Localized Corrosion Characteristics of Ultra-high Nitrogen Bearing Austenitic Stainless Steels in Artificial Seawater

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Abstract

In the use of stainless steels in seawater environment, localized corrosion such as pitting corrosion and crevice corrosion becomes a problem. It is well known that the alloying chromium, molybdenum or nitrogen is effective in order to improve localized corrosion resistance of stainless steel. From the viewpoint of resource saving, it is desirable to decrease chromium and molybdenum contents. To produce resource saving type stainless steel with excellent localized corrosion resistance, two key technologies were adopted. One is highly nitrogen alloying, the other purification of the material itself. In this study, localized corrosion resistance of nitrogen-bearing austenitic stainless steels of up to 1.2 mass % were electrochemically examined.

Three series of stainless steels were used in the test. One is highly purified stainless steels produced by VIF in which the nitrogen level changes from 0.17 to 0.23 mass %(V1-V6 in Table 1). Secondary, N_2 gas absorption treatments were carried out for these steels at 1200C(V1N-V5N). And third series were of highly purified ones with ultra-high nitrogen of about 1 mass% obtained by pressurized electroslag remelting (P-ESR) method (P1-P3). In this method, ingots produced by P-ESR were cut, forged and rolled followed by solution heat treatment. It was confirmed that all the materials used in the tests had austenite single-phase microstructure.

Localized corrosion resistance of the stainless steels was evaluated by means of electrochemical crevice corrosion test using multiple crevice specimens. After scanning the potential at 1mV/min from the corrosion potential to a fixed potential, then the specimen was held at the potential during for 48 hours. The fixed potential was raised up by every 25mV. Crevice corrosion potential (CCP) is defined as the noblest potential at which crevice corrosion does not occur through the test.

Figure 1 shows a relation between crevice corrosion resistance equivalent (CRE; %Cr+3*%Mo+10*%N) and CCP in artificial seawater. It was clearly seen that a positive correlation between CRE and CCP was recognized for all the specimens tested. Moreover, crevice corrosion of P2(1N-2Mo steel) and P3(1.2N-4Mo steel) could not be recognized in all the potential under 0.8 Vvs.SCE. It was also found that molybdenum containing ultra-high nitrogen stainless steels have superior crevice corrosion resistance.

Figure 2 shows the effect of molybdenum content on CCP in artificial seawater. It was found that molybdenum was an effective element to improve crevice corrosion resistance not only for low nitrogen steels (16.5Cr-14Ni-0.2N) but also for ultra-high nitrogen steels (23Cr-2/4Ni-1/1.2N). Though ultra-high nitrogen bearing steel of molybdenum free showed good crevice corrosion resistance, molybdenum bearing ones did better, which indicated there was a synergistic effect between molybdenum and nitrogen.

Crevice corrosion resistance of nitrogen bearing stainless steel was electrochemically investigated. It was shown that ultra-high nitrogen stainless steels have superior crevice corrosion resistance and the molybdenum was also effective for the crevice corrosion resistance improvement.

Table 1 Chemical composition of steels (mass%).

Sample	Ni	Cr	Mo	N	Remark
V1	14.1	16.7	0.00	0.19	VIF
V2	14.1	16.4	2.29	0.17	VIF
V3	14.1	16.5	3.93	0.17	VIF
V4	13.9	16.4	5.86	0.19	VIF
V5	14.1	20.3	1.95	0.23	VIF
V6	14.2	25.3	2.06	0.23	VIF
V1N	14.1	16.7	0.00	0.37	VIF+N_2 absorption
V3N	14.1	16.5	3.93	0.45	VIF+N_2 absorption
V4N	13.9	16.4	5.86	0.29	VIF+N_2 absorption
V5N	14.1	20.3	1.95	0.63	VIF+N_2 absorption
P1	4.5	23.6	0.02	0.96	P-ESR
P2	4.2	23.6	1.96	1.05	P-ESR
P3	2.3	23.6	4.11	1.23	P-ESR

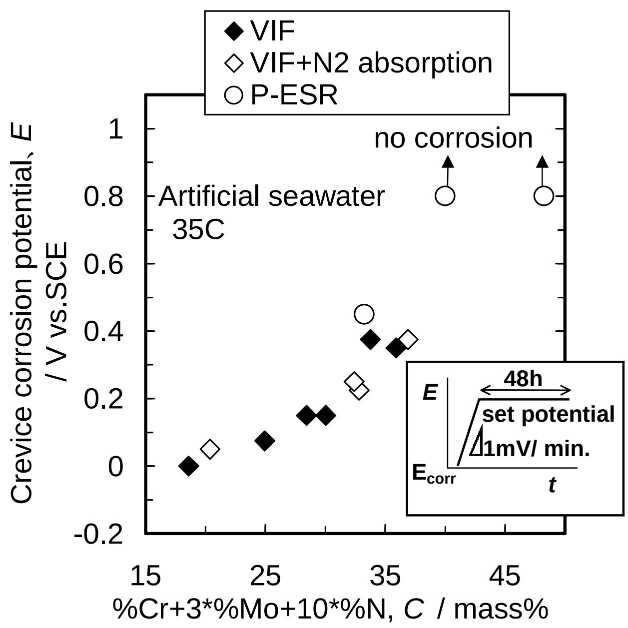

Fig.1 Relationship between crevice corrosion resistance equivalent (%Cr+3*%Mo+10*%N) and crevice corrosion potential of nitrogen bearing stainless steels in artificial seawater (35C).

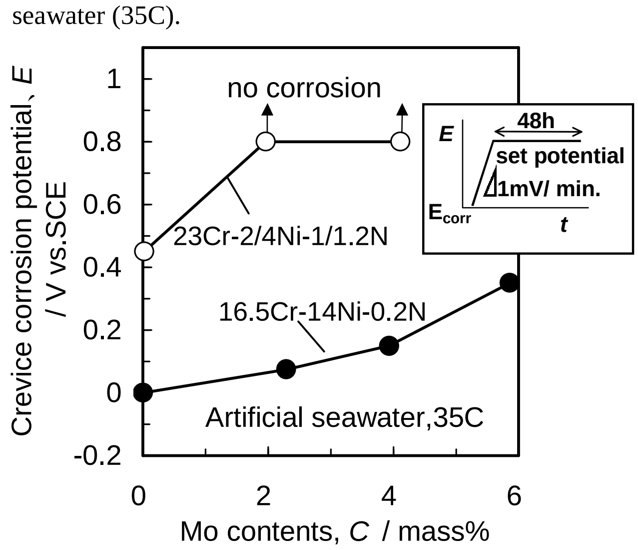

Fig.2 Effect of molybdenum content on crevice corrosion potential in artificial seawater (35C).