Evaluation of Corrosion Behavior with Various Corrosion Inhibitors in Closed Cooling Water System

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1. Introduction

The Closed Cooling Water (CCW) piping consists of carbon steel in many CCW systems. CCW can have a falling-off in quality of the system by corrosion, microbial growth, fouling to prevent corrosion, we must accurately evaluate influence of an inhibitor in CCW system [1]. In the case of CCW of some domestic nuclear power plants, during overhaul period, saturation of ion exchange resin caused by an inhibitor which has high conductivity for an increase in radiation exposure and radioactive waste [2]. Corrosion inhibition in recirculated cooling water systems historically depended on the oxidizing inhibitors. In most cases, carbon steel corrosion control in CCW systems is achieved by adding corrosion inhibitor chemicals. In nuclear plants, these inhibitors have included chromates, nitrites, molybdates, hydrazine, and silicate.

The objective of this study is to evaluate the corrosion behavior of structural materials according to corrosion inhibitor.

2. Experimental Method

2.1 Materials and inhibitor

The test materials were carbon steel (SA106 Gr. B), Ti alloy (SB338 Gr.B) used to CCW pipe material and carbon steel (SA516-70) used to shell side of heat exchanger. Chemical compositions of test materials are shown in table 1 and 2.

Table 1. Chemical compositions of Ti alloy (wt %)

Alloy	Ti	Al	Zr	V	Fe	O	H	N	C	Others
SB338 Gr.B	Bal.	-	-		≤0.30	≤0.25	≤0.015	≤0.03	≤0.10	≤0.4

Table 2. Chemical compositions of carbon steel (wt %)

Alloy	Mo	Ni	P	Si	Cr	S	Mn	C	Al	Cu	Nb	V
SA106 Gr. B	0.15	0.4	0.035	0.1	0.4	0.035	0.29/1.06	0.3	-	0.4	-	0.08
SA516-70	0.08	0.3	0.03	0.6	0.3	0.03	1.0/1.7	0.1/0.22	0.02	0.3	0.01	0.02

In order to analyze the corrosion behavior with environment, the inhibitor used nitrite, hydrazine, polysilicate and molybdate . Table 3 shows the detail of the test conditions.

Table 3. Water chemistry conditions

Inhibitor	Temperature	pH	Dissolved Oxygen
Nitrite (800ppm)	30, 60, 90	9.3±0.5	deaerated, air-saturated
Hydrazine (25ppm)	30, 60, 90	9.3±0.5	deaerated
Polysilicate	30, 60, 90	9.3±0.5	deaerated, air-saturated
Molybdate	30, 60, 90	9.3±0.5	deaerated, air-saturated

2.2 Surface analysis test

The specimen processes wire cutting from the base metal. It was polished by #2000 emery paper, and finally polished with 0.3 ㎛ alumina pastes. The polished specimens have been washed in acetone at ultrasonic cleaning, and weighed on an electric balance with a sensitivity of within 0.1 mg. The total surface area measured with 256.28 mm^2.

The cleanliness of the surface presence of foreign matter can exert a very strong influence on the initiation and rate of corrosion [3]. So the test that we extracted specimens from the reaction cell and cleansed it in acetone, which is used in ultrasonic cleaning process. In order to measure the corrosion rate, we measured the weight of specimens on an electric balance with a sensitivity of within 0.1 mg. Also we took a photograph of specimens to observe the change of the surface feature each of specimens.

2.3 Potentiodynamic polarization test

We used the commercial potentiostat system. That being, nitrogen gas purging for the removing dissolved oxygen were performed over 1 hour. Cathodic charging caught with -1000 mV during 10 min. Scan rate was 0.5 mV/s, and scan range was -1000~1000 mV. The sample area is $2cm^2$

After the test was completed, we measured the pH of the aqueous solution after being cooled.

3. Results and Discussion

3.2 Surface analysis test

To know the changes on surface of specimen in the corrosion inhibitor, surface of specimen was observed by using an optical microscope. As shown in Figure 1, surface of specimen in nitrite solution occurred corrosion less than deaerated water. Surface of hydrazine solution created corrosion product. Deaerated silicate and molybdate have the similar status that don't have many corrosion product.

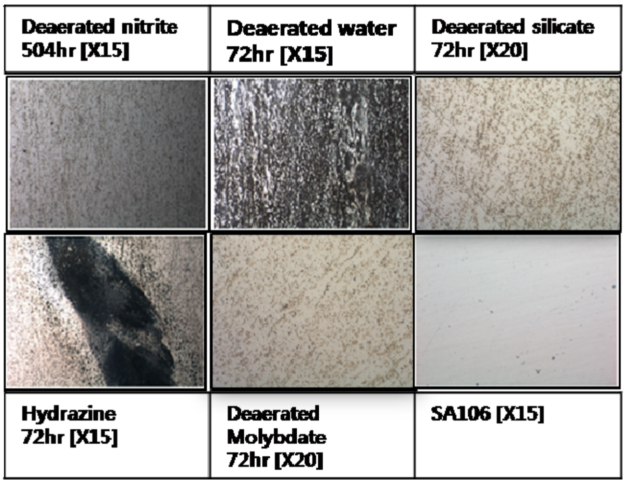

Figure 1. Specimen surface after immersion test (SA106 Gr.B)

3.3 Potentiodynamic polarization test

The corrosion potential is the voltage on the forward scan at which the specimen changes from cathodic to anodic. The current density is related to the corrosion rate of the specimen. As shown in Figure 2, nitrite is higher than distilled water on corrosion potential. Nitrite has a distinct active region and shows the current density that is lower than distilled water. The other hand, hydrazine is no passive region in the polarization curve and has corrosion potential that is higher distilled water. Also hydrazine has a high current density. All corrosion inhibitors needed to have a minimum requirement. But the amount of hydrazine existed less than that of minimum requirement, therefore, it might cause by limit of our test equipment that was not fully sealed against air.

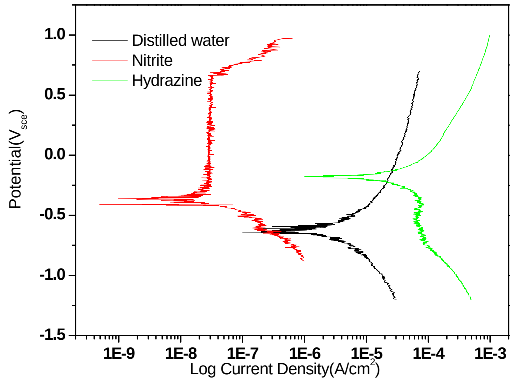

Figure 2. Polarization curves of SA106 Gr.B in 800 ppm sodium nitrite solution, in 25 ppm hydrazine solution and distilled water at 90°C

4. Summary

The surface analysis test determined that nitrite was good corrosion inhibitor. The potentiodynamic polarization test showed higher current density in hydrazine solution than in nitrite. We are examining the corrosive properties of various corrosion inhibitors and using to new test equipment.

Acknowledgment

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