EVALUATION OF CORROSION PROPERTIES OF AL 2024 BASED HYBRID MMC'S

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ABSTRACT

Reinforced Aluminium MMCs find potential applications in several corrosive environments especially in the Marine engine parts, such as drive shaft, cylinders, pistons and brake rotors. MMCs used in corrosive environment should have good mechanical properties and resistance to chemical degradation in air and acidic environment. Some published data indicate that the addition of E-Glass fibre particles do not appear to affect corrosion behavior substantially on some aluminum alloys because, the pits were found to be more numerous on the composites. Also they were comparatively smaller and shallower than those on unreinforced alloy. This study is focused on corrosion of E-Glass and Flyash reinforced Aluminium 2024Metal matrix composites as per ASTM standard by static immersion weight loss method with HCl solution with different normalities that is 0.25 N, 0.5 N, 0.75N and 1 N for 24, 48, 72 hours.

KEYWORDS: *E-Glass fibre, Aluminum 2024, Flyash, Corrosion, HCl solution.*

I. INTRODUCTION

Majority of modern structural materials, used for marine, aerospace & automotive applications are made up of composite materials. The earlier concept of composites is simply the mixing of two or more materials so that there will be improvement in resistance to corrosive and mechanical properties. For example, early cannons, which had barrels made of wood, were bound with brass because a hollow cylinder of wood easily bursts under internal pressure. In ancient times, bricks were made up of clay and straw following this principle. Combination of straw and mud to make huts is still in use today in villages in our country. Similarly, ordinary steel covered with paint to protect it from rusting can be regarded as a composite. If this is true, then almost all engineering materials are composites of some kind. In modern technology the concept of combining two dissimilar materials has acquired a broader significance: the combination has its own distinct properties. In terms of strength or resistance to heat or some other desirable quality, a composite material is superior to either of the constituting components taken alone or entirely different from either of them. The principal attraction of modern composite materials is that they are lighter, stiffer and stronger than anything made ever before. At present they are used principally to meet severe demands of supersonic flight, the exploration of space and ventures into the deep sea water of the oceans.

This study is conducted to improve the corrosion property of the Al2024 material. The material Al2024 is reinforced with E-glass fiber, Fly ash with an intention to reduce the corrosion level from 17mpy to 7mpy for a period of 72 hours. This experimental study is conducted as per ASTM standard test procedure. The details about specimen preparation, test procedure and methodology is mentioned in the experimental methodology (2.1). The ASTM standards for the present test are highlighted in corrosion test (2.2 and 2.3). The outcome of the same is mentioned in results and discussion section of this article (2.4). The conclusions and future works are also mentioned for carrying out further research work.

II. EXPERIMENTAL METHODOLOGY

2.1. Fabrication of Test Specimens

A stir casting setup consists of an Electrical resistance Furnace with stirrer assembly, was used to synthesize the composite. Three-phase electrical resistance type 10 KW capacity furnace is shown in the figure1 is used. The temperature range of the furnace is 1000^0 C with a controlled accuracy of ± 10^0 C fitted with digital temperature controller. The shooting capacity of the furnace is 500^0C per hour. Muffle furnace was used to preheat the particulate to a temperature of 500^0C. It was maintained at that temperature till it was introduced into the Al 2024 alloy melt. The preheating of reinforcement is necessary in order to reduce the temperature gradient and to improve wetting between the molten metal and the particulate reinforcement.

Fig.1: External View of Electrical Resistance Furnace

The melting range of Al 2024 alloy is of 700 – 800^0C. A known quantity of Al 2024 ingots were pickled in 10% NaOH solution at room temperature for 10 min. pickling was done to remove the surface impurities. The smut formed was removed by immersing the ingots for 1minute in mixture of 1 part nitric acid and one part water followed by washing in Methanol. The cleaned ingots after drying in air were loaded into the Graphite crucible of the furnace for melting. The melt was super heated to a temperature of 800^0C and maintained at that temperature. The molten metal was then degassed using Hexochloro ethane tablets for about 8min.
Alumina coated stainless steel impeller was used to stir the molten metal to create a vertex. The impeller was of centrifugal type with 3 blades welded at 45^0 inclination and 120^0 apart. The stirrer was rotated at a speed of 300 – 400 rpm and a vertex was created in the melt. The depth of immersion of the impeller was approximately one third of the height of the molten metal,from the bottom of the crucible. The preheated particulates of flyash and short E-Glass fibre were introduced into the vertex at the rate of 120gm/min. Stirring was continued until interface interactions between the particles and the matrix promoted wetting. The melt was degassed using Hexochloro ethane tablets and after reheating to superheated temperature (800^0C) it was poured into the preheated die.
Then after few minutes of stirring, the liquid metals with reinforcements are poured into the dies to get the required castings. The dies were pre heated and coated additives to ease the process of removing the castings. The dies were coated with a mixture of china clay, water and sodium silicate to prevent iron contamination. After solidification the required cast are obtained which are sent for proof machining on a centre lathe to remove the scaling from the surface. The casted specimens obtained were machined on a CNC Lathe according to ASTM standards for Tension, Compression, Hardness, Corrosion, Wear test.

