The Behaviour of Aluminium Alloy under the Influence of Varying Acidity

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Abstract - *The corrosion behaviour of aluminum alloy cast from different source such as; used tower (TA), roofing sheet (RS), motorcycle break pad (MC) and motorcycle piston (MP) in solutions of different pH of 4.2, 7.0 and 8.0 were investigated using PG start 101 potentiostat electrochemical testing machine. The chemical composition test of each of the sample was conducted to ascertain the weight percentage of each of the constituent elements in each aluminum alloy. MC shows highest weight percentage of iron (Fe^{3+}) as 1.128%. In pH of 4.2, MP exhibited lowest corrosion rate of 0.032617 while RS exhibited highest corrosion rate of 0.20169 mmpy. Also 0.0005048 mmpy observed as lowest corrosion rate in pH of 7.0 exhibited by TA while highest corrosion rate of 0.55829 mmpy was observed in pH of 8.0 exhibited by MC. It can be concluded that the weight percentage of iron (Fe^{3+}) and pH has significant effect on corrosion rate. Therefore, MP with lowest corrosion rate of pH 4.2 is recommended for use in acidic environment while TA with lowest corrosion rate in pH of 8 is recommended for use in alkaline environment.*

Keywords: *Aluminum alloy, Corrosion, Acidic, Alkaline, Environment*

I. INTRODUCTION

Most metals and alloys produce a film that creates a corrosion resistant surface. These films are called passive films and are the cause of passivity of a metal or alloy which are characterised majorly by different composition of element such as Al, Si, Fe, Cu, Mn, Mg, Zr, and Cr with different weight percentage (depending on type of alloy) found applications in many industries, (Hassan, 2012). Aluminum/aluminum alloys has great importance in aeronautical, automobile industries construction of machines, appliances, and alloy. The ability of aluminum to resist corrosion is caused by its capacity to passivate under certain conditions (Ghali, 2011). Due to their excellent properties; such as high fluidity, low shrinkage, high strength-to-

weight ratios, high thermal conductivity, high corrosion resistance, and excellent workability, Aluminum and its structures, as cooking utensils, as covers for housings, electronic equipment, pressure vessels for cryogenic applications, and in innumerable other areas. Meanwhile, the grievous economic effect of corrosion on aluminum and its alloy is of great concern to many. Olatunji (2009) reported that the major problem facing most of production and manufacturing industries which has a direct impact both on the industries and our national economy as a whole is corrosion and its grave effects on materials failures cannot be overemphasized. Huge economic losses resulting from plant shutdowns, material losses and contamination are some evident facts. As one of the main reason for failure of aged long structure, corrosion launches a destructive attack on the metal when an electrochemical reaction proceeds over entire surface.

According to Awajiogak and Emmanuel (2013), corrosion seeks to reduce the binding energy in the metals. When exposed to atmospheric conditions, most metals oxidize slowly changing to another form such as the mineral ore from which they were produced. Abdulkarim, *et.,al* (2009) established that the corrosion rate of aluminium and its alloys will increase with increase in acidity. Low pH acid waters clearly accelerate corrosion by providing a plentiful supply of hydrogen ions. Although even absolutely pure water contains some free hydrogen ions, free carbon dioxide in the water can multiply the hydrogen ion concentration many times. The corrosion resistance of metals and its alloys is a basic property related to the easiness with which these materials react with a given environment (Roberge, 2006). Popoola (2013), submits that, no particular material is the cure for all the evils of corrosion, hence proper knowledge of behaviour of specific engineering materials (aluminum alloys) under the influence of different industrial environments with vary level of pH to avoid wastage of replacement is of paramount interest to most engineers.

