Journal of Korean Institute of surface Engineering
Vol. 32, No. 3, Jun., 1999

CORROSION BEHAVIOR OF Al-Zn ALLOY AS A SACRIFICIAL ANODE OF ORV TUBES

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Abstract

ORV which vaporizes LNG to NG is consisted of tube and header whose substrate is aluminum alloy. The corrosion of the tube is very severe because of sea water being used as the heating source. In this research to protect ORV substrate material, the corrosion behavior of aluminum alloys was investigated for the sacrificial role of Al-Zn alloy for ORV tubes. The electrochemical behavior of aluminum alloys in sea water was investigated. The corrosion behavior of thermally-sprayed and cladded samples were compared through salt spray tests. Al-Zn alloy can act as a sacrificial anode and cladded Al-Zn alloy has a better corrosion resistance than that of thermally sprayed one. The galvanic effect of Al-Zn to substrate material was conformed from scratched sample tests.

Key words : *ORV, Sacrificial anode, Salt spraying test, Al-Zn alloy*

1. INTRODUCTION

Liquefied natural gas (LNG) is converted to natural gas (NG) through the Open Rack Vaporizer(ORV). To vaporize LNG, sea water has been used as the heating source in the ORV. The tube of the ORV is made of AA3003 aluminum alloy and the corrosion of the tube in the sea water is very severe[1),2)]. The ORV tubes were protected by the thermally sprayed Al-Zn alloy these days, however, the coating layer of Al-Zn is not dense and then sometimes the layer is peeled off and the pitting corrosion was developed under the coating layer[3)]. In this study, the role of Al-Zn alloy as the sacrificial anode was investigated and the corrosion behavior of the thermally-sprayed and cladded layer of the Al-Zn alloy were also investigated through the salt spray test.

2. EXPERIMENTAL PROCEDURE

The electrochemical behavior of AA3003, substrate material, and Al-Zn alloy in synthetic sea water were investigated with potentiostat. The thermally-sprayed and cladded Al-Zn sample were prepared from the fin of ORV tubes. Fins were cut and only single surface was exposed by covering with epoxy and then salt spraying tests were conducted for 600hrs. The samples were picked up with scheduled time for the weight loss measurement and the surface/cross-sectional morphology investigation. ASTM standard method was used for weight loss measurement and calculation[4]. In the salt spraying test, the galvanic effects of scratched samples were investigated for the feasibility of the Al-Zn alloy as the sacrificial anode.

3. RESULTS AND DISCUSSION

3. 1 Polarization plots

The polarization plot of AA3003 and Al-Zn alloys in sea water were obtained and compared. Fig. 1 shows the polarization plot of samples in sea water. From Fig. 1 the rest potential Al-Zn alloys were approximately 200mV lower than that of AA3003 and the corrosion current density of all aluminum alloys were the same order of magnitude. It is the indication of Al-Zn alloy as sacrificial anode for AA3003 substrate material.

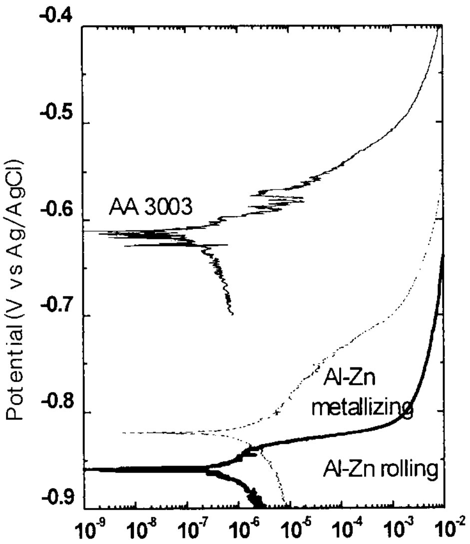


Fig. 1 Polarization plots in deaerated syntheic sea water at 25℃.

3. 2 Salt spraying test

From the salt spraying test results, the corrosion resistance of cladded Al-Zn alloy is superior to thermally-sprayed sample. Fig. 2 shows the results of salt spraying test. The weight loss of thermally-sprayed and cladded Al-Zn alloy after 600hrs test were 256g/m^2 and 127g/m^2 respectively. And those are equivalent to 50mpy and 23mpy respectively. The corrosion rate of thermally-sprayed one is almost twice of that of cladded one. It is due to the high surface area of thermally-sprayed one. The cross sections of samples were investigated by optical microscope.

Fig. 3 shows the cross-sectional view of tested samples. The cladded sample was not attacked severely. However, the thermally-sprayed one was severely attacked and corrosion products were found both on the surface of sample and on interface of Al-Zn and AA3003. To examine the interface of samples, the cross section of inter-

