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ELECTROCHEMICAL BEHAVIOUR OF Al-BRASS IN SEAWATER

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ABSTRACT

Corrosion of the Al-brass in 3.5 % NaCl solution and natural seawater was investigated with potentiodynamic polarization technique. Corrosion rate obtained in natural seawater was higher than in 3.56 % NaCl solution. The metallographic examinations indicated the occurrence of pitting corrosion in both cases.

Keywords: Al-brass, corrosion, potentiodynamic polarization technique

1. INTRODUCTION

In electricity utilities and process plants located in coastal zones, seawater is frequently used directly in heat exchangers and condensers as a coolant. Aluminium brass and copper-nickel alloys have been used for condenser tubes where seawater is used for cooling. Corrosion of the condenser tube can cause leakage and contaminates steam that is on shell side. For example leakage from one hole on condenser tube with diameter of 0.15 mm can contaminate all the steam condensate with NaCl for 3-4 hours [1]. This corrosion damage of steam condenser tubes can occur if the seawater is polluted with sulphide ions [2,3,4,5]. That reduces power plants steam turbine usefulness, reliability and durability with considerable material damage. Because of relatively low cost and high corrosion resistance Al-brass is used for tubes in seawater cooled steam condensers. In the present work, the corrosion characteristics of Al-brass alloy were investigated in different conditions. The electrochemical parameters were obtained by use of the Tafel plots and anodic potentiodynamic polarization curves of Al-brass under different conditions.

2. EXPERIMENT

For the electrochemical analyses the test electrodes were cut and prepared from the original steam condensers tube. Specimens were then mounted in cold setting resin. The open surface (1cm^2) $^{\text{was}}$ prepared by abrading on series of emery papers until the finest grade of 600 was reached. Polished specimens were then degreased with acetone and washed with distilled water just before setting up cell. The initial potential in anodic polarization was at -250 mV (SHE), and the scan rate was 1 mV/s. Anodic polarization studies were carried out with a three-electrode system using a computer-controlled Potentiostate/Galvanostate Model 342, with Softcorr Measurement Software, Model 342, (to control the potentiodynamic process)-EG and G/Princeton Applied Research Corp. Platinum electrode was used as counter electrode, a saturated calomel electrode (SCE) was used as reference electrode, and condenser tube material was used as working electrode. The specimens were immersed into different stagnant solutions: 1) 3.56% NaCl solution, 2) aerated natural seawater from Plomin bay. Temperature of solutions was 20°C. The surface analysis of corrosion products formed on inner wall of Al- brass steam condenser tube in natural seawater performed with Wavelength Dispersive Analysis-WDX is presented too.

3. RESULTS AND ANALYSIS

The chemical analysis of working electrode (condenser tube material) is presented in Table 1. This chemical analysis shows that condenser tube material corresponds to CuZn20Al2 .00 alloy.

Table 1. Chemical composition of test alloy

Elements, wt %					
Cu	Zn	Al	Sn	Fe	Mn
77.47	20.58	1.61	0.21	0.59	0.30

Corrosion data for CuZn20Al2.00 alloy obtained in different condition of samples exposure are presented in Table 2. It is obvious that the E_{corr} of Al-brass shifted toward the active direction in the aerated natural seawater in comparison with the E_{corr} in 3.56 wt% NaCl solution. Corrosion rate for Al-brass in natural seawater was two times higher than in 3.56 wt% NaCl solution.

Table 2. Corrosion data obtained for a CuZn20Al2.00 alloy electrode in different solutions

Solutions	E_{corr}, mV vs. SCE	Corrosion rate, x 10^{-2} mm year $^{-1}$
3.56 wt% NaCl	- 226	2.88
Aerated natural seawater	- 245	2.54

The anodic potentiodynamic polarization curves for Al-brass in each condition are given in Figures 1 and 2. Corrosion rates were carried out using the Tafel plots obtained in same conditions as tested alloy.

