IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 8, Issue 9Ver. I (Sep. 2015), PP 07-11
www.iosrjournals.org

Corrosion Characterization of Aluminium 7075 / Red Mud Metal Matrix Composites

[1]M.Mamatha, [2]P.V.Krupakara, [3]K Sreenivasa
[1]*Department of Chemistry, Nagarjuna College of Engineering, Bangalore*
[2]*Department of Chemistry, Adharsha Institute of Technology, Bangalore*
[3]*Department of Chemistry, SJC Institute of technology, Chickballapur, Karnataka*

Abstract: *Metal matrix composites are heterogeneous systems containing matrix and reinforcement. Their physical and mechanical properties can be tailored according to requirement. They are used in automobile, aircraft and marine industries because of their increased corrosion resistance. In this paper weight loss corrosion test, open circuit potential test and potentiostat test are conducted on Aluminium 7075/ Red Mud metal matrix composites in different concentrated neutral chloride solutions like sodium chloride solutions. Composites are prepared by liquid melt metallurgy technique using vortex method. Composites containing 2, 4 and 6 percent of red mud are prepared according to ASTM standards. Specimens are machined and made ready by standard metallographic methods. Weight loss corrosion studies open circuit potential studies and potentiostat studies are carried out in 0.035, 0.35 and 3.5% solutions of sodium chloride. The corrosion rate decreases with increase in the exposure time for all specimens in all corrodents in all the methods of testing. Corrosion rate also decreases with the increase in reinforcement content of the composites. Hence the composites can be used for the manufacture of the equipments used in marine environment so that they lost long.*

Key words: *Composites, Corrosion, Aluminium 7075, Red mud, Vortex*

I. Introduction

Metal matrix composites (MMCs) reinforced with ceramic particulates, whiskers, has received increasing attention due to their potentially high fracture toughness and strength[1-5]. Particle reinforced aluminum MMCs find potential applications in several thermal environments, especially in the automobile engine parts, such as drive shafts, cylinders, pistons, and brake rotors[6], and in space applications. With the exception of noble metals, no metal and alloy is stable in air at room temperature, which tend to form oxides. Most of the metals in the solid or liquid state are morphologically unstable in air at any temperature. An investigation relating to the temperature profiles of the piston area in a diesel engine has shown that the temperature can reach as high as 200-600°c in certain regions of the piston[7]. As the piston and cylinder areas are exposed to high temperature environment, the MMCs used here should have sufficient stability as well as good mechanical and chemical strength (oxidation). Oxidation occurring at grain boundaries in alloys and at the interface between particle and matrix in mmcs usually increases intergranular fracture, resulting in premature failure and severe brittleness[8-10]. Therefore, in high-temperature applications, it is essential to have a thorough understanding of the oxidation behaviour of the aluminum MMCs.

II. Experimental Procedure

Material selection

In the present study, liquid metallurgy technique is adopted and Aluminium 7075, which exhibits excellent casting properties and reasonable strength, is used as the base alloy Aluminium 7075 alloy with good strength is suitable for mass production of lightweight metal castings. The chemical compositions of the Aluminium 7075 alloy are given in Table I.

Table I Chemical Composition of Aluminium 7075 alloy

Component	Al	Mn	Si	Cr	Mg	Ti	Cu	Zn	Fe
Wt%	87.1-91.4	2.1-2.9	0.4	0.18-0.28	3	0.2	1.2-2.0	5.1-6.1	5

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 testing corrodent medium selected is 0.035, 0.35 and 3.5% solutions of sodium chloride.

Composites preparation

The liquid metallurgy route using vortex technique [11-12] is employed to prepare the composites. The weight percentage of red mud used was 3-7 weight percentages in steps 2%. Matrix was also casted in the same way for comparision.

Specimen preparation:

For weight loss corrosion test the composite along with matrix were cut in to cylindrical shaped specimens of dimesion18 cm x 18 cm and for open circuit potential test and potentiostat test specimens of size 20mm x 10 mm x 1mm were machined. Dimensions of all specimens were noted down using vernier gauge.

