POTENTIODYNAMIC POLARIZATION STUDIES OF ALUMINIUM 2024 / FLYASH METAL MATRIX COMPOSITES

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Abstract

This research paper is on the potentiodynamic polarization studies of Aluminium 2024-fly ash metal matrix composites. Both matrix alloy and reinforcement are commercially available. Liquid melt metallurgy technique using vortex method is adopted for manufacturing the composites. Electrochemical studies like potentiodynamic polarization studies are conducted using electrochemical work station manufactured by CH instruments USA. All the test are conducted at laboratory temp. The experiments are conducted in different concentrations of potassium chloride. In all the concentrations of potassium chloride the corrosion resistance of composite materials are found to be greater than that of matrix alloy.

Keywords: **Potentiodynamic, polarization, vortex, fly ash, electrochemical work station**

I. INTRODUCTION

Most of the engineering applications in today's world require materials with new combination of properties that cannot be exhibited by the conventional metal alloys, polymers or ceramics. This is applicable for the materials that are needed in Aerospace and Transportation Industries. There is a big demand for the better combination of properties in materials. Composite materials provide such combination of properties to great extent.

Metal matrix composites (MMC) are the combination of two or more materials in which matrix properties are realized. MMCs show significantly better properties including better corrosion resistance, high strength, good structural rigidity, damping capacity, good wear resistance and light weight compared to unreinforced alloys[1]. In automotive industries, there is a considerable development occurred in the potential use of metal matrix composites in last few years. The metal matrix composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy by casting[2]. Casting method is preferred as it is less expensive and applicable to mass production. More preference is given to the composites containing low density and low cost reinforcements. Fly ash is one of the most inexpensive and low density reinforcements among the various reinforcements used. It is available in large quantities in thermal power plants as a by-product from combustion of coal. The incorporation of fly ash particles in aluminium alloy has the potential for conserving energy intensive aluminium and thus reducing the cost of aluminium products[3]-[5].

In general, composites are synthesised by combining materials having different corrosion behaviours leading to adverse effects on the corrosion resistance relative to their counterpart's monolithic alloys. Aluminium alloys and their composites are prone to pitting corrosion in a corrosive media with a pH close to neutral. This type of corrosion is characterized by the formation of irregular shape of cavities on the surface of the metal. The diameter and depth of the cavities depend on several parameters related to the composites, the medium and service conditions[6]-[7].

Aluminium 2024 alloy is the most widely used aluminium– copper alloys in aircraft industry. This alloy has higher tensile and yield strength with lower elongation. Typical uses of this alloy are aircraft structures, truck wheels, rivets, hardware, and screw machine products. The available literature on aluminium 2024 alloy-fly ash composites is limited and also there is a lack of information on the influence of fly ash particles on the susceptibility of these aluminium2024-flyash composites to corrosion and workability data. Therefore, the present research makes an attempt to synthesize the aluminium 2024 alloy–fly ash composites by stir casting method and focused to study the potentiodynamic polarization effects of this newly developed aluminium 2024 alloy–fly ash composites at room temperature.

II. EXPERIMENTAL PROCEDURE

A. MATERIAL SELECTION

In the present study the matrix alloy selected is Al-Cu-Mg alloy (Al 2024) whose chemical composition is shown in Table 1. The reinforcement material is fly ash particulates, which are collected from Raichur Thermal Power Station, Shakthinagar, Raichur District, Karnataka.

Table I: Composition of Al 2024

Cu	Mg	Mn	Fe	Si	Zn	Zr	Ti	Cr	Al
4.4	1.5	0.6	0.25	0.25	0.125	0.1	0.15	0.15	Balance

B. COMPOSITE PREPARATION

The synthesis of Al2024-flyash composites are carried out by liquid melt technique using vortex method[8]. Cylindrical rods (18mm and 170mm length) of aluminium 2024 alloy are taken into a graphite crucible and melted in an electric furnace. After maintaining the temperature at 770C, a vortex is created using mechanical stirrer made of graphite. While stirring is in progress, the preheated fly ash particulates at 800^{o}C for 2h are introduced. Care is taken to ensure smooth and continuous flow of the fly ash particles added in the vortex. The molten metal is stirred at 400rpm under argon gas cover; stirring is continued for about 5min after addition of fly ash particles to get the uniform distribution in the melt. During stirring degasifying tablets made up of hexachloroethane is added to degasify and the melt is poured into preheated (200^{o}C) iron moulds[9]. Aluminium metal matrix composites reinforced with 2,4 and 6% fly ash are prepared.