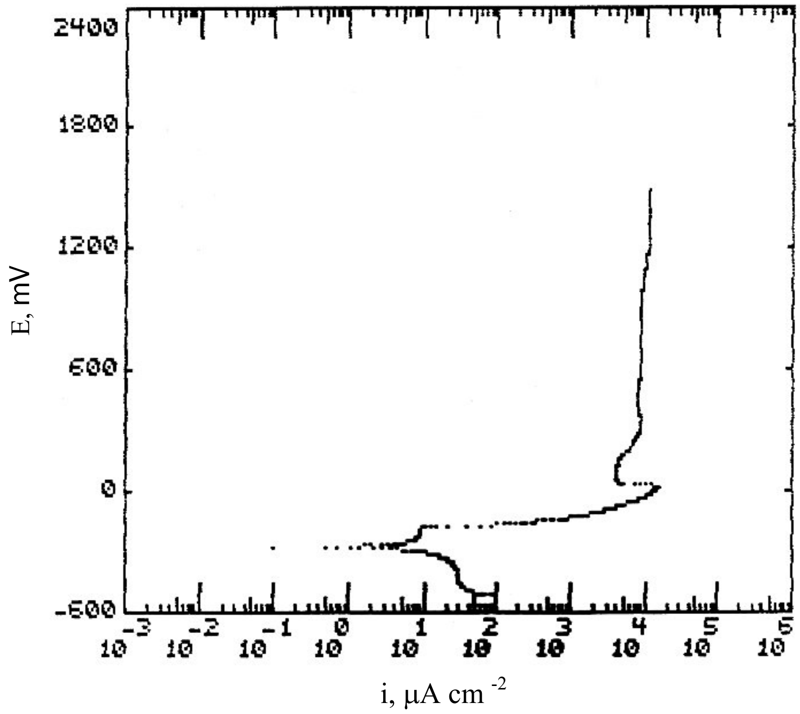


Figure 1. Anodic polarization curve obtained for Al-brass in 3.56 wt% NaCl solution

Figure 1 show that the value of current density, i_{crit} obtained for Al-brass in 3.56 wt% NaCl solution is very high, close to 10^4 µA cm $^{-2}$. For the homogeneous protective passive films the i_{crit} value is lower. At a very high i_{crit} value the protective passive film cannot occur. This film is porous and is not protective and because of this corrosion of Al-brass continuous propagates. Corrosion rate obtained using the Tafel plots for the Al-brass in these conditions was 2.88 x 10^{-2} mm year $^{-1}$.

