Corrosion Studies of Aluminium 356 Hybrid Metal Matrix Composites in Acid Chloride Medium

Kusuma S[1], V.Bheemaraju[2], P.V.Krupakara[3]
[1]Research Scholar, Dr.Ambedkar Institute of Technology, Bangalore, chenduss123@gmail.com
[2]Professor, Department of Chemistry, RNS Institute of Technology, Bangalore
[3] Professor and Head, Department of Chemistry, Adarsha Institute of Technology, Bangalore

Abstract:

Hybrid composites are recently being in detail due to their applications in automobile and aircraft industries. They exhibit improved mechanical and physical properties whencompared to matrix alloy. Normally hybrid composites contain a matrix made up of metal or alloy and two different reinforcements. In this work hybrid composites containing Aluminium 356 as matrix and two different reinforcements viz., silicon carbide and fly ash particulates are manufactured by liquid melt metallurgy technique using vortex method. Three types of hybrid composites containing constant fly ash content and different amounts of silicon carbide particulates are manufactured. Matrix alloy was also casted in the same way for comparison. Static weight loss corrosion tests were carried out in different concentrations of acid chlorides like hydrochloric acid. The corrosion rate results reveal that the hybrid composites show increased corrosion resistance when compared to matrix alloy. Hence hybrid composites are more suitable for applications.

Key words: Hybrid, silicon carbide, fly ash, weight loss

1. Introduction

Al and Al alloys became attractive candidate for the application in aerospace, defence and automotive industries owing to their versatile properties. A major requirement for such applications is the high strength along with reasonable ductility. There has been a constant effort to enhance the mechanical properties of Al alloys by alloying additions, heat treatment, thermo-mechanical processing, severe plastic deformation (SPD) and so on. However, these methods have their own limitations which are difficult to overcome[1]. In the race for production of MMCs, aluminium metal matrix composites (AMMCs) receivedparticular attention in the automobile and aerospace industries as potential advancedstructural materials in the past three decades owing to their high specific strength, stiffness,superior wear resistance, excellent elevated temperature resistance and the widespreadavailability of the low cost fabrication techniques [2-6].

Hanumanthe Gowda and P. Rajendra Prasad evaluated the wear and corrosion Resistance of A356 alloy based hybrid composite at different aging conditions. The hybrid composite was manufactured by them by stir casting methods. The reinforcements used by them were rice husk ash (RHA) and Al_2O_3. They have concluded that corrosion loss decreased with increase in RHA and Al_2O_3 particles in the matrix alloy under different test conditions. Thus the corrosion resistance of the hybrid composites is highly influenced by the heat treatment. The corrosion test was conducted in 5% sodium chloride solution[7].Arun L. R et al studied the hybrid metal matrix composites made up of Aluminium 6061 alloy and Silicon carbide, fly ash. They found that the mechanical properties like ultimate tensile strength, hardness and compression strength of the composites were improved when compared with that of matrix alloy.[8]

Prajval.S and Dr. P. Rajendra Prasad prepared hybrid composites of aluminium 356 alloys with mica and titanium dioxide and studied the corrosion properties in 5% NaCl, 0.1N HCl and sea water continuously for 96 hours and found that there is a decrease in the corrosion loss due to the increase in the reinforcement. Thus the corrosion resistance of the hybrid composites is highly influenced by the heat treatment[9].

Material Selection

The matrix material selected is Aluminium 356 alloy. It is commercially available and has good cast ability, machinability, weld ability, heat treatable and corrosion resistance properties. The main chemical composition is silica with up to 7.5 weightpercentage which provides greater hardness. Its composition is given in table1.

comparison. The castings were taken out as cylindrical bars of 150mm length and 23 mm dimeter.

Specimen preparation

The cylindrical bar castings were cut into 20x20mm pieces using an abrasive cutting wheel. Matrix specimens were also prepared in the same way. The specimen 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 were weighed to fourth decimal place using electronic balance and the specimen dimensions were noted down using Vernier gauge[11].

Corrosion Test

The corrosion behaviour of Aluminium 6061 alloy was studied by immersion test. The Samples were

Table 1 Composition of Aluminium 356 alloy

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Others	Al
%	6.5-7.5	0.2	0.2	0.1	0.25-0.45	0.1	0.2	0.15	Balance

The reinforcements used in this study are fly ash and silicon carbide particulates. Fly ash is a waste product obtained after burning coal in thermal power stations. It is procured from Raichur thermal power station (RTPS) at Shaktinagar, Raichur District, Karnataka. Silicon carbide particulates are commercially available.

