Nickel boride as an inhibitor for the ODSCC of Alloy 600

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1. Introduction

Steam generator Alloy 600 tubes has been known to be susceptible to intergranular stress corrosion cracking (IGSCC) in the primary and secondary side conditions in commercial pressurized water reactors (PWR). The outer diameter stress corrosion cracking (ODSCC) of Alloy 600 tubes occuring in the secondary side is one of the leading causes of S/G plugging worldwide. [1] Remidial techniques to mitigate the phenomenon have been extensively studied and one of the techniques is to insert an inhibitor to the secondary side of the steam generators in PWRs. Recently, Hur et al. proposed CeB_6 as a better inhibitor than ones that had been proposed previously.[2] Yi et al. compared the inhibiting efficiency of several candidate inhibitors and reported that borides could inhibit the IGSCC of Alloy 600 in a 40% NaOH solution.[3]

In this study, from the standpoint of solubility, two types of boride, the SCC inhibition of CeB_6 and NiB were evaluated since, to apply an inhibitor to nuclear power plants, the chemical should be dissolved into the secondary side water. To do this, slow strain rate tensile (SSRT) tests were performed in a simulated secondary side water containing NH_3.

2. Experimental procedure

Chemical composition of the alloy 600 used is given in Table 1.Tensile samples with a gage length of 25.4 mm, a gage width of 4 mm, and a thickness of 1.07 mm were cut from steam generator tubes with an outer diameter of 19.05 mm and a thickness of 1.07 mm and used in the as-received conditions. SSRT tests were conducted in a static autoclave made of Alloy 625. The reference solution was prepared by adding small amount of ammonia, NH_3, to distilled water and the pH of the solution ranged from 9.5 to 9.7 at room temperature. Two other solutions were prepared by adding CeB_6 and NiB of 2g/l to the reference solution, respectively. The strain rate was 3 x 10^{-7} s^{-1}. Surface appearance in the gage length after the SSRT tests were examined with SEM. Surface chemical composition and depth profiles of the samples were evaluated using an Auger electron spectroscopy (AES, PHI 680 Auger nanoprobe) with an electron gun operating at a beam energy of 5 kV and a sample current of approximately 20-25nA.

3. Results

Figure 1 shows SEM micrographs of the gage lengths of samples tested in the solutions. The sample tested in the reference solution showed IG cracks as shown in the figure. When the borides were added into the reference solution no cracks were observed on the samples. This observation is consistent with the test results in 40% NaOH solution. [3] The concentration profiles of main elements measured by an AES are summarized in Figure 2. The oxide thiskness formed in the solutions containing borides were thinner than that formed in the reference solution. Also, the figure shows that the thinnest oxide was formed in the solution containing NiB, implying that NiB suppress the corrosion of Alloy 600 in the simulated secondary side water. This is considered to be attributable to the solubility of the candidate inhibitors. According to the information from Johnson Matthey Company [4] supplying the chemicals, NiB can be decomposed in water while CeB6 does not dissolve in hot and cold water.

4. Conclusion

It is concluded that NiB could be applicable to the secondary side water in nuclear power plants as a proper inhibitor for the ODSCC of Alloy 600.

REFERENCES

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[4] Information from Alfa Aesar, A Johnson Matthey Company.

TABLE 1 Chemical compositions of Alloy 600 (wt%)

C	Ni	Cr	Fe	Ti	Al	Mn	Si	Co	Cu	N	B	P	S
0.026	72.4	16.81	9.01	0.36	0.16	0.83	0.33	0.01	0.01	0.018	0.001	0.007	0.001