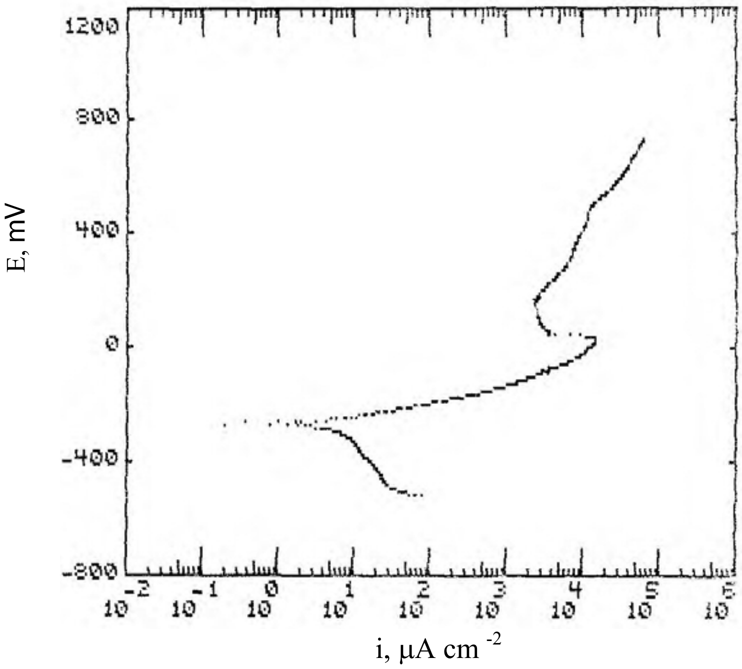


Figure 2. Anodic polarization curve of Al-brass in aerated natural seawater

The anodic polarization curve in Figure 2 is similar to curve in Figure 1 but in this case the pseudo-passive film [5] was formed. High current density i_{crit} value as i_{pass} indicates that this film is porous and pitting corrosion is possible to occur. A very high increase of current density at transition from E_{pit} in trans-passive area (Figure 2) shows that the formed passive film was very weak. Corrosion rate obtained using the Tafel plots for the Al-brass in these conditions was 2.54 x 10^{-2} mm year $^{-1}$. Figure 3 showed cross-section of inner wall of steam condenser tube CuZn20Al2.00 alloy after 370 hours in exploitation into condenser. The average temperature of cooling seawater was 19^0 C. Velocity of cooling seawater was 1.5 m/s. In these conditions on Al-brass the pitting corrosion was occurred. Black pits occurred on the inner wall of condenser tube (Figure 3) and high corrosion rate indicates that the natural cooling seawater was polluted with sulphides.

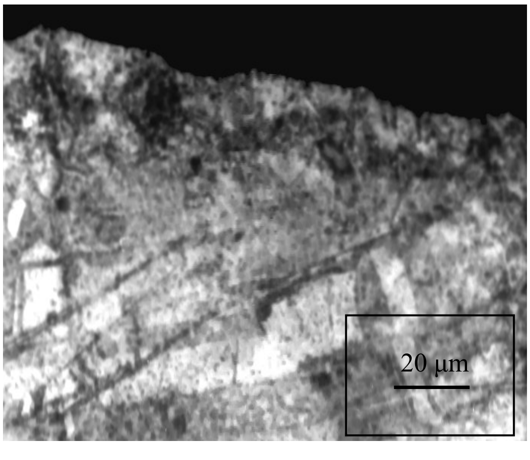
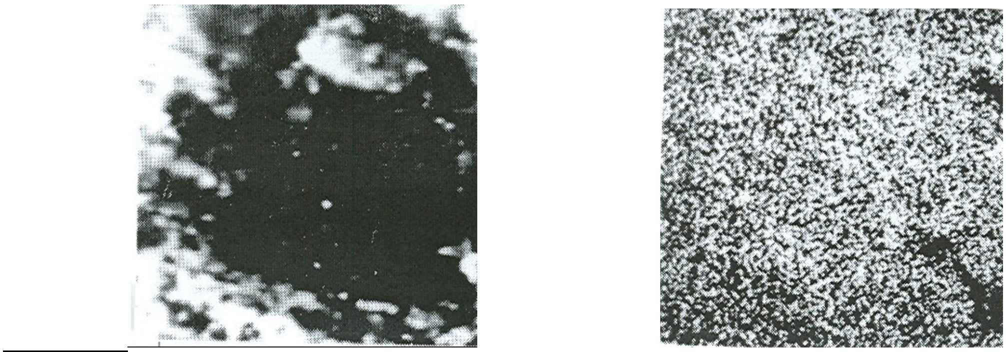


Figure 3. Cross-section of inner wall of steam condenser tube CuZn20Al2.00 alloy cooled by seawater; magnification: 500x

Figure 4 shows the electronic image (a) of corrosion pit detected on the cross section surface of the inner wall of Al-brass steam condenser tube cooled by natural seawater and sulphur presence on corrosion pit obtained by WDX-analysis (b).



a b

Figure 4. (a)The electron image of corrosion pit surface on the cross-section surface of inner wall of steam condenser tube specimen (magnification: 300x); (b) WDX-image of sulphur present on pit surface

WDX image on Figure 4 shows great concentration of sulphur on whole pit surface.

4. CONCLUSION

The obtained electrochemical parameters presented in Table 2 shows that corrosion rate of CuZn20Al2.00 alloy was two times higher in aerated natural seawater than in 3.56 wt% NaCl solution. For both cases (Figures 1 and 2) the anodic potentiodynamic polarization curves showed a small passive region. This region is termed as "pseudo-passivity". The corrosion film formed in such a way is not a protective one, but contributes to the formation and propagation of pitting corrosion of the condenser tube CuZn20Al2.00 alloy. The difference between values of i_{crit} is very small for the both of anodic potentiodynamic polarization curves (Figures 1and 2), and that means that the passive protective layer was not formed. For the formation of compact homogenous protective passive film, in these conditions, the value of i_{crit} must be smaller than obtained.

5. REFERENCES

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