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Corrosion Behaviour of Magnesium Alloys in Chloride Medium

Inder Singh and A.K. Bhattamishra
National Metallurgical Laboratory,
Jamshedpur-831 007, India

ABSTRACT

Magnesium and its alloys find wide application as sacrificial anode in cathodic protection of pipelines and burried structures where hot zones exist . Magnesium alloys containing different alloying elements, such as Sn, Cd and Zn were cast in the form of rod of dia. 1/2" and studied potentiodynamically and galvanostatically. PARC-273 was used for the polarization studies. OCP, E_{corr} and I_{corr} were measured. The total immersion test was also carried out to record weight loss. It was observed that alloy containing Cd and Zn showed higher corrosion rate in comparison to other alloys studied under identical conditions. Addition of Sn to the alloy improves the corrosion resistance properties marginally. Magnesium alloy containing Sn and Cd only was found to have superiority over other alloys in respect to corrosion resistance properties. The weight loss data substantiate the polarization data . The data are discussed in detail in the paper.

INTRODUCTION

Magnesium and its alloys have been well accepted as sacrificial anodes for cathodic protection of pipelines, buried structures, hot spot areas, etc. The performance of the alloys, in general, is dependent on their chemistry, micro-structural features, the environments, nature of film formation in the specified medium, ect. . Also, the dissolution of the alloys varies with the media and the alloying elements or impurities in the magnesium alloys. As reported, cathodic impurities, like Cd,Tin and Zn have substantial influence on the performance of magnesium anodes in corrosion media. Still, systematic studies on the corrosion behaviour of the magnesium alloys containing these elements are lacking. The paper discusses the data generated on corrosion rates as a function of composition of Mg- alloys, containing Cd, Tin and Zn.

EXPERIMENTATION

Four magnesium alloys containing Cd, Tin and Zn were cast and machined upto 12.5 mm dia rod (Table-1). These alloys were mechanically polished upto 600 grit finish, washed, cleaned and

degreased with acetone. Samples for different experiments were cut as per the requirement from these cast rods.

Table-1
Chemical composition of Mg-alloys
(wt %)

Alloys	Elements			
	Sn	Cd	Zn	Mg
A	1	1	5	93
B	-	1	5	94
C	1	-	5	94
D	1	1	-	98

Total immersion test was carried out using cut slice (2 mm thick x 12.5 mm dia) of the rod samples in 3.5 % NaCl solution for 96 hours, Initial and final weights of the samples were measured, using Metler Digital balance. Corrosion products from the surface after the exposure were removed by chromate solution as per ASTM-G(1). Corrosion rates were determined., Data are set-forth in Table-2.

Table-2
Corrosion rate of Mg alloys under total immersion in 3.5 % NaCl solution. Surface area exposed - 2.8 cm^2

Alloy	Corrosion rate,mpy
A	0.02853
B	0.0409
C	0.0280
D	0.0244

Electrochemical tests on four Mg-alloys were carried out using PARC-273 Potentiostat/Galvanostat in 3.5 % NaCl solution. Surface area of 1 cm^2 was used for polarization studies at the scan rate of 2 mV/Sec. Saturated calomel electrode and graphite rod were used as reference and auxiliary electrodes respectively. I_{corr} E_{corr} ,OCP and corrosion rate were measured. (Table-3).

Table-3
Electrochemical test data on Mg-alloys exposed in 3.5 % NaCl solution
(Potentiodynamic polarization)

Alloy	$E_I = 0$ -mV	E_{corr} -mV	I_{corr} uA/cm^2	corrosion rate mpy
A	1676	1683	66.26	59.17
B	1666	1664	112.66	100.94
C	1663.71	1856	21.4	19.18
D	1662	1698	11.02	9.88

RESULTS AND DISCUSSION

Data on total immersion test in 3.5 % NaCl solution indicate that the corrosion rate of the Mg-Zn-Cd alloy is on higher side followed by Mg-Zn-Cd-Sn alloy. The alloy containing Zn and Sn has slightly better corrosion resistance, but Mg-alloy with Sn and Cd only has shown superior corrosion resistance in comparison to other alloys studied.

Potentiodynamic polarization studies in chloride medium also reveal that Mg-alloy containing Cd and Sn only has lowest I_{corr} as well as the corrosion rate, but Mg -alloy containing Zn and Sn has slightly improved corrosion resistance. The highest I_{corr} as well as the corrosion rate have been observed in case of Mg-Zn-Cd alloy which may be due to higher dissolution rate under galvanic actions. It has also been observed (Fig. 1) that all the alloys are showing strong anodic polarization whereas the alloy containing Sn and Cd is cathodically controlled to a great extent. Also, in the galvanostatic polarization experiment, the Mg-alloy containing Sn and Cd develops lowest negative potential at equilibrium condition.

CONCLUSIONS

1.Alloying addition of Zn in Mg-Sn-Cd system is not beneficial from corrosion resistance point of view.

2.Addition of Cd has deleterious effect in Mg-Zn alloys

3.Dissolution tendency of the alloys studied in 3.5 % NaCl solution decreases in the following order

$$B > A > C > D$$

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