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Prevention of Crevice Corrosion of STS 304 Stainless Steel by a Mg-alloy Galvanic Anode

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Prevention of crevice corrosion was studied for STS 304 stainless steel using a Mg-alloy galvanic anode in solutions with various specific resistivity. The crevice corrosion and corrosion protection characteristics of the steel was investigated by the electrochemical polarization and galvanic corrosion tests. Experimental results show that the crevice corrosion of STS 304 stainless steel does not occur in solutions of high specific resistivity, but it occurs in solutions of low specific resistivity like in solutions with resistivities of 30, 60 and 115 Ω · m. With decreasing specific resistivity of the solution, the electrode potential of STS 304 stainless steel in the crevice is lowered. The potential of STS 304 stainless steel in the crevice after coupling is cathodically polarized more by decreasing specific resistivity indicating that the crevice corrosion of STS 304 stainless steel is prevented by the Mg-alloy galvanic anode.

Keywords : *stainless steel, crevice corrosion, cyclic polarization, cathodic protection, Mg-alloy galvanic anode*

1. Introduction

Stainless steels have been widely used for hot-water boiler, hot-water storage tank and pipeline etc. However, the steels are subjected to localized corrosion by chlorine ion.

Stainless steels show good resistance to uniform corrosion, but low resistance to pitting and crevice corrosion. Unlike uniform corrosion, the pitting and crevice corrosion are localized initially on the metal surface, but inward propagation rate is unusually fast. The pitting corrosion brings about a leak of equipment in a relatively short time. Crevice corrosion is similar to pitting corrosion in many aspects, including the mechanism, but unlike pitting corrosion, it causes severe corrosion damage because crevice forms from the beginning of the service.

In this work, the crevice corrosion and its prevention were investigated for STS 304 stainless steel in solutions with various specific resistivities using a Mg-alloy galvanic anode by cyclic polarization and galvanic corrosion tests.

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2. Specimens and experimental method

Material used in this study is STS 304, austenitic stainless steel. The chemical compositions and mechanical properties of the material are shown in Table 1. A Mg-alloy galvanic anode applied to protect crevice corrosion has the chemical compositions shown in Table 2.

Table 1. Chemical compositions and mechanical properties of STS 304 stainless steel

Chemical composition (wt %)	C	Si	Mn	P	S	Ni	Cr
	0.04	0.5	1.09	0.02	0.005	8.1	18.4
Mechanical properties	Tensile strength (MPa)		Yield strength (MPa)		Elongation (%)		
	519		205		55		

Table 2. Chemical compositions of Mg-base alloys galvanic anode

Chemical composition (wt%)	Al	Zn	Cu	Mn	Fe	Ni	Mg
	6.0	3.1	0.15	0.06	0.003	0.001	Balance

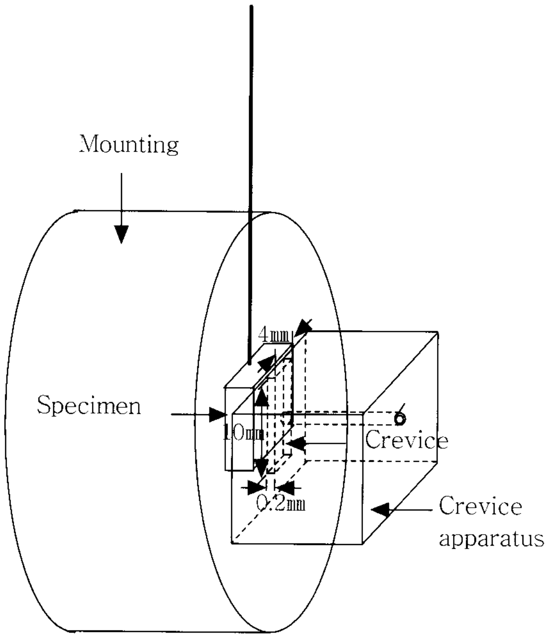
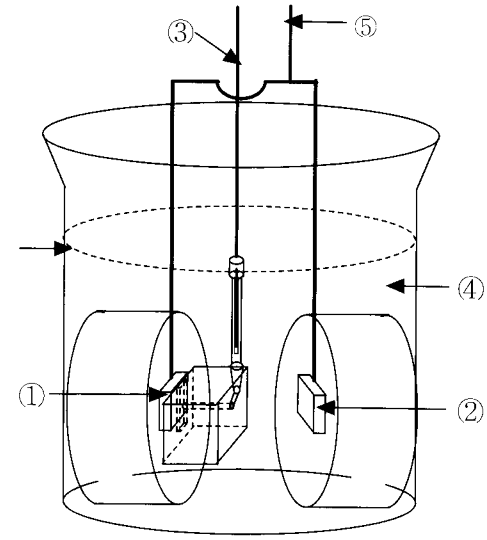


Fig. 1. Shape and dimension of electrochemical crevice corrosion test specimen (unit: mm)



① Cathode(STS 304 stainless steel)
② Anode(Mg-alloy galvanic anode)
③ Reference electrode(SCE) ④ Electrolyte
⑥ Working electrode

Fig. 2. Schematic diagram of test cell.