2.2. Composition of Specimens Prepared

Table 1. Different casting composition For Al-2024 Hybrid Composites

Specifications	Fly ash %	E fibre %	AL 2024 %
A2F1E	2	1	97
A2F3E	2	3	95
A2F5E	2	5	93
A4F1E	4	1	95
A4F3E	4	3	93
A4F5E	4	5	91
A6F1E	6	1	93
A6F3E	6	3	91
A6F5E	6	5	89
A8F1E	8	1	91
A8F3E	8	3	89
A8F5E	8	5	87

2.3. Corrosion Test

The Corrosion test was carried out using static immersion weight loss method as per standards. The test specimens were machined into standard discs of 20 mm diameter and 20mm thick. Before testing specimen the surfaces were ground with silicon carbide paper of 1000 grit size and polished in steps of 1.5 to 3 micron diamond paste to obtain a mirror surface finish. After subsequent rinsing with water and acetone the specimens were weighed accurately to a hundredth of milligram accuracy before starting the test by the weight loss method [1]. The corrosion procedures as per ASTM were carried out with all percentage specimens and the uniform dispersion of reinforcements was studied by optical microscope. The corrodant used was hydro choric acid solution. The corrosion tests were conducted using conventional weight loss method similar to ASTM-G67-80 test standards as shown in Fig.2. The tests were conducted on all types of specimens of and the exposure time was varied from 24 to 72 hours, in steps of 24 hours. The cradles containing the measured specimens were kept inside the flask, which contains the corrodant. According to ASTM standards a ratio of 50ml of hydrochloric acid to 1mm^2 of surface area was maintained. After the corrosion test the specimens were immersed in acetone solution for 10 minutes and gently cleaned with a soft brush to remove adhered scales. After drying thoroughly the specimens were weighed to determine the percentage weight loss as shown in Fig.3. After the corrosion test the corroded surface of the specimens were studied under the Scanning Electron Microscope. Present study is focused on corrosion of flyash and E-glass reinforced with aluminum metal matrix composites with HCl solution with different normalities i.e., 0.25, 0.5, 0.75 and 1N for 24, 48, 72 hrs and the results are tabulated.

Fig 2: Test Specimens in Hcl solution

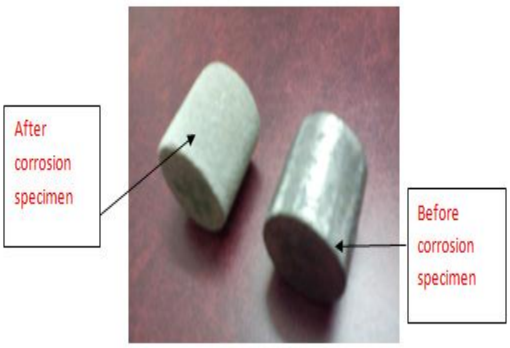

Fig 3: Corrosion Test Specimens

2.4. Results and Discussion

The corrosion rate was measurement as a function of percentage of the both reinforcement in the static immersion test as shown in graphs. From the table and graphs it can be clearly observed that for both Al 2024 Hybrid composites, corrosion rate decreases monotonically with increase in the reinforcement 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 surfaces.

In the case of lower % reinforced hybrid composites the severity of the acid used induces cracks 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 provides in any form the lower % reinforced hybrid composites fails to provide any sort of resistance to the acidic medium. Hence the weight loss in the case of lower % reinforced hybrid composites is higher.

Both reinforcement are being ceramics, they remain inert and are hardly affected by the acidic medium during the test. As the flyash and E-Glass fibre are inert, they are not expected to affect the corrosion mechanism of composites[2]. The corrosion results indicate an improvement in corrosion resistance as the % of flyash and E-Glass increased the hybrid composites. This shows that the Flyash and E-Glass directly or indirectly influence the corrosion property of the composites. In previous work on corrosion of aluminum based particle reinforced MMCs states that, the corrosion is not affected to a significant extends by the presence of SiC particles in aluminium, whereas the particles definitely play a secondary role as a physical barrier as for as MMCs corrosion characteristics are concerned. Thus reinforcement act as a relatively inert physical barrier to the initiation and development of corrosion pits and also modifies the micro structure of the matrix material and hence reduces the rate of corrosion.