Corrosion test

The corrosion tests were conducted at room temperature using the conventional weight loss method. Weighed specimens were immersed in the corrodents and taken out at 24, 48, 72, and 96h. Weight loss was calculated and converted into corrosion rate and expressed in mils penetration per year (mpy) [13].
Corrosion rate is calculated using the following formula

$$\text{Corrosion Rate in mpy} = 534W/DAT \quad \ldots\ldots\ldots (1)$$

Where W is the weight loss in grams, D is density of the specimen gm/cc, A is the area of the specimen ($inch^2$) and T is the exposure time in hours.

For open circuit potential test the specimen were coupled with calomel electrode and connected to a multi meter, then dipped in corrodent solutions and the potential developed was noted down every hour.
For potentiostat test the equipment used is a potentiostat-Galvanostat (model CL95) in connection with a function generator and graphic plotter. These devices are interfaced with a personal computer in order to simulate the results obtained. Corrosion rate in mpy is directly obtained in the computer.

III. Results And Discussion

Figures 1 to 3 give the corrosion rate of composites by conventional weight loss method and Figures 4 to 6 shows the simulation curves for open circuit potential with different percentage of Red mud in MMCs and matrix in different concentrated solutions of sodium chloride. Figs 8 to 16 are the simulation curves for potentiostatic studies of the MMCs in comparison with matrix.

