Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

Effect of Cr content on the Flow Accelerated Corrosion of pressure pipe

T. J. Park* H. P. Kim
Nuclear Materials Development Division, Korea Atomic Energy Research Institute,
989-111 Daedeokdaero, Yuseong-gu, Daejeon 305-353, Republic of Korea
**Corresponding author: ptj@kaeri.re.kr*

1. Introduction

Since the Surry Unit 2 accident in 1986, flow accelerated corrosion (FAC) has been extensively studied. However, many accidents caused by FAC have been reported such as an accident at Mihama Unit 3 in 2004 and at domestic plants [1-3]. During the FAC, a protective oxide layer on carbon steel dissolves into flowing water leading to a thinning of the oxide layer and accelerating corrosion of base material. As a result, severe failures occur in the piping and equipment of nuclear power plants (NPPs). Numerous parameters such as the geometry, pH, flow velocity, steam quality, dissolved oxygen (DO), temperature, and materials have an influence on FAC [4,5]. This paper describes the effect of chromium content in material on FAC of carbon steel at 150℃.

2. Experimental

We designed a small-scale FAC test loop and constructed it to test carbon steel in an NPP environment, as shown in Fig. 1. This loop consists of a 1 gallon stainless steel autoclave with a magnetic driver, a 100ℓ chemical makeup tank, a high-pressure pump, a charging pump, a pre-heater, a cooling system, a back-pressure regulator, an ion-exchange system, and several valves. The dissolve oxygen (DO), conductivity, pH, pressure, flow rate, and temperature were measured in the loop.

Fig. 1. Photograph of FAC evaluation test loop.

Chemical compositions of specimens used in this work is shown in Table 1. Specimens with different chromium content were tested to validate the effect of chromium content on FAC. The SA106 Gr. B is used in the secondary piping of the domestic nuclear power plants. The test specimen dimension was 20 x 30 x 3 (mm^3)

and the test holder is shown in Fig. 2. The initial pH value of the solution was 6.3. Before testing, the solutions were deaerated with a high-purity (>99.99%) nitrogen gas for an hour to adjust the DO content below 1ppb. FAC test was performed at flow velocity of 4m/sec at 150℃ for 192 h duration. Surface was observed by Optical Microscopy and Oxide on specimens was examined with SEM/EDS, and XRD after the FAC test.

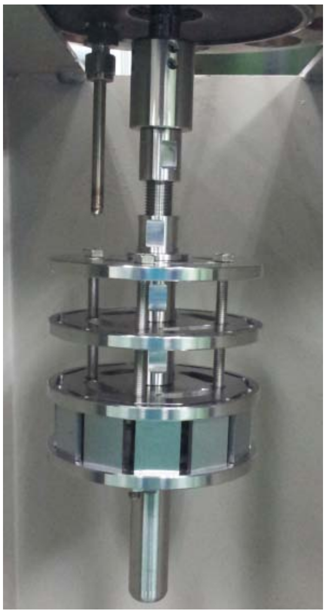

Fig. 2. Feature of the test specimen holder.

Table 1
Chemical compositions of specimens (%)

	Cr	Mo	C	Cu	Mn	Ni	Fe
SA106 Gr.B	0.02	0.01	0.19	0.04	0.37	0.02	bal
SA 508 Gr.3	0.17	0.46	0.22	0.03	1.22	0.68	bal
A534 8620H	0.61	0.21	0.21	0.20	0.88	0.48	bal
SA508 Gr.4N	1.803	0.491	0.184	0.001	0.330	3.441	bal
A336 F22V	2.4	0.9	0.10	0.1	0.4	0.1	bal

3. Results and Discussion

The surface of the specimens was covered with magnetite with black color. Pits were observed on specimen surface, indicating that test duration of 192 hours is initiation stage of FAC as shown in Fig. 3. The region around pit was examined with SEM-EDS. The specimen surface which had been in contact with specimen holder was exposed to very low flow velocity because flow was restricted in that surface. FAC was not observed on that surface because of low flow velocity. Weight loss of specimen decreased with increasing chromium content in material.

Fig. 3. The left photograph does not show pit(FAC) (ASTM A336 F22V) and the right photograph shows more pit(SA 508 Gr.3)

4. Summary

A small-scale FAC test loop was constructed and used for evaluation of chromium content of material on FAC in a nuclear power plant environment. DO was maintained at less than 1ppb. Appearance of specimen surface, oxide on specimen, degradation mode and weight loss were examined and discussed in terms of chromium content in material.

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