C. POTENTIODYNAMIC POLARISATION STUDIES

The cylindrical bar castings of Aluminium 2024 / fly ash composites containing 2,4 and 6 weight percent of fly ash particulates are subjected to machining. Rectangular specimens of size 10mm x 20mm x 1 mm are manufactured using metal turning lathes. Aluminium 2024 alloy is also subjected to same machining and same size rectangular specimens are prepared for comparison. Experiments with respect to potentiodynamic polarization techniques in 0.035%, 0.35% and 3.5% potassium chloride medium are conducted. Experiments are conducted using electrochemical analyzer/ work station model 608E series manufactured by CH instruments, USA. It is connected to a cell with a reference electrode, counter electrode and a provision for connecting the manufactured specimen as working electrode. Figure 1 given below shows the electrochemical workstation.

The electrochemical investigation are performed in open air using 100ml beaker as cell with an Ag/AgCl electrode as the reference electrode and a platinum electrode as a counter electrode(CE). Magnetic stirring is employed at the bottom of the cell to increase the mass transfer at the electrode. One square centimeter area of the specimen is exposed to the corrosive environment.

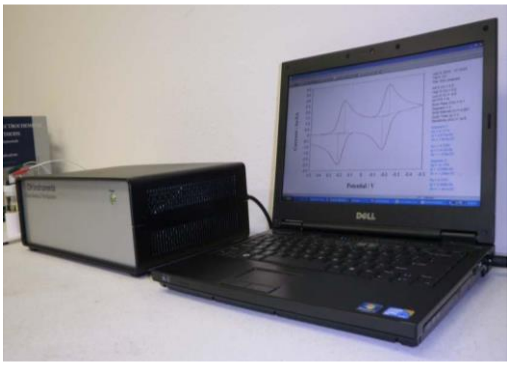

Figure 1: Electrochemical workstation

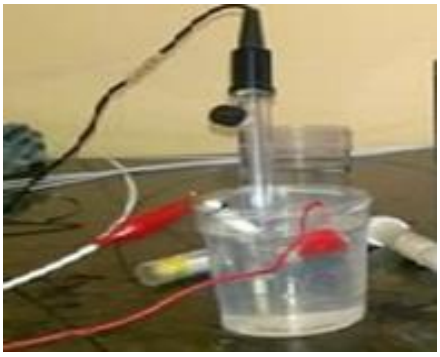

Figure 2: Cell containing electrodes

Figure 2 given above shows the cell used for the test. A Tafel plot for a metal specimen can be obtained by polarizing the specimen to about 300 mV anodically and cathodically from the corrosion potential, E_{corr}

III. RESULT AND DISCUSSION

The results obtained for the potentiodynamic polarization tests conducted in different concentrated solutions of potassium chloride solution are given below in the form of computer simulations.