The shape and dimension of specimen and crevice assembly are as shown in Fig. 1. The specimen was mounted using a resin to have effective exposure area of specimen is 1.0 cm^2. The crevice generation apparatus is manufactured to the dimension of 4 mm wide, 10 mm long and 0.2 mm slot.

For the electrochemical polarization test, SCE(saturated calomel electrode) was used as reference electrode and high density carbon rod as counter electrode. Test solution is made by adding NaCl to distilled water to have specific resistivities of control 30, 60, 115 and 5850 Ω · m solution. The temperature of test solution was 60±1℃.

The schematic diagram of test cell for crevice corrosion prevention by Mg-alloy galvanic anode is shown in Fig. 2. The potential of internal crevice after electrical connection of STS 304 stainless steel to galvanic anode was measured at the point of 3 mm from the upper surface of crevice washer using a potentiostat/galvanostat (EG&G Model 273).

3. Results and discussion

3.1 Cyclic polarization of STS 304 stainless steel

Fig. 3 shows cyclic polarization curves of STS 304 stainless steel in solutions with various specific resistivities. Cyclic polarization behaviors is shown to be dependent upon the resistivity of the solution. In a solution with specific resistivity of 5850 Ω · m, current density is higher in anodic polarization than in reverse polarization, but the reverse is the case in solutions with lower specific resistivity, that is, in solutions with specific resistivities of 30, 60 and 115 Ω · m. The passive film of STS 304 stainless steel destroyed at positive scan may be restored in 5850 Ω · m solution, but may not be in 115, 60 and 30Ω · m solutions.

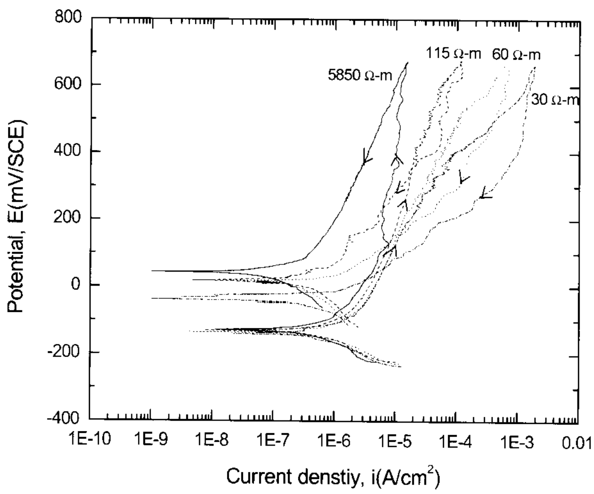


Fig. 3. Cyclic polarization curves of STS 304 stainless steel in solutions of various specific resistivities at 60 ℃

This indicates that STS 304 stainless steel may be passivated in a solution with specific resistivity of 5850 Ω · m and crevice corrosion can easily occur by chlorine ion in solutions with specific resistivities of specific resistivities of 30, 60 and 115 Ω · m.

The size of hysterisis loop of STS 304 stainless steel is shown to be larger with decreasing specific resistivity of solution. The magnitude of corrosion current density in the anodic scan increases with decreasing specific resistivity.

3.2 Electrode potential in the crevice

Fig. 4. shows electrode potential of STS 304 stainless steel in the crevice in solutions with various specific resistivities. Electrode potential in the crevice was high in the early stage and decreased with time. Fig. 5 shows mean electrode potential of STS 304 stainless steel in the crevice in solutions of various specific resistivities. As the specific resistivity decreases, mean electrode potential of STS 304 in the crevice is lowered.

