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INVESTIGATION PITTING CORROSION OF ASTM 321 STAINLESS STEEL

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ABSTRACT

This paper presents results of research pitting corrosion of ASTM 321 stainless steel. Investigated pitting corrosion was performed in 0,9 and 3,0% NaCl solutions with and without air. The severity of pitting corrosion of stainless steel ASTM 321, was used to compare with the intensity of pitting corrosion of stainless steel ASTM 316 L. Investigations were conducted in the corrosion cell according to ASTM G5 on instrument potentiostat/galvanostat PAR 263A-2 with the software PowerCORR®. Corrosion was investigated with method of cyclic polarisation.

Keywords: ASTM 321 stainless steels, titanium, pitting corrosion, cyclic polarisation.

1. INTRODUCTION

Stainless steels are iron-base alloys containing at least 10.5% Cr [1]. With increasing chromium content and the presence or absence of some ten to fifteen other elements, stainless steels can provide an extraordinary range of corrosion resistance. Stainless steels generally are subject to pitting corrosion. Pitting corrosion represents an important limitation to the safe and reliable use of many alloys in various industries. Pitting is a very serious type of corrosion damage because of the rapidity with which metallic sections might be perforated. The unanticipated occurrence of pitting and its unpredictable propagation rate make it difficult to take it into consideration in practical engineering designs. Pitting corrosion is defined as an extremely localized corrosive attack. Simply stated, pitting is the type of localized corrosion that produces pits, that is, sites of corrosive attack that are relatively small compared to the overall exposed surface. In the presence of halide ions, especially chloride, may lead to formation of pitting [2]. Pitting corrosion of stainless steels is manifested by the rapid growth of current at achieving specific values of anode potential, caused by the formation of pitting. Pitting corrosion can be prevented if the anions present in solution, hindering the adsorption of chloride, or push chloride from the metal surface. Adding other anions in the solution containing chloride (chromate, nitrate, environmentally-friendly organic compounds…) moves the value of pitting potential in anodic area [1]. The resistance to pitting corrosion can be enhanced by increasing the content of chromium, molybdenum and nitrogen at stainless steel.

Type 321 is a standard austenitic 18/8 chromium nickel alloy with the addition of titanium making it an excellent choice in elevated temperature environments. The titanium stabilises the material removing its susceptibility to the effects of intergranular corrosion. 321 is therefore the stainless steel material of choice for applications in working environments up to 900^0 C. A drawback of Type 321 is that the titanium does not transfer well across a high temperature arc, so it is not recommended as a welding consumable [1]. The steel has excellent forming and welding qualities and excellent toughness even at cryogenic temperatures.

2. EXPERIMENTAL PART

Investigations were conducted in the corrosion cell according to ASTM G5, on instrument potentiostat/galvanostat PAR 263A-2, with the software PowerCORR®. Corrosion was investigated with method of cyclic polarisation [4, 5]. Corrosion test was performed on stainless steels ASTM 321 and ASTM 316 L, the chemical compositions given in Table 1.

Table 1. Chemical compositions of tested stainless steels

Designation ASTM	C	Si	Mn	P_{max}	S	N	Cr	Mo	Ni	Others
316L	≤ 0,03	≤ 1,00	≤ 2,00	0,045	≤0,015	≤ 0,11	16,5-18,5	2-2,5	10-13	-
321	≤ 0,08	≤ 1,00	≤ 2,00	0,045	≤0,015	-	17-19	-	9-12	Ti: 5xC

Investigated pitting corrosion was performed in 0,9 and 3,0% NaCl solutions with and without air. Tests were performed at room temperature. Deairation content of electrolytes within the cells was performed with argon, 30 minutes, as required by ASTM standard G5-94.

3. RESULTS AND DISCUSSION

To test pitting corrosion of 321 stainless steel were used method of cyclic polarization. The method of cyclic polarization includes scans the potential to a vertex potential and reverses at the current threshold after crossing the vertex potential. The results of test pitting corrosion of 321 stainless steel are given in Figures 1, 2 and 3. Figure 1 shows the effect of the concentration of chloride on pitting corrosion of ASTM 321 stainless steel. Figure 2 shows pitting corrosion of ASTM 321 stainless steel in 3% NaCl with and without the presence of air.