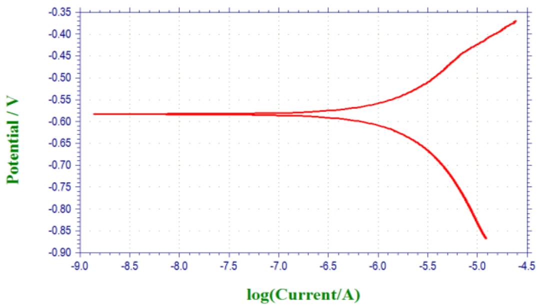

Figure 3: Potentiodynamic polarization test in Al2024/0% flyash in 0.035%KCl

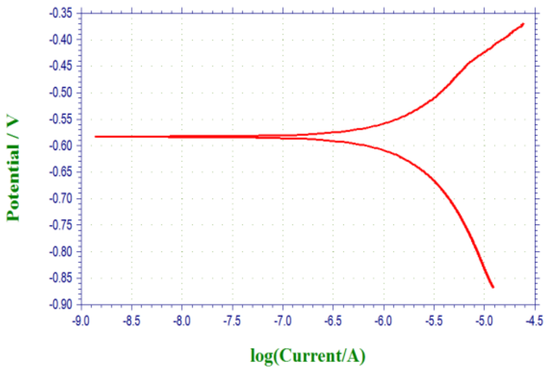

Figure 4: Potentiodynamic polarization test in Al2024/2% flyash in 0.035%KCl

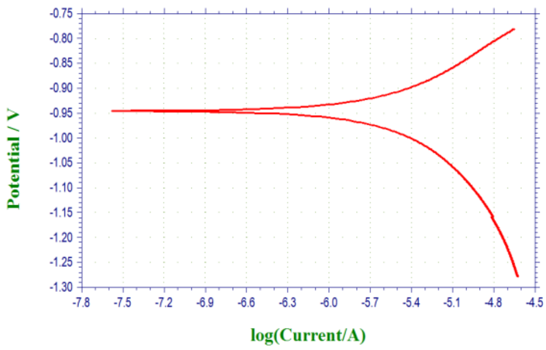

Figure 5: Potentiodynamic polarization test in Al2024/4% flyash in 0.035%KCl

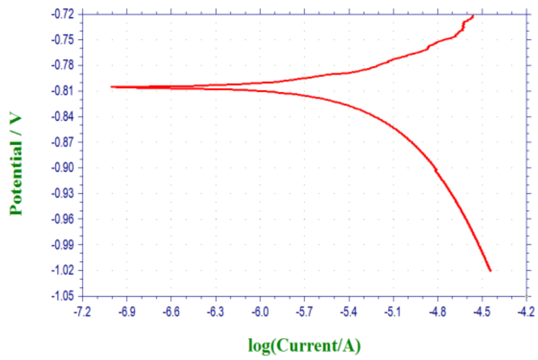

Figure 6: Potentiodynamic polarization test in Al2024/6% flyash in 0.035%KCl

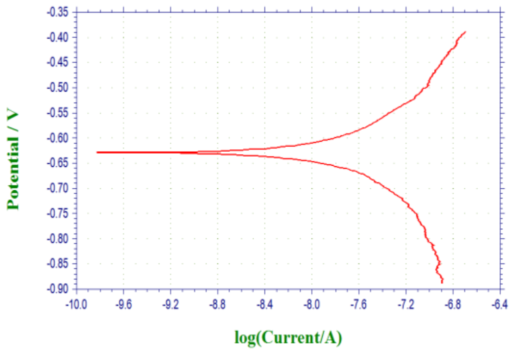

Figure 7: Potentiodynamic polarization test in Al2024/0% flyash in 0.35%KCl

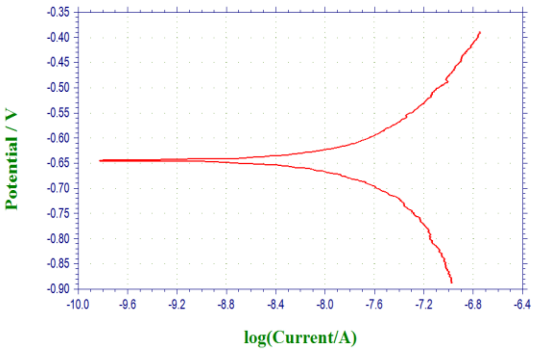

Figure 8: Potentiodynamic polarization test in Al2024/2% flyash in 0.35%KCl

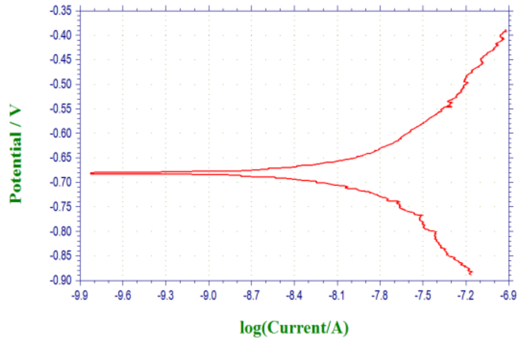

Figure 9: Potentiodynamic polarization test in Al2024/4% flyash in 0.35%KCl

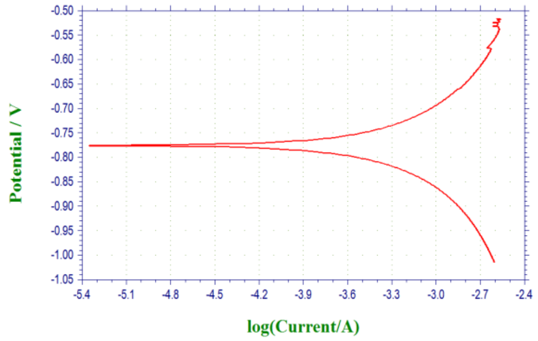

Figure 10: Potentiodynamic polarization test in Al2024/6% flyash in 0.35%KCl

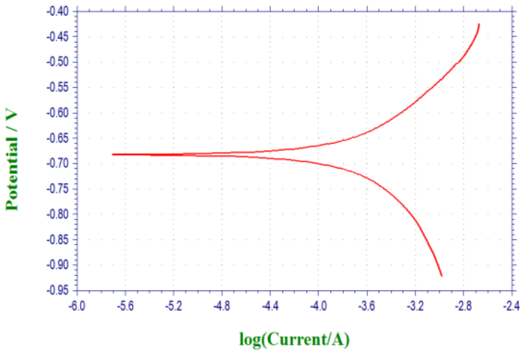

Figure 11: Potentiodynamic polarization test in Al2024/0% flyash in 3.5%KCl

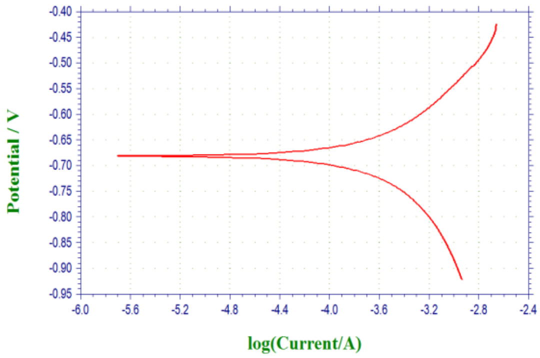

Figure 12:Potentiodynamic polarization test in Al2024/2% flyash in 3.5%KCl

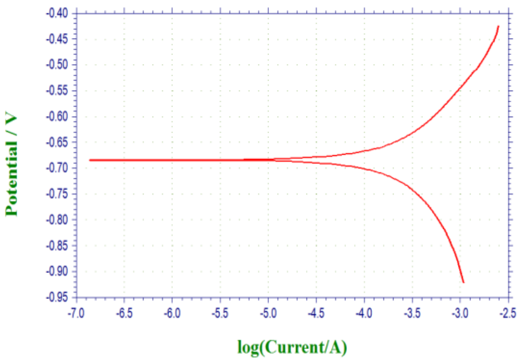

Figure 13: Potentiodynamic polarization test in Al2024/4%flyash in 3.5%KCl

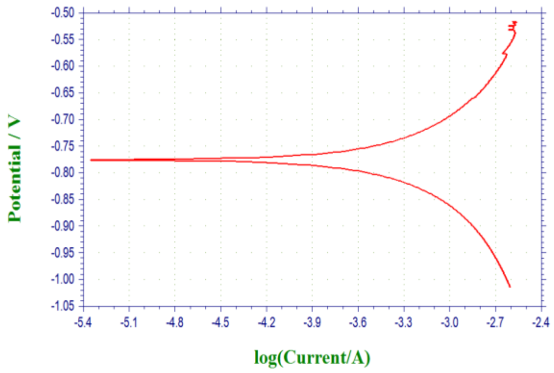

Figure 14:Potentiodynamic polarization test in Al2024/6% flyash in 3.5%KCl

Figures 3-14 shows the polarization curves for the Al2024/flyash MMC's that are typical for both composite and matrix alloy, varying with different concentrations of potassium chloride solutions. They are plotted by taking logarithm of current density on X axis and potential on Y axis. The concentration shows a marked effect on the corrosion rate of all the samples. The point of intersection between the cathodic and anodic curves gives corrosion current density Icorr. The corrosion rate is calculated using the conversion formula

