier gauze and after weighing the samples they are immersed in sea water and taken out at twenty four hours of intervals up to 96 hours. The specimens after stipulated hours of exposure to corrosion medium are taken out, dipped in Clarke's solution and gently rubbed with a brush to remove the corrosion product, washed with distilled water and acetone then air dried. Weight of the corroded specimens was determined, weight loss is calculated and the corrosion rate is expressed in mpy. [15.]

3. Results and Discussion

3.1. Microscopy

Microstructure of as cast matrix and 6% red mud reinforced composite are shown in the figures 1 and 2 respectively. The polished specimens of the both mentioned above are etched with Keller's reagent and microstructures are taken. The microstructure of the composite demonstrates uniform distribution of the reinforcement with good bonding between matrix alloy and reinforcement.

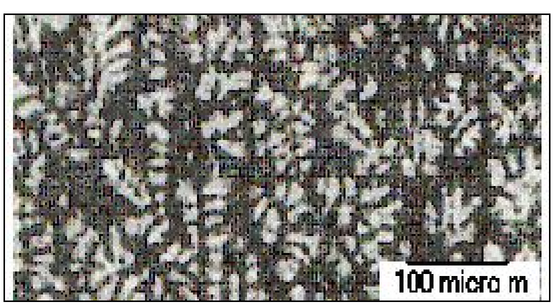

Figure 1: Microstructure of matrix

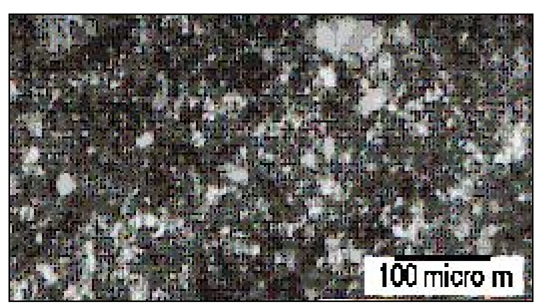

Figure 2: Microstructure of 6%Composite

3.2. Corrosion Test Result

Figure 3 shows the weight loss corrosion rate of matrix and composite in sea water. The corrosion rate decreases with increase in exposure time irrespective of matrix and percentage of reinforcement. The corrosion rate also decreases monotonically with increase in the reinforcement content.

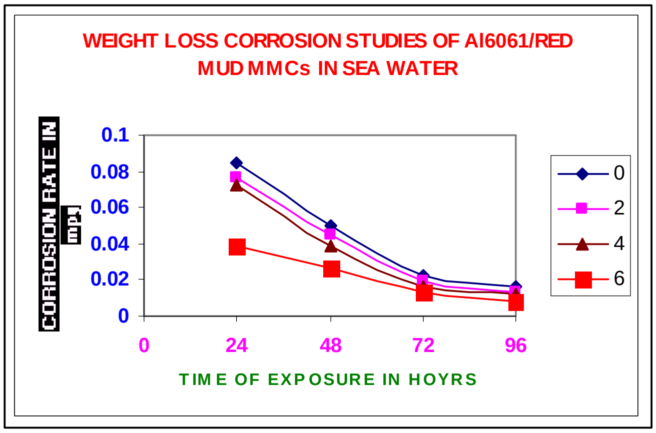

Figure 3: Weight loss corrosion in sea water

3.3. Corrosion Morphology

Figures 4, 5 and 6 are the SEM micrographs of Matrix,4% and ^ % composite. Virtual examination of the specimens after the corrosion experiment showed few deep pits, flakes and cracks formed on the unreinforced matrix alloy and the cracks are perpendicular to the axis of matrix specimen.

Whereas more wide spread superficial pitting was observed and a few are no cracks were seen on the surface of the reinforced composites. The formation of pits and cracks on the surfaces of the composites decrease with increase in the content of the reinforcement in the composite.

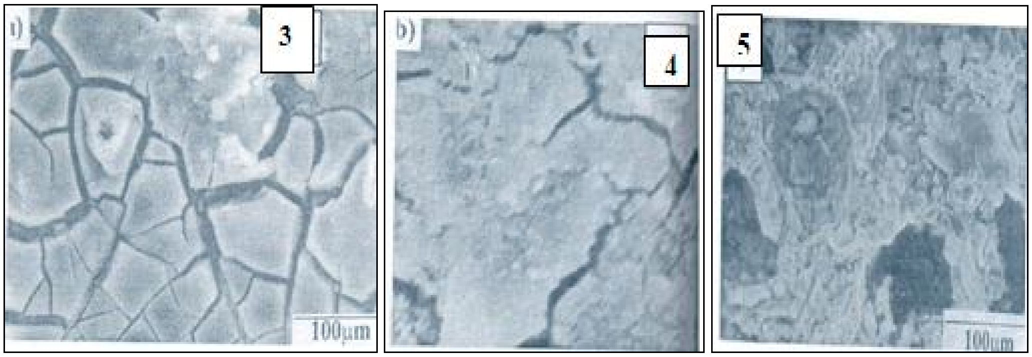

Figure 4: SEM micrographs showing corroded matrix 4%MMC
Figure 5: SEM micrographs showing corroded 6% MMC
Figure 6: SEM micrographs Showing corroded

4. Discussion

The corrosion product formed and settled on the surface of the composites was removed carefully and subjected to analysis and found to be made up of aluminium oxide formed due to reaction of the matrix with sea water. The phenomenon of the gradually decreasing corrosion rate is probably due to non porous oxide layer of the aluminium. [16-17]

Quartz particles are inert and not expected to affect the coercion mechanism of the composite. The results indicate that the corrosion rate decreases with the increase in the percentage of reinforcement quartz. This shows that the corrosion rate is directly or indirectly influences the corrosion property of the composites. Many researchers have obtained the similar results when a matrix alloy is reinforced with ceramic particulates. [18]

Wu.Jinaxin et.al.[19] in their work related to aluminium reinforced with SiC particles state that the particulates reinforced definitely play a secondary role as physical barrier as for as the corrosion characterization is concerned. A particle acts as relatively physical barrier to the initiation and development of corrosion pits and also modifies the microstructure of the matrix material and hence reduces corrosion rate. Rodrigues[20] in his work states that interphsae between the base matrix and the reinforcement is the weakest part of the particulate or fiber reinforced composite. Hence, the nature of the bond, whether weak or strong is critical in the corrosion process.

5. Conclusion

- Metal matrix composites Al6061 / quartz composites are prepared by liquid melt metallurgy technique using vortex method.
- MMCs are subjected to weight loss corrosion test in sea water.
- The corrosion rate of composites decrease win increase in exposure time.
- The corrosion rate of composites decrease with increase in percentage of reinforcement.
- The extent of corrosion damage decreased with increasing reinforcement which may be due to increase in bonding strength.
- Material loss from corrosion was significantly high in matrix alloy with respect to metal matrix composites.

6. References

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