One more reason for decrease in the corrosion rate is the inter-metallic region, which is the site of corrosion forming crevice around each particle[3]. This may be due to formation of magnesium inter-metallic layer adjacent to the particle during manufacture as discussed Literature review. Pitting in the composite is associated with the particle-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 particle-matrix interface. The active nature of crevices would catholically protect the remainder of the matrix and restrict pit formation and propagation.

Table 2. Results of Corrosion rate for Aluminium 2024 Hybrid Metal Matrix Composites

Normality (N)	Duration (Hours)	Corrosion Rate for Al 2024 Hybrid Composites (mpy)											
		A2F1E	A2F3E	A2F5E	A4F1E	A4F3E	A4F5E	A6F1E	A6F3E	A6F5E	A8F1E	A8F3E	A8F5E
0.25	24	21.21	20.23	17.26	21.15	17.48	16.82	21.03	16.48	16.01	21.72	17.43	15.89
	48	12.50	11.80	11.20	12.30	11.32	10.56	11.80	10.55	10.28	10.44	11.00	10.00
	72	9.80	8.5	7.2	08.82	07.06	07.38	8.23	7.32	06.70	08.65	08.98	07.62
0.50	24	23.43	20.05	19.56	22.48	19.01	17.69	22.87	18.34	17.23	24.54	20.29	17.28
	48	15.34	13.88	13.14	14.90	12.88	12.67	13.54	12.91	12.43	13.87	13.56	12.54
	72	11.26	09.27	08.20	08.95	8.54	07.54	09.27	07.45	07.12	10.43	09.87	08.73
0.75	24	25.32	23.45	21.73	24.43	22.43	20.48	23.58	21.02	20.01	26.24	21.65	19.54
	48	16.23	15.34	15.05	15.47	14.95	14.35	15.43	14.28	13.48	15.01	14.10	14.63
	72	11.34	12.88	10.50	09.79	10.45	09.59	09.24	09.57	08.23	10.35	10.08	09.56
1.00	24	33.50	30.43	27.79	32.25	28.84	27.26	32.65	29.23	25.65	30.67	25.87	23.56
	48	20.34	19.76	19.34	20.02	18.68	18.45	19.21	17.67	17.00	18.78	18.09	17.37
	72	15.22	12.65	11.59	13.89	12.00	11.87	12.72	10.48	10.02	12.19	11.35	11.03

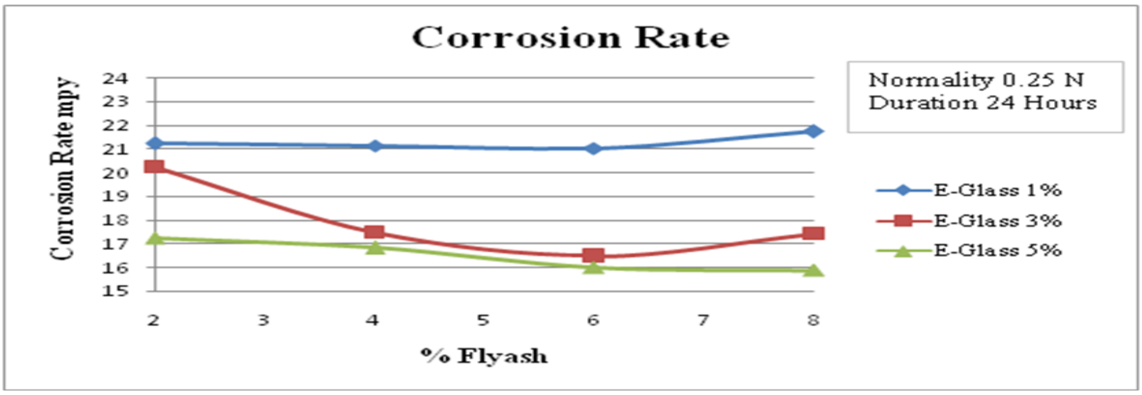

Fig. 1. The effect of Flyash and E-Glass Fibres on the Corrosion rate of the Al 2024 Hybrid composite at Normality 0.25 N & Duration 24 hrs