The corrosion testing medium used was 0.025, 0.05 and 0.1 normal hydrochloric acid.

Composites preparation

The hybrid composite of Aluminium 356 with fly ash and silicon carbide particulates were prepared by liquid melt metallurgy technique using vortex method as described by P.V.Krupakara[10]. 2% of fly ash was added to molten matrix alloy with 2, 4 and 6 weight percentages of silicon carbide particulates were casted in same manner. Thus three hybrid composites with constant reinforcement of 2% fly ash and different 2, 4 and 6 weight percentages of silicon carbide particulates were manufactured. Matrix alloy aluminium 356 was also casted in the same way for

suspended in the 200 cm3 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[12]. 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. The results were subjected to computer simulations to obtain graphs with exposure time on x axis and corrosion rate on y axis.

Results and Discussion

Figures 1-3 show the results of corrosion test in 0.025, 0.05 and 0.1 normal hydrochloric acid solutions.

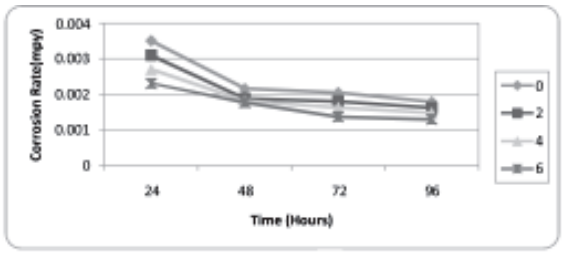


Fig.1: Static weight loss corrosion test in 0.025N Hydrochloric acid solution

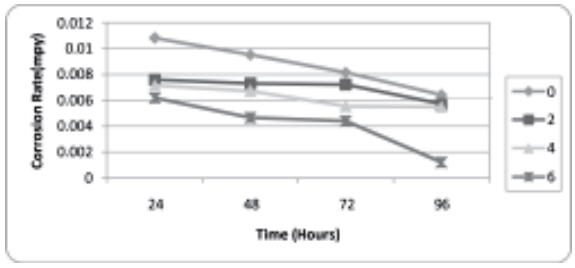


Fig.2: Static weight loss corrosion test in 0.05N Hydrochloric acid solution

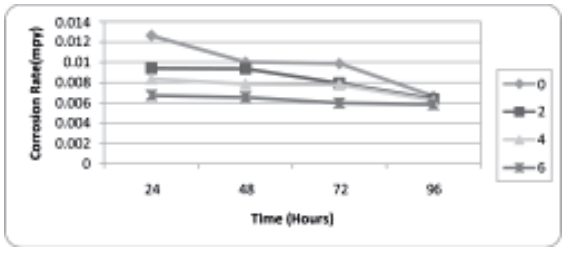


Fig.3: Static weight loss corrosion test in 0.1N Hydrochloric acid solution

Effect of test duration

The corrosion rate measurement as a function of exposure time in the static immersion test is shown in figure 1-3. The trend shows decrease in corrosion with increase in test duration. It is clear from the graphs 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.

Effect of red mud content

From figures 1-3 it can be clearly seen that for both as cast and composite, corrosion rate decreases monotonically with increase in reinforcement content. The weight loss in case of unreinforced alloy is higher than in the case of composites. Reinforcements being ceramic materials remain inert and are hardly affected by hydrochloric acid solutions during the test and are not expected to affect the corrosion of the composite. The results indicate an improvement in corrosion resistance as the percentage of reinforcement particulates increased in the composite, which shows that the fly ash and silicon carbide particulates directly or indirectly influence the corrosion property of the composites. This is also due to decrease in porosity of composites.[13] 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[14-15] 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[16] 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 [17].

Conclusion:

- Aluminium 356 MMCs reinforced with fly ash 2 percent and silicon carbide particulates of weight percentage from 0 to 6 percent could be successfully produced by liquid melt metallurgy technique using vortex method.
- The rate of corrosion of both the alloy and composite decreased with increase in time of exposure in all concentrations of hydrochloric acid.
- The corrosion rate of the composites was lower than that of the corresponding matrix alloy in all concentrations of hydrochloric acid.
- The reinforcement content in aluminium 356 alloy plays a significant role in the corrosion resistance of the material.
- Increase in the percentage of silicon carbide particulates will be advantageous to reduce the density and increase in the strength of the alloy and the corrosion resistance is significantly increased.
- The Composite materials are more suitable in acidic environments than matrix alloy.

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