Corrosion rate in mpy $= CE_wI_{corr}/d$

Where C is the conversion constant (1.287 x10^5), Ew is the equivalent weight of the sample (g), d is the density of the sample (gcm^{-3}).

Table 2: Icorr and Corrosion rate of Al2024/flyash in 0.035% KCl

% of flyash in Al2024	I_{corr} (A)	CR mpy
0	1.880	4.536
2	2.751	4.224
4	4.443	3.92
6	5.0125	3.125

Table 3: Icorr and Corrosion rate of Al2024/flyash in 0.35%KCl

% of flyash in Al2024	I_{corr} (A)	CR (mpy)
0	1.452	6.043
2	2.629	7.198
4	2.979	5.240
6	5.304	3.208

Figure 14:Potentiodynam

Table 4: Icorr and Corrosion rate of Al2024/flyash in 3.5%KCl

% of flyash in Al2024	I_{corr} (A)	CR mpy
0	2.395	9.824
2	2.656	6.408
4	3.499	5.025
6	4.125	4.148

From the above results it is clear understood that as the percentage of fly ash increases in the matrix alloy the corrosion rate E_{corr} decreases in all the concentrations of potassium chloride solutions. The reinforcement material fly ash is an inert material which will be ceramic in nature will not be affected by the salt solution. As the percentage of fly ash increases, the exposure of matrix alloy to the corrosion medium decreases. Hence the corrosion rate decreases. Chandrashekar et al[10] also obtained the same type of results when they conducted the polarization tests in sodium chloride solutions for the MMCs manufactured by them using Aluminium 6013 as matrix and red mud particulates as reinforcement. They also conclude that the composite material are more suitable than the matrix alloy in applications where the medium contains more salt.

ACKNOWLEDGEMENT

Authors wish to thank continuous encouragement given by Management and Principal of T. John Institute of Technology, Bannerghatta road, Bangalore and Cambridge Institute of Technology-North Campus, Devanahalli, Bangalore.

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