ARC Centre of Excellence Design in Light Metals

Australian Government
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Corrosion of Pure Magnesium in 3.5% NaCl Saturated with Mg(OH)2 solution

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1. BACKGROUND

In order to simulate the galvanic corrosion process of Mg and Mg alloys, corrosion rate should be measured by electrochemical methods accurately;

The current problem is the corrosion rate calculated from weight loss and hydrogen evolution does not match well with the electrochemical measurement.

AIMS

Explore the error sources and eliminate their negative effects;

Provide the accurate fundamental data for the future modelling.

2. EXPERIMENTAL

Specimen preparation:

-- Cold epoxy resin and hot compressed moulding;

--Free moulding: hanging with fishing line (immersion test) and copper wire plug-in sample (electrochemical test)

Corrosion test: Weight loss and hydrogen collection

Electrochemical measurement

Tafel polarisation curves, corrosion potential monitoring and electrochemical impedance measurement

Microstructure

SEM and MeX software to build 3D images

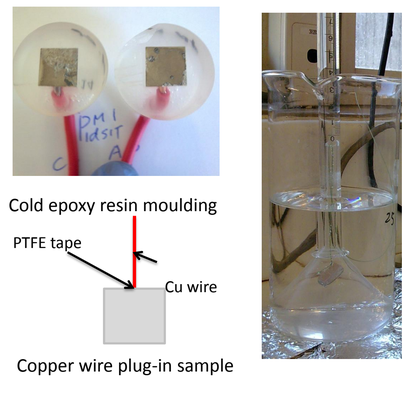

Fig. 1 (a) Moulded and free-moulding samples; (b) H_2 collection apparatus

3. RESULTS AND DISCUSSION

3.1 Effect of moulding pressure on corrosion rate

During immersion test, it was found that the cold moulded samples showed a severe crevice corrosion in the long term test. The severe crevice corrosion affects accuracy of the weight loss and hydrogen collection due to the area change and incomplete removal of part of corrosion product in crevice

In order to reduce the effect of crevice corrosion, the hot compressed sealed samples were tested. The corrosion data in Fig 2 showed the pressure affected the corrosion rate of pure magnesium and the crevice behaviours of sample.

Higher pressure reduced the crevice corrosion but high pressure changed the shape of sample and affected corrosion rate also.

Free moulding samples avoided the crevice corrosion.

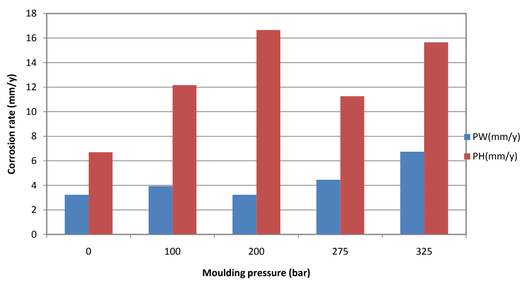

Fig. 2 Corrosion rate of pure magnesium moulded under different pressure in 3.5% NaCl + $Mg(OH)_2$solution at room temperature.

3.2 Corrosion rate from weight loss and H_2 collection

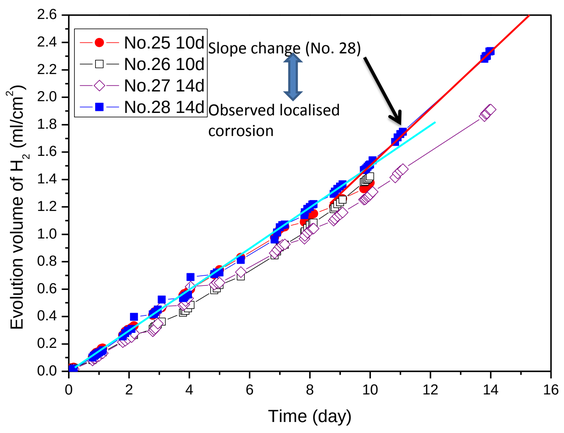

Fig. 3 Hydrogen evolution curves of pure Mg1 in 3.5%NaCl+$Mg(OH)_2$ solution for 10 and 14 days