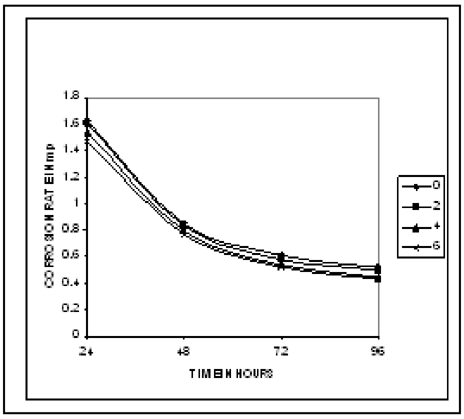

Fig.1: Weight loss corrosion in 0.035% Sodium chloride solution

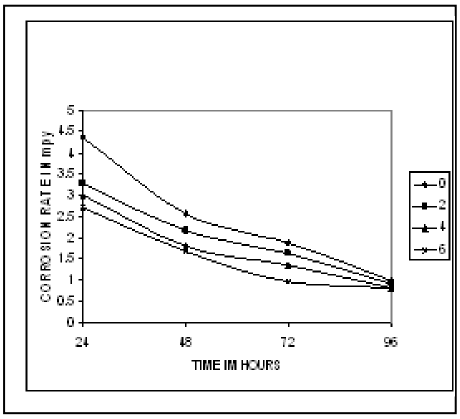

Fig.2: Weight loss corrosion in 0.35% sodium chloride solution

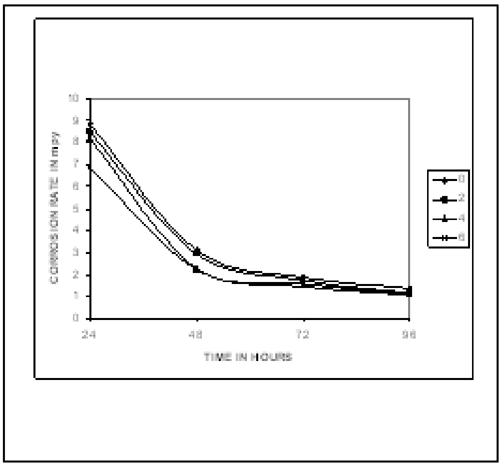

Fig.3: Weight loss corrosion in 3.5% sodium chloride solution

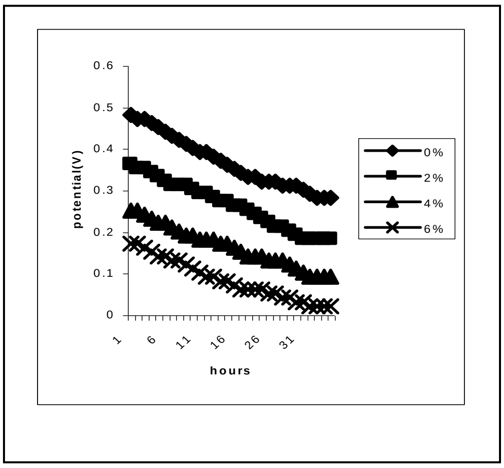

Fig 4: Open circuit potential test in 0.035%sodium chloride solution

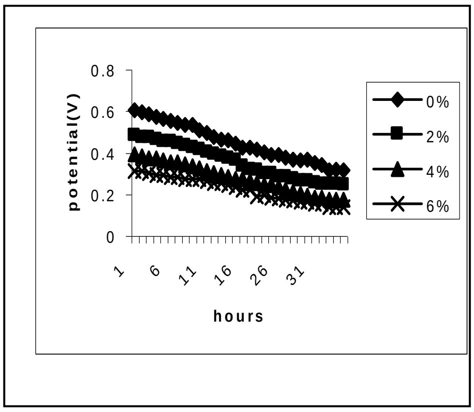

Fig 5: Open circuit potential test in 0.35 % sodium chlorides solution

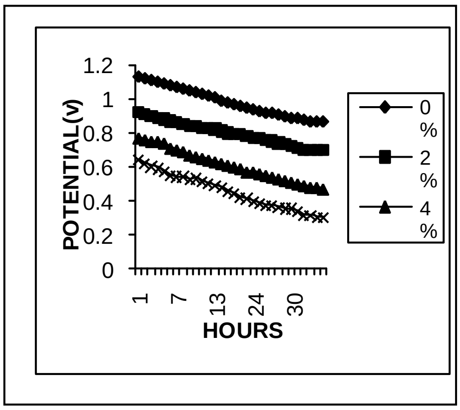

Fig 6: Open circuit potential test in 3.5 % sodium chlorides solution

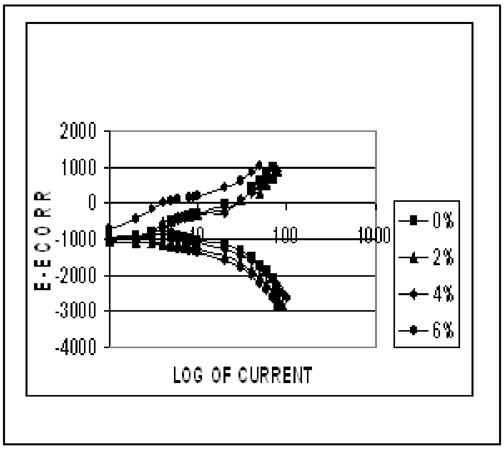

Fig 7: Ptentiostat test in 0.035 % sodium chlorides solution

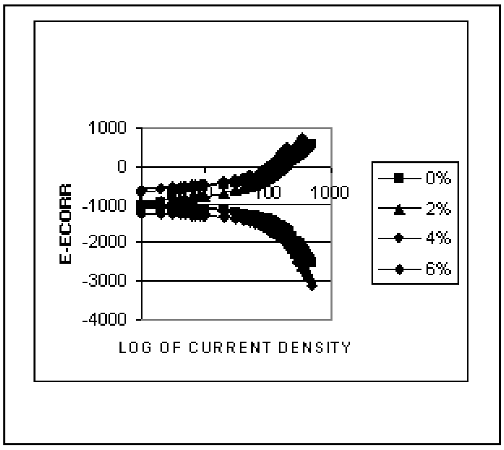

Fig 8: Potentiostat test in 0.35 % sodium chlorides solution

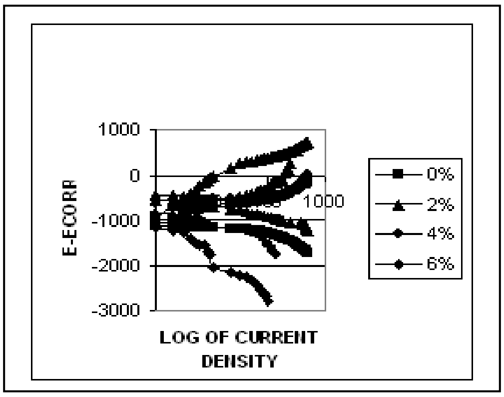

Fig 9: Potentiostat test in 3.5 % sodium chlorides solution

Wt%	0	3	5	7
Conc. Of NaCl	Corrosion rate in 10^4mpy			
0.035%	1.3289	0.985	0.7502	0.073
0.35%	1.8004	1.8004	1.7361	1.5218
3.5%	3.6009	3.6009	3.2365	2.3577

Table 2: Corrosion rate for different concentrations of sodium chloride solutions for matrix alloy and its composites.

Effect of exposure time

In weight loss corrosion test (figures 1-3) it is observed that MMCs and matrix exhibit a decrease in corrosion rate with increase in test duration in all concentrations of sodium chloride solutions. It is clear from graphs that the corrosion resistances of the composites are higher when compared to that of matrix in all mediums. Same trend is observed in open circuit potential test also (figures 4-6), where the potential developed for MMCs and matrix go on decreasing with exposure time and become constant after thirty hours of exposure. The potentials experienced by MMCs are less when compared to that of matrix. In both the tests there will be a black deposit development on the specimens. The phenomenon of gradually decreasing corrosion rate indicates a possible passivation of the matrix alloy. De Salazar et al [14] explained that the protective black film consists of hydrogen hydroxy chloride film, 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 is still not established.