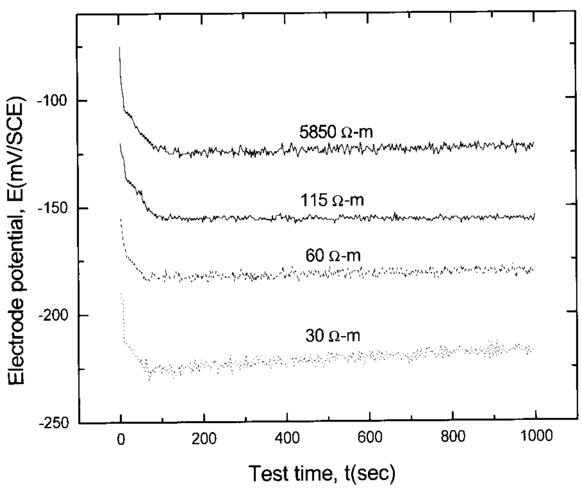


Fig. 4. Electrode potential of STS 304 stainless steel in solutions of various specific resistivities

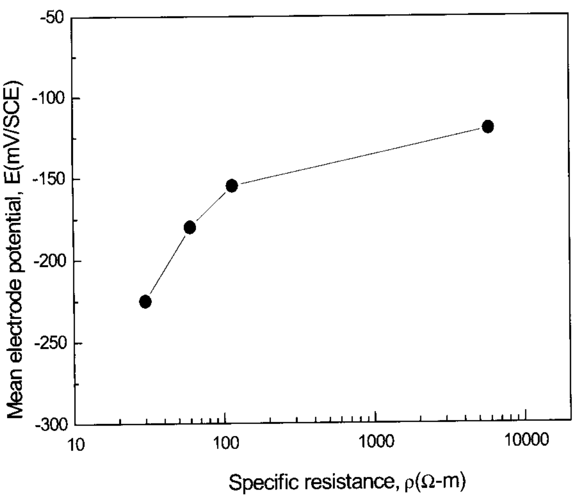


Fig. 5. Mean electrode potential of STS 304 stainless steel in solutions of various specific resistivities.

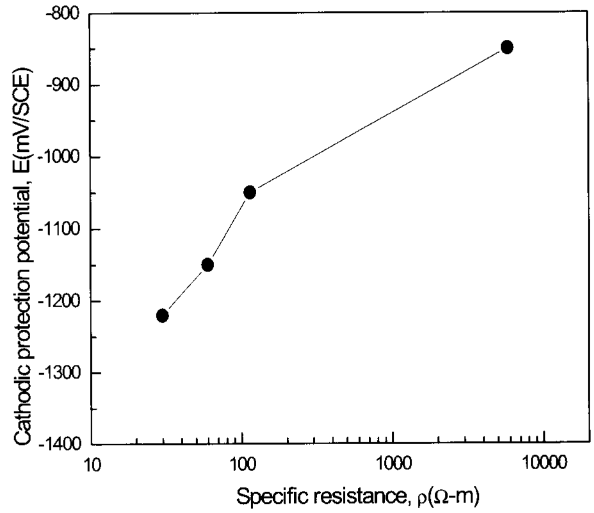


Fig. 6. Cathodic protection potential of STS 304 stainless steel by Mg-alloy galvanic anode in solutions of various specific resistivities

3.3 Crevice corrosion protection

Fig. 6 shows the potential of STS 304 stainless steel measured in the crevice after galvanic coupling with a Mg-alloy galvanic anode. The potential in the crevice is lowered with increasing specific resistivity. In all solutions investigated, the potential in the crevice is cahtodically polarized by about 730～1000 mV/SCE compared with respect to the uncoupled electrode potential. This indicates that the crevice corrosion of STS 304 stainless steel is prevented by the Mg-alloy galvanic anode.

4. Conclusions

The crevice corrosion behavior and corrosion protection characteristics of STS 304 stainless steel was investigated using a Mg-alloy galvanic anode. Conclusions drawn from this work are as follows:

1) The crevice corrosion of STS 304 stainless steel does not occur in a solution with high specific resistivity, but occurs in solutions with low specific resistivities, 30, 60, 115 Ω · m.

2) With decreasing the specific resistivity, the electrode potential of STS 304 stainless steel in the crevice is lowered.

3) The coupled potential of STS 304 stainless steel in the crevice is cathodically polarized more with decreasing specific resistivity, indicating that the crevice corrosion of STS 304 stainless steel is protected by the Mg-alloy galvanic anode.

References

1. Y. H. Lee, "Corrosion and protection data book", KICAT, p. 153 (1997).
2. Hisashi hashimoto, "Examples of corrosion and protection hot water tank", boiler **266**, 49 (1994).
3. Denny A. Jones, Principles and prevention of corrosion, Macmillan Publishing Co., p. 118 (1996).
4. O. Ito, "Corrosion and protection", Owna Co., Japan, p. 180 (1986).
5. W. S. Tait, "An introduction to electrochemical corrosion testing for practicing engineers and scientists", p. 65 (1994).
6. S. Yoshizawa, K. Yamakawa, and A. Katagiri, "An introduction to corrosion and protection of metals", p. 97 (1989).
7. D. H. Jeon, "Practical corrosion protection engineering", Taehwa Co., p. 106 (1990).