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EXPERIMENTAL INVESTIGATION OF EROSION CORROSION BEHAVIOUR OF MAGNESIUM AND ITS ALLOYS

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ABSTRACT

Corrosion is the major challenge faced by Light weighting of automobiles has been an important issue in the transportation industries. Magnesium alloy seems to be the most promising substitute to Aluminium alloy and steel used in automotive and aerospace industries due to its low density of 1.74 g /cm^3, high strength to weight ratio and good mechanical properties. In this present work, our aim is to study the erosion corrosion behavior of pure Mg, AZ31 and AZ91 in the 3.5% NaCl environmental condition. Various parameters that affect the corrosion behavior of the material are pH value, exposure time, concentration, temperature and velocity of the fluid. The specimens are exposed to continuous flow of 3.5% NaCl solution under 1 bar pressure in order to analyze their erosion corrosion behavior using the experimental setup. Further SEM analysis was done to study microstructure behaviour .Weight loss method was performed .It was found that the corrosion rate increases as time of exposure increases. Comparative study of corrosion rate in static condition and erosion corrosion was done. It was found that the corrosion rate due to erosion corrosion is higher than corrosion rate due to weight loss method.

KEYWORDS: *Corrosion, Magnesium, AZ31, AZ91, Weight loss measurement, Erosion corrosion.*

1. INTRODUCTION

Automotive industry in India is growing prominently and has shown global impact [1].Light weighting of vehicle is the critical objective considered without comprising other aspects like size, acceleration, emission, dynamic stability and surface integrity. Magnesium's primary advantage is its density. Magnesium has been chosen for this purpose and finds wide application depending upon the functional requirement [2],[3].Erosion Corrosion involves both mechanical and electrochemical mechanism and this combined effect produces an increased material loss. Erosion corrosion depends on mechanical detachment of protective layer caused by flowing fluid. It also depends on mass transfer coefficient considering both surface pH and dissolution rate. Erosion corrosion rate will be higher since the rate of film formation will be less than rate of dissolution and transfer to bulk fluid. Its effects is found aqueous solution, gases, organic liquids and liquid metals[4].

2. EXPERIMENTAL PROCEDURE

2.1MATERIALS USED

Magnesium, AZ31 and AZ91 are the materials used for the investigation. Chemical composition as represented by ASTM A240 specifications are indicated in the table 1.

Table 1 Chemical composition of the Magnesium alloy

GRADE	%Al	%Zn	%Mn	%Fe	%Ni	% Mg
Mg	0.00	0.006	0.01	0.001	0.001	99.9
AZ31	2.98	0.94	0.02	0.003	0.001	Bal
AZ91	9.05	0.98	0.16	0.002	0.001	Bal

Magnesium , AZ31 and AZ91 were purchased in the form rod and were cut into samples of size 10 mm x5 mm. The samples were polished up to 1200grit using silicon carbon emery sheet, washed in distilled water cleaned in acetone and dried. The surface area and weight of the samples were measured before conducting the test. Working fluid was prepared as per the standard, Sodium chloride in distilled water with concentration of 3.5% wt .Each samples was exposed to the working fluid for continuous 6 hours. All the tests were performed at 298K temperature.

2.2 TESTING

2.2.1 EXPERIMENTAL SETUP

The experimental setup used in the present work is shown in fig.1.For stagnant test, weight loss methods was used. It consists of 3.5% wt, of NaCl salt solution in the 250 ml beakers. The test samples are prepared as per ASTM standards G31.For the dynamic condition , experimental set up(flow loop system) was constructed and used in the present work to perform erosion corrosion test which is shown schematically in Fig 1.It consists of motor of 0.373kW power, PVC piping system, storage tank , pressure gauge and flow regulating valve[5]. Two PVC unions are attached in flow line for placing and removing the samples .Before the test samples was weighed. Tests was conducted at the salt concentration (3.5 g/l) and time of exposure upto 6 hours at atmospheric temperature to study the effect of the parameters on erosion corrosion [4]. After conducting the test, the samples were cleaned in distilled water and dried and weighed again.

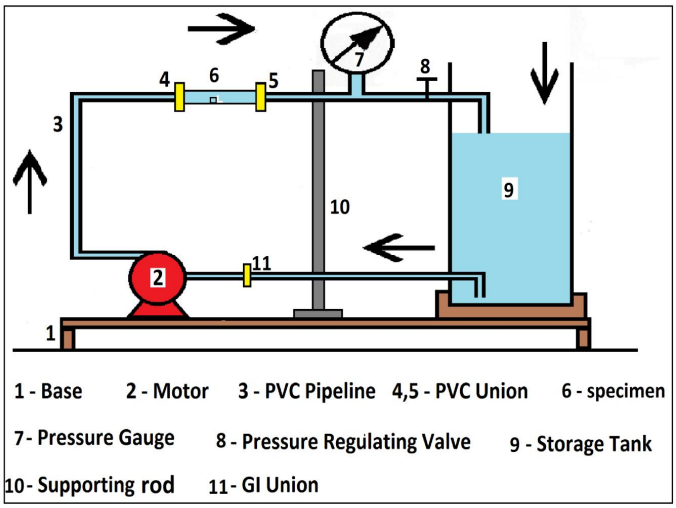


Fig 1: Erosion Corrosion experimental setup

3. RESULTS and DISCUSSION

3.1 CORROSION RATE CALCULATION

There are various techniques to determine the corrosion rate. The weight loss method was used.
Corrosion rate= (mpy) [1]

where

W- Mass loss in mg; A- Area of the test sample in cm^2; D-Density of the sample in g/cm^3; T-Time of exposure in hours.