Effect of red mud content

From the figures1-6, it can be clearly observed that for MMCs, corrosion rate decreases monotonically with increase in red mud 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, cracks on the surface. In the case of the base alloy, the severity of the base used induces crack formation on the surface, which eventually leads 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 basic medium. Hence the weight loss in the case of un-reinforced alloy is higher than in the case of composites. Same explanation can also be adopted to open circuit potential test.

Potentiostat test results in different concentrations of sodium chloride are shown in table 2. For all specimens irrespective of percentage of red mud reinforcement the corrosion rate increased with increase in normality of NaCl solution. An increase in the weight percentage of red mud particulates appeared to shift the polarization curve slightly towards the current axis than that of alloy. Ceramic reinforcement particles act as insulator and remain inert in the acidic medium during the test. Hence the corrosion rate decreases with increase in red mud content in MMCs, which may decrease the area of exposure of alloy with increase in the reinforcement. Less exposure of the MMCs area to aggressive chloride environments in corrosion testing led to lesser pitting as well as corrosion than that of the matrix alloy. Reinforcements in the MMCs decrease the corrosion density, which further decreases with additional reinforcement [16-17]. The pits on the matrix alloy were more when compared with those of MMCs. This may be due to the exposure of less matrix alloy surface in MMCs than matrix alloy, by the addition of reinforcement.

From table 2 it can be clearly seen that the ceramic reinforcement particles act as insulator and remain inert in the acidic medium during the test. Hence the corrosion rate decreases with increase in red mud content in MMCs, which may decrease the area of exposure of alloy with increase in the reinforcement. Less exposure of the MMCs area to aggressive chloride environments in corrosion testing led to lesser pitting as well as corrosion than that of the matrix alloy.