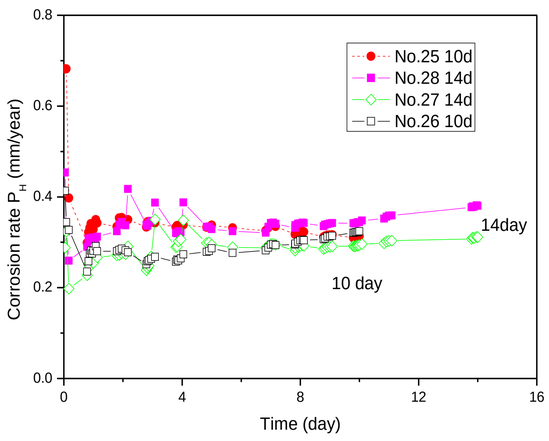

Fig. 4 Average corrosion rate of pure Mg1 calculated from hydrogen evolution in 3.5% NaCl + $Mg(OH)_2$

Corrosion rate calculated from weight loss, hydrogen collection and corrosion current density should match with each others without the influence of crevice corrosion according to the following equations.

$Pw=2.1\Delta W$ $P_H=2.279V_H$ $P_i=22.85icorr$

From Table 1, the corrosion rate of the free moulding samples calculated from weight loss and hydrogen collection matched very well. Table 2 listed the corrosion rates calculated from Tafel curves matched with the above results also.

	ΔW (mg/cm².d)	V_{H2} (ml/cm2.day)	Pw (mm/year)	P_{H2} (mm/year)
No. 25	0.1634	0.1375	0.3431	0.3133
No. 26	0.16486	0.1422	0.3462	0.3240
No. 27	0.1279	0.1365	0.2685	0.3114
No. 28	0.1303	0.1669	0.2737	0.3804

Table 1 Corrosion rate of pure Mg in the long term immersion test. ($Pw=2.1\Delta W$ $P_H=2.279V_H$)

3.3 Corrosion rate calculated from Tafel polarisation curves

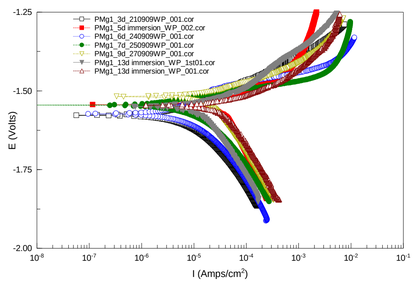

Fig. 5 Tafel polarisation curves of pure Mg in 3.5%NaCl+$Mg(OH)_2$ solution, scanning rate 10mV/min

	Ba (mV)	Icorr (A/cm2)	Ecorr(V)	Pi (mm/year)
3d WP	71.51	2.78E-6	-1.5775	0.0635
7d WP	27.855	1.367E-6	-1.5461	0.0312
9d WP	59.465	1.7235E-5	-1.5185	0.3938
13d WP	119.78	1.6946E-5	-1.5341	0.387
13d1	118.58	9.49E-5	-1.5826	2.168
	Bc(mV)	Icorr (A/cm2)	Ecorr(V)	Pi (mm/year)
3d Wp	-197.72	8.058E-6	-1.5775	0.1841
7d WP	-193.03	1.107E-5	-1.5461	0.2529
9d WP	-248.7	1.8878E-5	-1.5187	0.431
13d WP	-239.44	1.2589E-5	-1.5413	0.2876
13d1	-268.96	3.26E-5	-1.5826	0.7446

Table 2 Corrosion rate of pure Mg measured by Tafel curves. ($P_i=22.85icorr$)

3.4 Morphology of corroded specimens

Fig. 6 showed that the corrosion morphology of free hanging pure magnesium samples in 3.5% NaCl +$Mg(OH)_2$ solution initiated from visible uniform corrosion with the corrosion product participation on the surface. With increasing immersion time, the localised corrosion was found near the edge and the corrosion product layer broke-down nearby.

The free moulding samples did not show crevice corrosion.