3.2 EROSION RATE CALCULATION

Erosion rate = Mass of eroded material/time (mg/ yr) [2]

3.3 CORROSION KINETICS

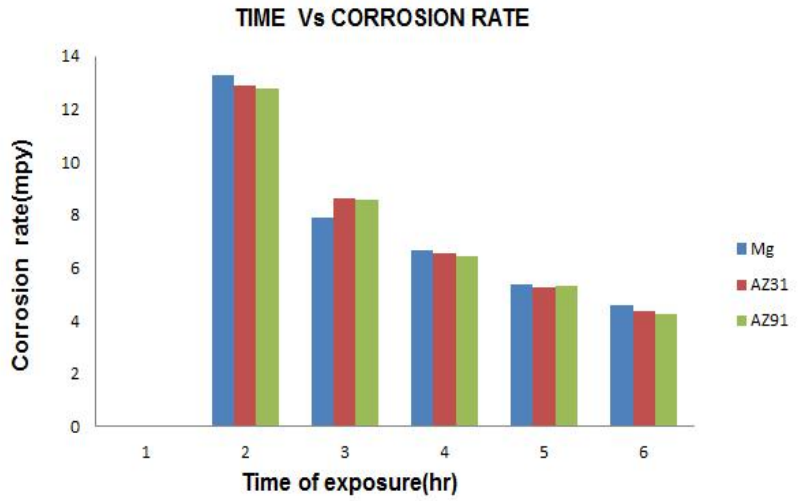
The time of exposure Vs corrosion rate plots for Mg, AZ31 and AZ91 at 298 K in NaCl with concentration of 3.5 g/l for 6 hours (Fig. 2 and Fig. 3).It was found that the corrosion rate was found to be high as the time of exposure increases in both stagnant and dynamics test condition[5].This is due to dissolution of chloride ion in the environment which acts aggressively on the protective layer of Magnesium alloy[6]. It was found that material loss was more as time of exposure increased which proves the fact that the erosion rate increases due to rate of film formation is less the rate of dissolution of metal ions. For most of the application, corrosion rate less than 20mpy is acceptable. The corrosion rate and erosion rate are given in the Table. 2 and Table3 for NaCl salt solution environment.

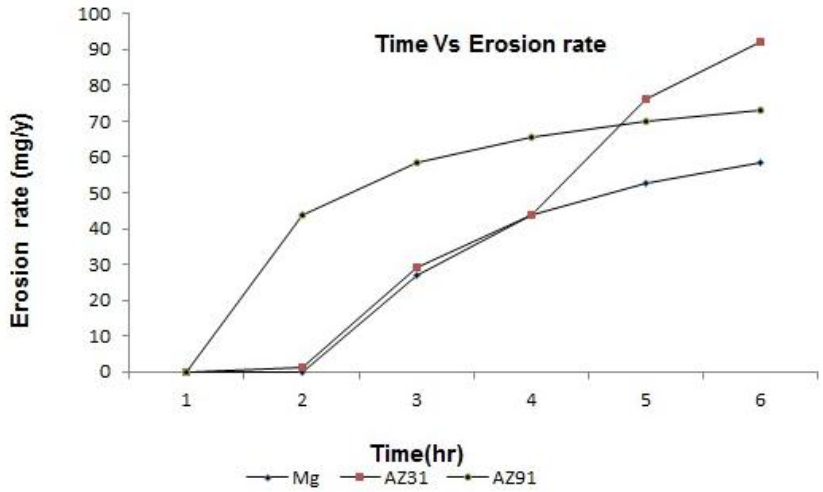
Table 2 Erosion corrosion rate of Magnesium and its Alloy in 3.5% NaCl

Sl No	NaCl	Test Sample	Exposure Time (hrs)	Corrosion Rate (mpy)	Erosion Rate (mg/y)
1	3.5% wt	Mg	1	0	0
			2	13.3	0
			3	8.91	29.2
			4	6.68	43.8
			5	5.34	52.5
			6	4.45	58.4
2	3.5% wt	AZ31	1	0	0
			2	0	0
			3	8.70	29.2
			4	6.44	43.9
			5	15.40	87.6
			6	8.70	92.2
3	3.5% wt	AZ91	1	0	0
			2	12.80	43.7
			3	8.55	58.4
			4	6.41	65.7
			5	5.13	70.1
			6	4.27	73.0

Table3. Corrosion rate of Magnesium and its Alloy in 3.5% NaCl

Sl No	NaCl	Test Sample	Exposure Time (hrs)	Corrosion Rate (mpy)
1	3.5% wt	Mg	1	0
			2	13.3
			3	7.8
			4	6.68
			5	5.34
			6	4.56
2	3.5% wt	AZ31	1	0
			2	12.9
			3	8.6
			4	6.57
			5	5.25
			6	4.35
3	3.5% wt	AZ91	1	0
			2	12.8
			3	8.55
			4	6.42
			5	5.31
			6	4.27





4. CONCLUSION

(1) From the present study, it was inferred that the material loss is more in erosion corrosion than by corrosion in weight loss method. Among the three materials, pure magnesium has less weight loss when compared to both AZ31 and AZ91 in both test condition. Initially there was less weight loss due to the passive layer formation of hydroxides of magnesium, aluminium, and zinc.

(2) Weight loss measurement shows initially an increase of corrosion rate in order of Mg<AZ91<AZ31 in 3.5% NaCl. Decrease in the value of corrosion rate with immersion time of is due to the formation of magnesium hydroxide layer at the surface which increase the corrosion resistance property whereas mixed hydroxide of magnesium, aluminium and zinc forms on the surface of the alloy is not as protective as pure magnesium hydroxide layer[8].

(3) It is inferred that the erosion corrosion rate is higher than corrosion rate by weight loss method. From the tests, erosion corrosion rate is high inAZ31 than Magnesium and AZ91

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