II. METHODOLOGY

Four different aluminum alloy namely`; TA aluminum alloy (aluminum alloy obtained from used tower), RS aluminum alloy (aluminum alloy obtained from roofing sheet), MC aluminum alloy (aluminum alloy obtained from motorcycle break pad) and MP aluminum alloy (aluminum alloy obtained from motorcycle piston) were casted in foundry workshop of mechanical engineering in Osun State Polytechnic Iree (Fig.1and 2) and subjected to chemical composition test analysis to ascertain the weight percentage of constituent element. 10 mm by 10 mm of casted aluminum alloy were cut and polished with zero emery paper for obtaining smooth surface. The surface of each specimen was cleaned by distilled water, and finally cleaned with ethanol to degrease. The metals were air dried and stored in desiccators. The samples were subjected to electrochemical testing machine using PG start 101 potentiostat from corretest instrument corp. ltd, with test solution containing water of different pH (4.2, 7.0 and 8.0) (Fig.3), in corrosion Laboratory Federal University Akure. An electrochemical potential (voltage) were generated between the various electrodes of the machine. The corrosion potential (`E_{corr}), was measured by the potentiostats as an energy difference between the working electrode (Bav) and the reference electrode (BcMV). The applied potential increases with time while the current (Icor) was constantly monitored to determine the corrosion rate (CR) of each of the samples.

Fig. 1; Aluminum casting process

Fig 2; Cast aluminum alloy

Fig. 3; Corrosion test experiment with potentiostat electrochemical testing machine

III. RESULT AND DISCUSSION

The electrochemical behaviour of casted aluminum alloy in solution of pH of 4.2, 7.0 and 8.0 were investigated and the result were presented.

Table 1 shows the chemical composition test analysis of the cast aluminum alloy (samples),with TA and MP alloy exhibited the highest and lowest percentage of pure aluminum (99.09% and 82.88%) respectively. The analysis fixed RS and TA alloy with 1.128% and 0.5359% of Fe^{3+} as the highest and lowest weight percentage respectively. The electrochemical test results of the samples in test solution of different pH (4.2, 7 and 8) were stated in table 2, 3 and 4 respectively. Aluminum alloy of RS was observed from table 2 and 3 with highest corrosion rate of 0.20169 mmpy in solution of PH of 4.2 and 0.0051983 mmpy in solution of pH of 7.0 , while MC aluminum alloy was observed with highest corrosion rate of 0.55829 mmpy in solution of pH of 8.0 in table 4.Meanwhile, TA aluminum alloy exhibited the lowest rate of corrosion of 0.00050048 mmpy and 0.043069 mmpy in solution of pH of 7 and solution of pH of 8.0 as shown in table 3 and 4 respectively. From table 2, MP was observed with lowest corrosion rate of 0.032617mmpy in solution of pH of 4.2. The result was further subjected to graphical illustration showing MP, and TA `exhibiting lowest rate of corrosion in solution of pH of 4.2, 7.0,and 8.0 respectively, as shown in figure 4,5 and 6.

Table 1: Chemical Composition of Aluminum Alloy

Elements	Weight (%)			
	TA	RS	MC	MP
A1	99.06	98.42	85.17	82.88
S1	0.1669	0.4309	10.35	13.43
Fe	0.3886	0.5359	1.128	0.5241
Cu	0.0142	0.0379	1.545	1.375
Mn	0.0164	0.2205	0.1527	0.1380
Mg	<0.000	<0.000	0.1369	0.7419
Zn	0.0171	<0.001	0.9770	0.0661
Cr	<0.002	<0.000	0.0173	<0.000

Table 2; Result of electrochemical test in `solution of pH 4.2

	MC	RS	TA	MP
CRMMPY (Corrosion rate)	0.11397	0.20169	0.048802	0.032617
Ecor (Corrosion potential)	-469.447	-439.052	-472.054	-359.181
Icor (Current density)	-9.814	-1.736	-4.202	-2.808
BaV (Anodic beta)	1.164	211.359	538.118	221.302
BcMV (Cathodic beta)	452.356	154.069	239.992	315.342

Table 3; Result of electrochemical test in solution of pH 7.0

	MC	RS	TA	MP
CRMMPY (Corrosion rate)	0.0038823	0.0051983	0.00050048	0.0051843
Ecor (Corrosion potential)	-744.105	-911.464	-483.956	-669.024
Icor (Current density)	-334.338	-447.669	-43.1	-446.463
BaV (Anodic beta)	230.917	344.259	190.203	421.291
BcMV (Cathodic beta)	990.747	117.236	169.728	855.787

