International Journal of Research in Chemistry and Environment
Vol. 1 Issue 1 July 2011(85-88)
ISSN 2248-9649

Research Paper

Weight Loss Corrosion Studies of Aluminium-7075 Metal Matrix Composites Reinforced with SiC Particulates in HCl Solution

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Available online at: www.ijrce.org

(Received 3rd May 2011, Accepted 10th May 2011)

Abstract *- Present paper involves the studies on corrosion resistance properties of Al 7075/SiC metal matrix composites (MMCs) in acid medium. The liquid melt metallurgy technique using vortex method was utilised to fabricate MMCs. Pre heated but uncoated silicon carbide particulates of 50-80 micro meters in size are added to the matrix as reinforcement. Al 7075 containing 2, 4 and 6 weight percentage of silicon carbide is prepared. Corrosion tests were conducted by weight loss method for different exposure time where 1N HCl was used as corrodent. The corrosion rate of MMCs was lower than that of matrix Al 7075 alloy under the corrosive atmosphere.*

Key words: MMCs, vortex method, weight loss corrosion, SiC etc.

Introduction

Designers get many advanced benefits in designing the components for automobile and aircraft industry through metal matrix composites (MMCs). These materials maintain 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 engine which work particularly at high temperature and pressure environments.[6-7] For the last two decades particulates reinforced MMCs has been the most popular.

Aluminium alloy MMCs have most popular families being represented by Al 7075 alloy reinforced with ceramic particulates. By the addition of second phase into matrix material enhances not only physical and mechanical properties, but also change the corrosion behaviour significantly. In industries Aluminium alloys are used extensively with respect to their excellent fluidity, castability and mechanical properties. For the past few years Aluminium family of alloys has been used widely among zinc based foundry alloys. Aluminium alloys have got many advantages over the aluminium based ones, especially with respect to high strength with a low casting temperature. [8] These alloys have very good tribological properties.[9] These alloys are also used to various wear resistant application. Lo et.al [10] found that ZA alloys are having better properties than copper, aluminium and cast iron. Al 7075 alloys have been used in bearing and bushing application as a replacement for bronze bearing owing to their low cost and equivalence or superior performance.[11] Aluminium alloy have a relative high strength compared to a Zinc or aluminium alloy with a low melting temperature.[12] Hence this Al 7075 is the matrix alloy in the present research.
Very little research has taken place so far with respect to the environmental behaviour of these Al 7075alloys. The aim of the present research is to study the corrosion properties of these Al 7075 alloys reinforced with ceramic particulates like SiC and computer simulation of the results. Acid medium was selected to conduct the corrosion properties of these alloys. Acid chloride of unit normality was selected as corrodent.

Material and Methods

Al 7075 alloy, which exhibits excellent casting properties and reasonable strength, was used as base alloy. This alloy is best suited for mass production of lightweight metal casting. The chemical composition of Al 7075 alloy is given in Table 1.

Table 1 Composition of ZA-27.

Aluminium	Copper	Magnesium	Zinc
Balance	2-205%	0.01-0.02%	26-27%

SiC 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.

Composite preparation

The liquid metallurgy route using vortex technique[13] is employed to prepare the composites. A mechanical stirrer was used to create the vortex. The reinforcement material used was SiC particulates of size varying 50-80 µm. The weight percentage of SiC used was 2-6 weight percentage in steps 2%. Addition of SiC in to the molten Al 7075 alloy melt was carried out by creating a vortex in the melt using a mechanical stainless steel stirrer coated with alumina (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 SiC particles were pre heated to 200°C and added in to the vortex of liquid melt at a rate of 120 g/m. The composite melt was thoroughly stirred and subsequently degassed by passing nitrogen through the melt at a rate 2-3 l/min for three to four minutes. 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 also cast under identical conditions for comparison.

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 were weighed up to fourth decimal place using electronic balance and also the specimen dimensions were noted down using Vernier gauze.