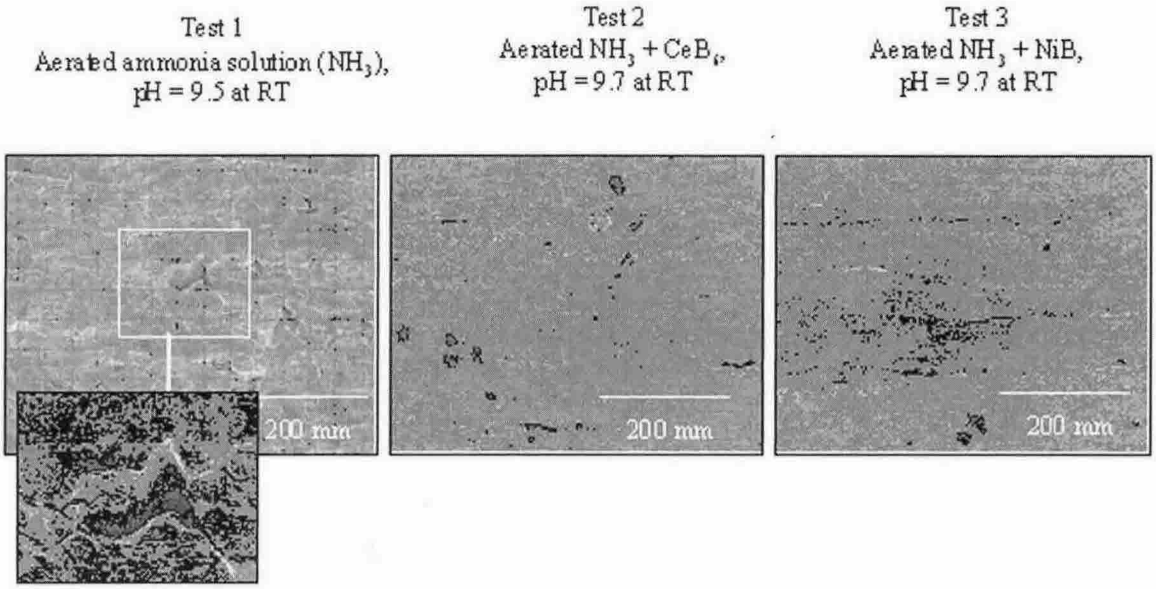

Figure 1. SEM micrographs of gage lengths of thesamples after SSRTs

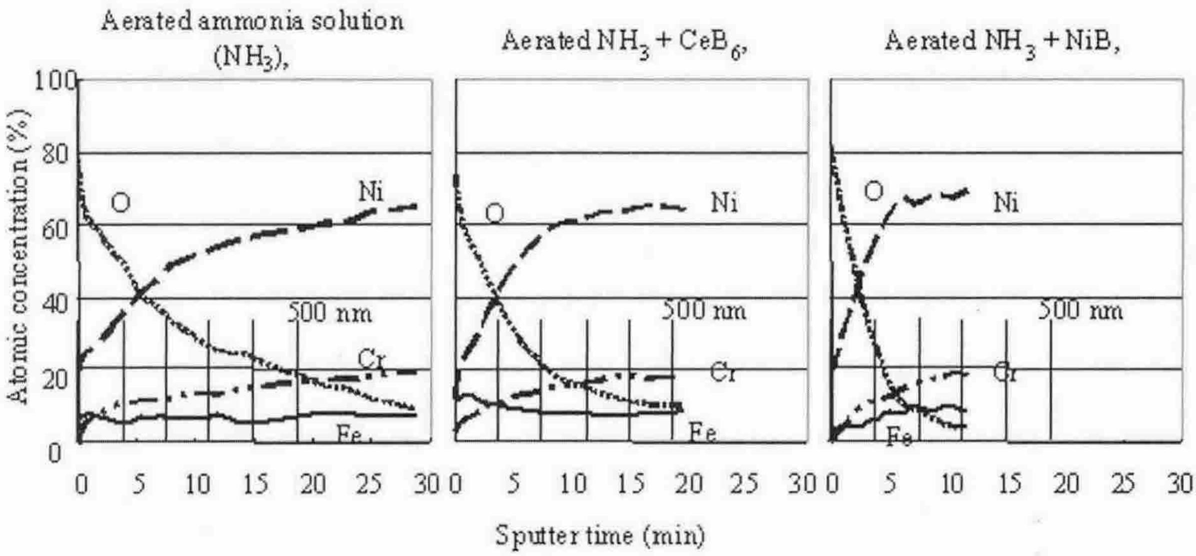

Figure 2. AES depth profile of the samples showing the oxide thickness and concentration profiles.