IV. Conclusions

- Aluminium 7075 based MMCs reinforced with 2, 4 to 6% of red muds were successfully produced by liquid melt metallurgical technique.
- The rate of corrosion of both the alloy and composite decreased with time duration.
- The potential developed by both the alloy and composite decreased with time duration.
- Normality of NaCl plays a significant role in the corrosion of MMCs. Corrosion rate of the alloy and MMCs increased with increase in the concentration of NaCl solutions. The cathodic polarization curves were function of the normality of NaCl and reinforcement concentration with hydrogen reduction increasing with increase in reinforcement.
- The corrosion rate of the composites was lower than that of the corresponding matrix alloy.
- The corrosion by weight loss of the composite decreased with increase in the weight percentage of the reinforcement.
- The use of MMCs in bearing applications in marine environment more suitable than matrix alloy

References:

[1]. Elomari, s., Boukhili, r. & Skibo, M.D., "Dynamic mechanical analysis of prestrained Al_2O_3/Al metal-matrix composite" Jour. Mater. Sci., vol.30, (1995) pp.3037.

[2]. Fridlymander, J.N., Metal Matrix Composites, Chapman and hall, oxford, 1995.

[3]. Jones, H., Lavender, C.A. & Smith, M.T., Scripta Metall., vol. 21, (1987) pp.1565.

[4]. Girish, B.M., Kamath, R., & Satish, B.M., "Fractography, fluidity, and tensile properties of aluminum/hematite particulate composites" Jour. Of Mat. Engg. & Perf. vol.8 (1999) pp.1999.

[5]. Feest, E.A., "Metal matrix composites for industrial application" Mater. Design, vol. 7 (1986) pp.58

[6]. John E. Allison & Gerald S. Cole, Jour. Metals, vol. 45, (1993) pp.29.

[7]. Bowles, R.R., Macini, D.L. & Toaz, M.W., in "Advanced Composites- The Latest Developments" edited by Peter Beardmore and Carl F.Johnson, Proceeding of the Second Conference on Advanced Composites, (ASTM International, Michigan, 1990) pp.21.

[8]. Rizhan, Z., Manjiou, G., & Yu, Z., Oxid. Metal., vol.27,(1987) pp.253.

[9]. Brincknell, R.H., & Woodford, D.A., "Grain boundary embrittlement of the iron-base superalloy IN903A" Metall. Trans. Vol.2A, (1981) pp.1673-80

[10]. Woodford, D.A., & Bricknell, R.H, "The embrittlement of nickel following high temperature air exposure" Metall. Trans., vol.12A,(1981) pp. 425.

[11]. Abdul Jameel, Krupakara P V**,** Jayaprakash H V, Veeraiah M K "Corrosion studies of Al6061/ Red mud Metal Matrix Composites" J. Electrochem Soc. India, 60 **(**2011)100-104

[12]. Min, K.S., Ardell, A.J. Eck, S.J., & Chen, F.C., Jour. Mater. Sci., vol. 30 (1995), pp.5479.

[13]. P.P.Trzaskoma, E.McCafferty in Aluminium Surface treatment technology, ed. R.S.Alwitt, G.E.Thompson (pennington, JH: The electrochemical Society 1986), p.171.

[14]. J.M.G.De Salazar, A. Urefia, S.Manzanedo, M.I.Barrena, "Corrosion behaviour of AA6061 and AA7005 reinforced with Al_2O_3 s in aerated 3.5% chloride solution: potentiodyanamic measurements and microstructure evaluation", Corrosion Science, vol.41, 1999, pp.529-545.

[15]. J.E.Castle, L.Sun, and H.Yan, "The use of scanning auger microscopy to locate cathodic centres in SiC_p/Al-6061 MMC and to determine the current density at which they operate", Corrosion Science, vol.36(6), 1994, pp.1093-1110.

[16]. O.P.Modi, M.Saxena, B.K.Prasad, A.H.Yogeswaran and M.L.Vaidya, Jour.Mater.Sci.27 (1992) 3896

[17]. M.Saxena, O.P.Modi, B.K.Prasad and A.K.Jha, "Erosion and corrosion characteristics of an aluminium alloy-alumina fibre composite" Wear, 169 (1993) 119