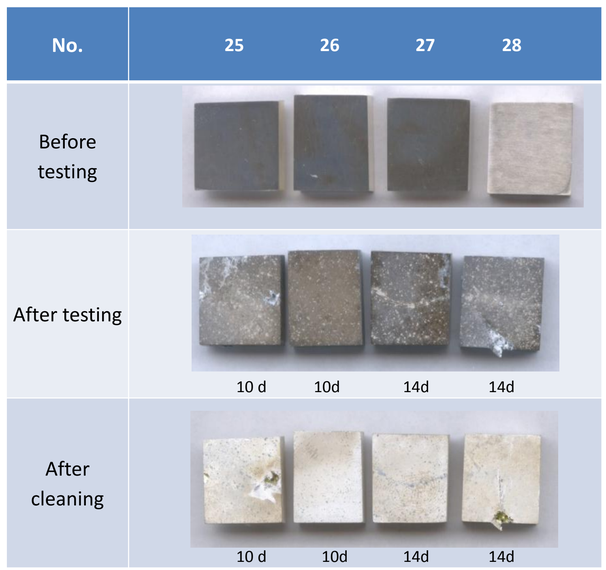

Fig. 6 Morphology of corroded pure magnesium in 3.5%NaCl +$Mg(OH)_2$ solution

3.5 Microstructure

The microstructure of the corroded samples was observed in SEM. In order to explore the real images of the sample, the corrosion product was removed from the surface. In the meantime, the SEM images observed with a special tilt angel were used to build the 3D images of the surface by Alicona MeX 4.1 software in order to calculate the surface roughness after removal of corrosion product. The surface roughness increased with the immersion time.

3D image

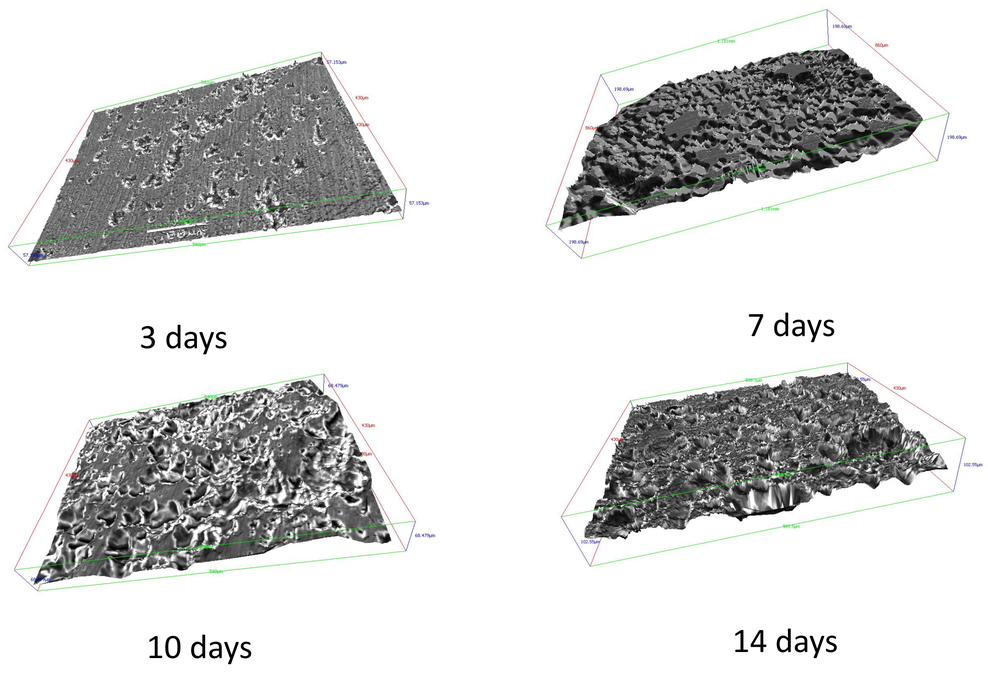

Fig. 7 3D images of corroded pure magnesium in 3.5%NaCl +$Mg(OH)_2$ solution after removal of corrosion product

4 CONCLUSIONS

1. The corrosion rate of the moulded samples was affected by the crevice corrosion for the long term test;
2. The accuracy of the corrosion measurement of magnesium could be improved by avoiding or reducing crevice corrosion;
3. The corrosion rate calculated from weight loss and hydrogen evolution should match with the corrosion rate calculated from Tafel polarisation curves without the influence of crevice corrosion.

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