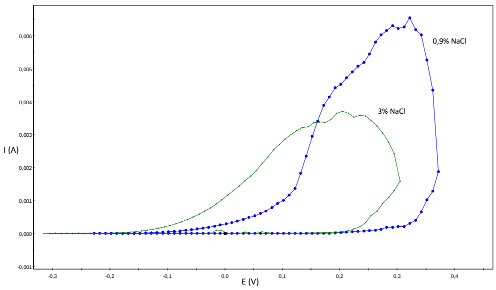

Figure 1. Cyclic polarization curves

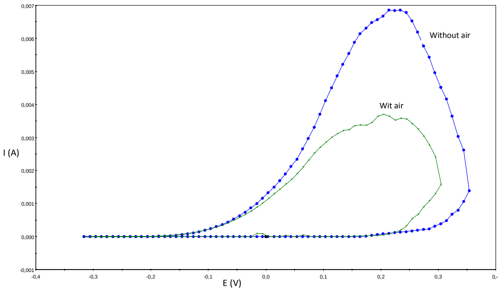

Figure 2. Cyclic polarization curves

Pitting corrosion of stainless steels is manifested by the rapid growth of current at achieving specific values of anode potential, piting potential. Negative values of pitting potential mean that steels prone to pitting corrosion. In Figure 1 can be seen that the 3% NaCl more aggressive medium for steel ASTM 321 than 0.9% NaCl. This is because the pitting potential of steel ASTM 321 treated in 3% NaCl more negative than pitting potential of steel ASTM 321 treated in 0.9% NaCl. Deaeration of 3% NaCl solution is an increase in the value of pitting potential of steel ASTM 321, Figure 2. Figure 2 shows that the presence of air in a solution of 3% NaCl increases the intensity of the pitting corrosion of steel above. For insights into evaluating the intensity of pitting corrosion stainless steel ASTM 321, conducted its evaluation by comparison with the intensity of pitting corrosion of stainless steel ASTM 316 L, Figure 3. The test was performed in 3% NaCl solution without deaeration. Type 316L is a molybdenum-containing austenitic stainless steel intended to provide improved corrosion resistance relative to type 304/304L which represents standard Cr-Ni steel. Molybdenum in combination with chromium is very effective in terms of stabilizing the passive film in the presence of chlorides. Molybdenum is especially effective in increasing resistance to the initiation of pitting and crevice corrosion[1, 3].

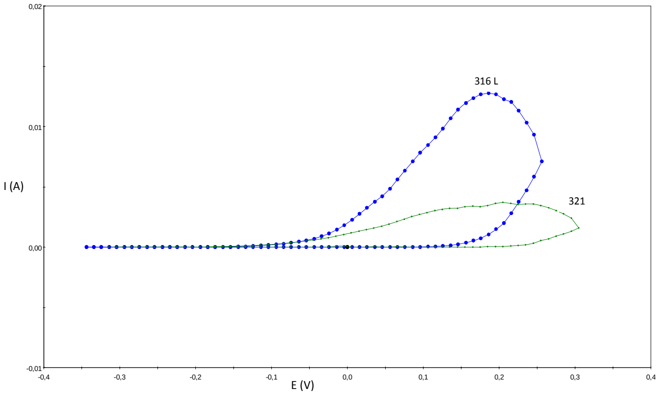

Figure 3. Cyclic polarization curves

From figure 3 it can be seen that in 3% NaCl solution pitting corrosion more intensive on steel ASTM 316 L than pitting corrosion on steel ASTM 321. The reason is that the pitting potential of steel ASTM 321 in a solution of 3% NaCl more positive than pitting potential of steel ASTM 316 L. Also hysteresis loop area is smaller for steel ASTM 321 than for steel ASTM 316 L. Hysteresis loop area is a rough measure of the intensity of pitting corrosion. Larger size means greater intensity of pitting corrosion.

Addition of titanium in austenitic stainless steel ASTM 321 significantly reduced the pitting corrosion. Addition of titanium to stainless steel ASTM 321 is more influenced by the decrease in the intensity of pitting corrosion than the addition of molybdenum in stainless steel ASTM 316 L.

4. CONCLUSION

Test results show that in real conditions of exploitation intensity of pitting corrosion on stainless steel ASTM 321 increased with increasing concentrations of chloride as well as in the presence of air. Addition of titanium with chromium and nickel significantly reduced the severity of pitting corrosion of stainless steel ASTM 321. Addition of titanium in stainless steel ASTM 321 moves pitting potential to more positive values, thus reducing the intensity of pitting corrosion. Results show that the addition of titanium to stainless steel ASTM 321 is more influenced by the decrease in the intensity of pitting corrosion than the addition of molybdenum in stainless steel ASTM 316 L.

5. REFERENCES

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