Corrosion test

The corrosion behaviour of Al 7075 alloy was studied by immersion test. The static immersion corrosion method was adopted to measure the corrosion loss. Acid chloride corrodent was used to characterize the corrosion behaviour. 1N hydrochloric acid was used for this purpose. 200 ml of the prepared solution was taken in a beaker. Samples were suspended in the corrosive medium for different time intervals up to 96 hours in the steps of 24 hrs. To minimize the contamination of the aqueous solution and loss due to evaporation, the beakers were covered with paraffin paper during the entire test period. After the specified time the samples were cleaned mechanically by using a brush in order to remove the heavy corrosion deposits on the surface. The corresponding changes in the weights were noted. At least three samples were tested and average value was taken. Corrosion rates were computed using the equation

Corrosion rate: = 534 W/DAT mpy

Where W is the weight loss in gms, 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.

Results and Discussion

Fig 1 gives the corrosion rate of composites with different percentage of SiC composites reinforced with SiC particulates.

Effect of test duration

The corrosion rate mpy measurement as a function of exposure time in the static immersion test is shown in the Fig1. The trend observed in all the cases show 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. This eliminates the possibility of hydrogen bubbles clinging on to the surface of the specimen and forming a permanent layer affecting the corrosion process. The phenomenon of gradually decreasing corrosion rate indicates the possible passivation of the matrix alloy. De Salazar[14] explained that the protective black film consists of hydrogen hydroxy chloride, which retards the forward reaction. Castle et. al.[15] pointed out that the black film consists of aluminium hydroxide compound. This layer protects further corrosion in acid media. But exact chemical nature of such protective film still is not determined.

Effect of SiC content

From the Fig 1 it can be clearly observed that for both as cast and composite, corrosion rate decreases monotonically with increase in SiC content. In the present case, the corrosion rate of the composites as well as the matrix alloy is predominantly due to the formation of pits and cracks on the surface. In the case of base alloy, the strength of the acid used induces crack formation on the surface, which eventually lead to the formation of pits, thereby causing the loss of material. The presence of cracks and pits on the base alloy surface was observed clearly. Since there is no reinforcement provided in any form the base alloy fails to provide any sort of resistance to the acidic medium. Hence the weight loss in case of unreinforced alloy is higher than in the case of composites.

SiC being the ceramic remains inert and is hardly affected by acidic medium during the test and is not expected to affect the corrosion mechanism of the composite. The corrosion result indicates an improvement in corrosion resistance as the percentage of SiC particulates increased in the composite, which shows that the SiC particulates directly or indirectly influence the corrosion property of the composites. B.M.Sathish et.al. [16] who obtained similar results in glass short fiber reinforced Al 7075 alloy composites reported that the corrosion resistance increases with increase in reinforcement. Wu.Jinaxin et.al[17] in their work on corrosion of aluminium based particulate reinforced MMCs, state that the corrosion is not affected to a significant extent by the presence of SiC particulates in aluminium, where as the particulates definitely play a secondary role as a physical barrier as far as MMC corrosion characteristics are concerned. A particulate acts as a 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.

One more reason for the decrease in corrosion rate is the intermetallic region, which is the site of corrosion forming crevice around each particulates, which may be due to formation of magnesium inter- metallic layer adjacent to the particulate during manufacture as discussed by Trzaskoma[18]. Mclntyre[17] et.al. further showed that the magnesium inter-

metallic compounds are more active than the alloy matrix. Pitting in the composites is associated with the particulate matrix interface, because of the higher magnesium concentration in this region. With increase in time pitting would continue to occur at random sites on the particulate matrix interface. The active nature of the crevices would cathodically protect the reminder of the matrix and restrict pit formation and propagation.

Conclusion

The SiC content in Al 7075 alloys plays a significant role in the corrosion resistance of the material. Increase in the percentage of SiC will be advantageous to reduce the density and increase in the strength of the alloy, but the corrosion resistance is thereby significantly reduced.

Al 7075 MMCs when reinforced with SiC 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. The corrosion rate of the composites was lower than that of the corresponding matrix alloy.

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