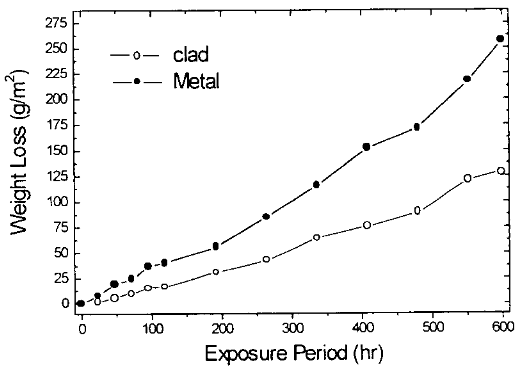
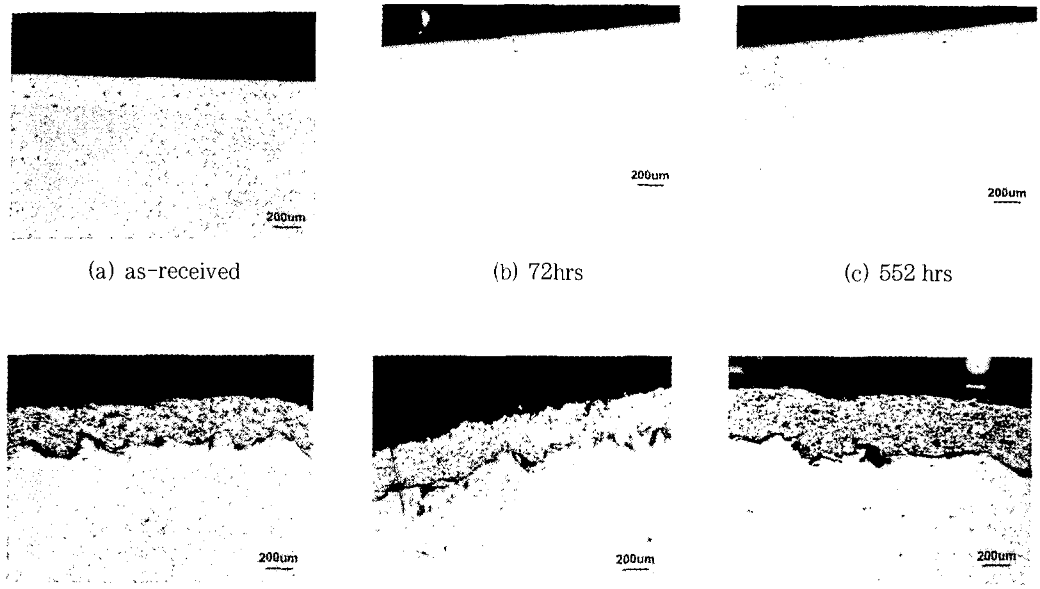


Fig. 2 Weight loss with time in salt spraying test.



(a) as-received (b) 72hrs (c) 552 hrs

(d) as-received (e) 72hrs (f) 552 hrs

Fig. 3 Cross-sectional view of tested samples in salt spraying test.
(a), (b), (c) ; cladded layer , (d), (e), (f) ; thermally-sprayed layer

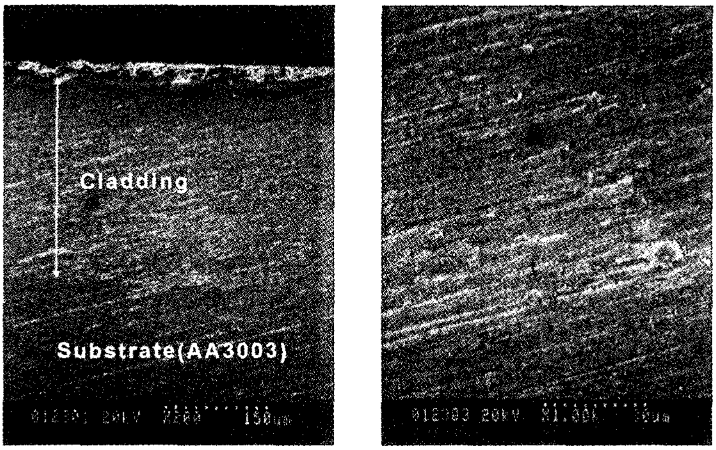
face were observed by SEM. Fig. 4 shows the cross sectional view of samples by SEM. In cladded sample, corrosion products were found only on surface of sample. However, in thermally-sprayed one, corrosion products were found not only on surface of sample but also on interface of sprayed layer and substrate. It is due to the penetration of anions to the interface through pores in sprayed coating layer.

The galvanic effects were investigated through scratched samples. Samples were scratched with 1mm depth, enough to expose substrate, and salt spraying tests were conducted for 600hrs. After 600hrs salt spraying test, only coated layers of both samples were attacked for both samples. The substrates were protected by galvanic effect of Al-Zn alloy to AA3003. And then Al-Zn alloy can act as sacrificial anode.

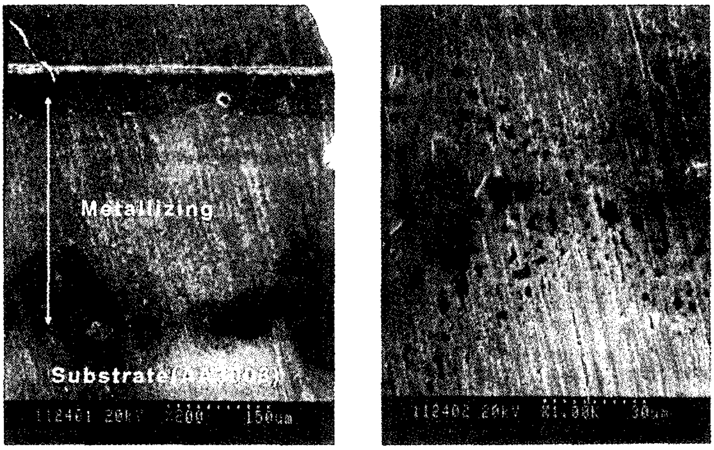
4. CONCLUSION

1) From the results of polarization plots, the rest potential of Al-Zn alloy in sea water was approximately 200mV lower than that of AA3003. And then Al-Zn alloy can be acted as the sacrificial anode for the ORV tubes. The galvanic effect of Al-Zn alloy to AA3003 was observed through scratched sample salt spraying test.

2) The corrosion rate of thermally-sprayed sample is 50mpy and it is twice of that of cladded one. It is due to that the cladded one can form more protective coating layer than thermally-sprayed sample. The corrosion products were found on interface of coated layer and substrate in thermally-sprayed sample.



(a)



(b)

Fig. 4 SEM images of cross-sections of tested sample after 600hrs salt spraying test.
(a) cladded (b) thermally-sprayed

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