Table 4; Result of electrochemical test in solution of pH 8.0

	MC	RS	TA	MP
CRMMPY (Corrosion rate)	0.55829	0.11533	0.043069	0.061611
Ecor (Corrosion potential)	-609.999	-675.839	-894.974	-612.204
Icor (Current density)	-4.807	-9.931	-3.709	-5.305
BaV (Anodic beta)	633.906	504.285	345.274	425.266
BcMV (Catholic beta)	266.921	807.75	602.935	143.393

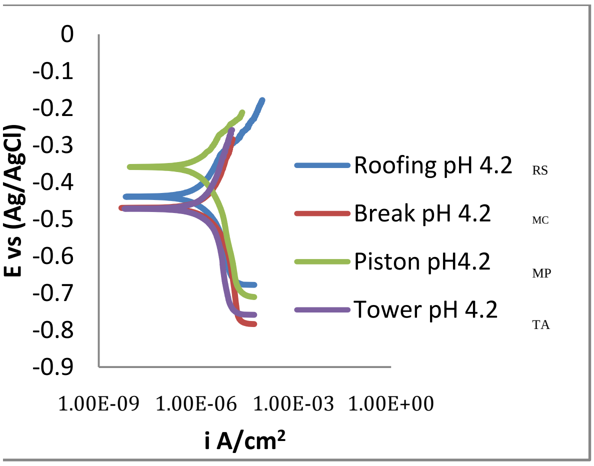

Fig 4; Comparative graph of samples in solution of pH

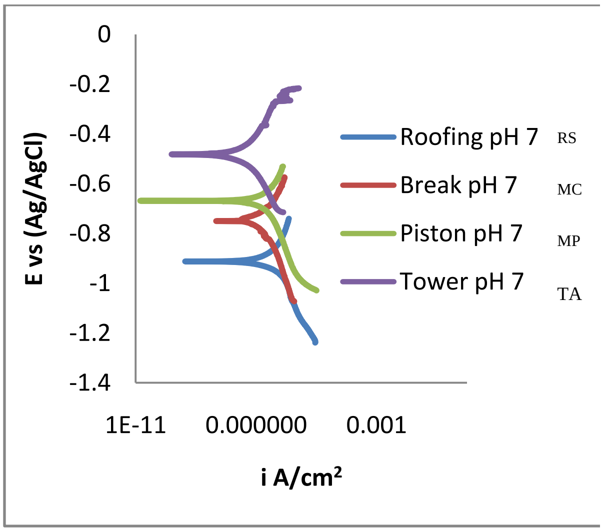

Fig 5; Comparative graph of samples in solution of pH 7

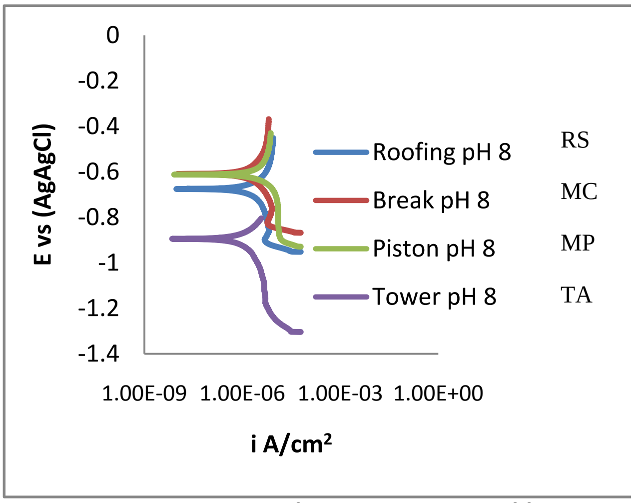

Fig 6; Comparative graph of samples in solution of for pH 8

IV. CONCLUSION

The corrosion behaviour of aluminum alloys were investigated in different pH of solutions by electrochemical techniques. The percentage of Fe^{3+} in the samples contributed to their resistance to corrosion irrespective of pH level of the solution. With least rate of corrosion (0.032617 mmpy) exhibited by MP in solution of pH of 4.2 and TA demonstrated least rate of corrosion (0.043069 mmpy) in solution of pH of 8, MP and TA are recommended for application as engineering material in acidic and alkaline environment respectively.

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