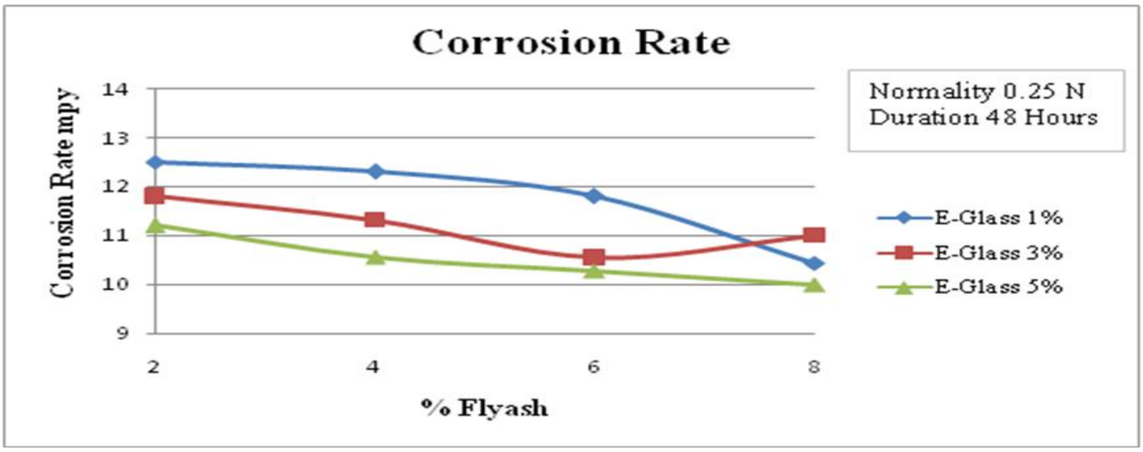

Fig. 2. The effect of Flyash and E-Glass Fibres on the Corrosion rate of the Al 2024 Hybrid composite at Normality 0.25 N & Duration 48 hrs

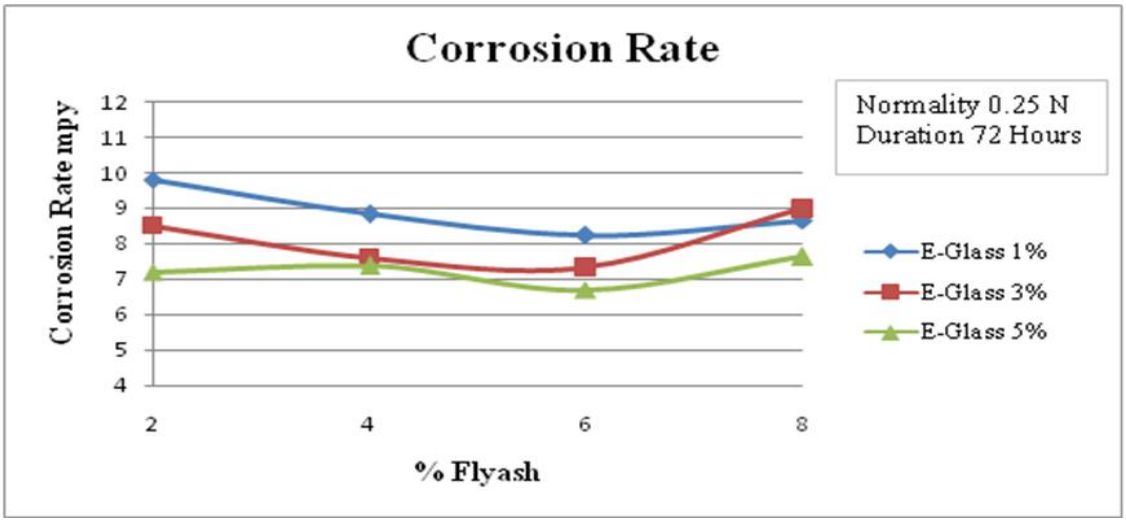

Fig. 3. The effect of Flyash and E-Glass Fibres on the Corrosion rate of the Al 2024 Hybrid composite at Normality 0.25 N & Duration 72 hrs

III. CONCLUSIONS

- It is found from the graph(Fig.1,2,3) that corrosion level decreases from 17 mpy to 7mpy for a period of 72 hours due to presence of E-glass fibre & flyash .

- Corrosion rate decreases for Al 2024 hybrid composites with duration of the exposure to the corroding solution. The improvement in corrosion resistance due to a protective layer formed on the surface of the material which gradually builds up and reaches a steady state with time.
- The composite specimen showed better corrosion resistance than the un-reinforced matrix alloy, also it is seen that corrosion rate increases with increases in normality of solution.
- Corrosion resistance was also found to improve with increase in E-Glass concentration and Flyash concentration, because they act as physical barriers to the corrosion process.
- The E-Glass content in aluminium alloys plays a significant role in the corrosion resistance of the material. Increase in the percentage of addition will be advantageous to reduce the density and increase in the strength of alloy and thus the corrosion resistance is there by significantly reduced.

IV. SCOPE FOR FUTURE WORK

This study is focused only on corrosion of E-Glass and Flyash reinforced Aluminum 2024Metal matrix composites as per ASTM standard by Static immersion weight loss method with HCl solution with different normalities .Corrosion rate & Experimental test can be carried out using NaCl solution can be carried for different normalities using different composition of E-Glass and Flyash.

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