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Wall Thinning Evaluation of Welded Pipeline using FAC Demonstration Facility

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1. Introduction

Carbon steel and low-alloy steel are mainly used for piping in the secondary cooling system of nuclear power plants. As a nuclear power plant operates for a long period of time, flow accelerated corrosion(FAC) occurs due to the flow of cooling water, and this is affected by the material of the pipe and water chemistry conditions[1]. In particular, it is well known that dissimilar metal welds made of carbon steel and low alloy steel are very vulnerable to flow-accelerated corrosion[2]. In this study, we built a facility that can demonstrate the flow-accelerated corrosion under nuclear power plant operating conditions and performed FAC tests on dissimilar welds according to flow speed.

2. Methods and Results

In this section an FAC tests including the monitoring methods of thickness reduction in a welded pipeline are described and the test results are discussed.

2.1 Overview of FAC facility

The FAC demonstration test facility was constructed to test and evaluate the wall thinning rate of pipeline in a nuclear power plant secondary system waterchemistry environment. In order to demonstrate the pipe wall thinning phenomenon, the FAC test performed with a high temperature water at high fluid speed condition. The FAC facility consists of a main circulation loop connected with a test section, an injection water line and an extraction water line.

Fig. 1. FAC demonstration facility.

A purification system was added on the extraction water line in addition to a hydration system that was installed in the injection water line to ensure that the water chemical conditions, i.e., the DO and pH of the solution, could be controlled. An ion exchage resin, which is the purification system, was installed in the discharge water line, and a water chemistry control system was configured in the injection water line.

FAC test condition is as follows:

- Pressure, Temperature: 1.0 Mpa, 150℃
- Flow velocity : 7, 10, 12 m/s
- DO < 5 ppb, pH ~ 7, 9.5
- Test time : 50 days(1,200 hrs)

2.2 Test specimen

The test specimen was designed to measure wall-thinning caused by FAC as shown in Fig. 2. The test specimen was prepared as welded pipe using the commercial SA 106 Grade B carbon steel and SA335 P22 low alloy steel and each materials chemical compositions are shown in table 1.

Table 1 Chemical composition of pipe materials (wt%) supplied by Nippon Steel & Sumitomo Metal Corporation

Alloy	C	Si	Mn	Cu	Cr	Ni	Mo
SA106 Gr.B	0.19	0.24	0.98	0.02	0.04	0.02	0.01
SA335 P22	0.1	0.22	0.42		2.08		0.94

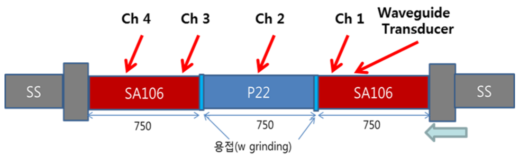

Fig. 2 Test section pipeline welded with low alloy steel (P22) between carbon steel (SA106) pipe. Four channel and waveguide ultrasonic transducers were attached for measurement of wall thickness.

2.3 FAC thickness monitoring methods

The thickness of pipline is continuously monitored during the test period using a high-temperature ultrasonic transducers. The total thining is measured by manual ultrasonic testing(UT) before and after FAC tests at room-temperature. High-temperature FAC monitoring systems are four channels of the buffer rod type(GE Rightrex model) BR-UT system(a) and KAERI made waveguide ultrasonic transducers type SH-UT system(b) shown in Fig. 3.

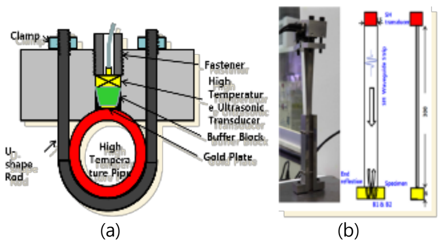

Fig. 3. Wall thickness monitoring transducers for a high temperature pipe: (a) BR-UT (b) SH-UT system.

2.4 FAC results and discussion

The results of pipe wall thickness on-line monitoring are obtained in condition of different flow rates and pH environment with four-channel buffer rod type (Fig. 4) and shear horizontal waveguide type UT measurement system (Fig. 5). Using the FAC demonstartion facility, a 2-inch outer diameter pipeline is tested under 7, 10, 12 m/s flow rate, and pH 7, 9.5 conditions. There was a difference in thinning rate between carbon steel and low allow steel pipe sections. KAERI developed a shear horizontal(SH) ultrasonic pitch-catch waveguide technique and it is applied to the FAC proof test facility. This measurement system was verified stable operation at a temperature cycling of up to 150℃ for several months and shows a superior performance over the commercial BR-UT measure system.

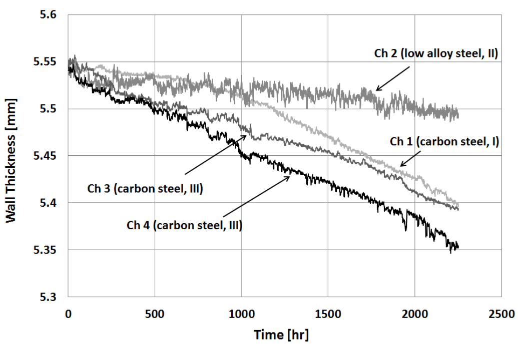

Fig. 4. FAC monitoring results by BR-UT system.

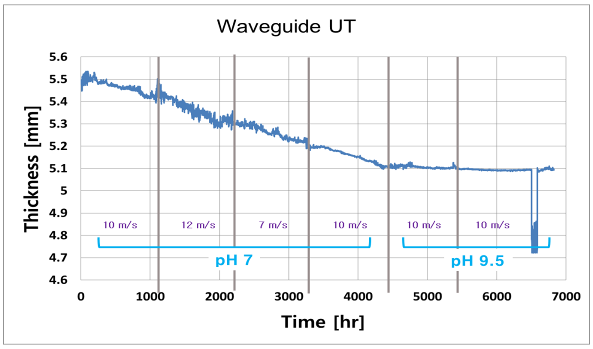

Fig. 5. FAC monitoring results by SH-UT system.

Even in the same carbon steel pipe, the amount of thinning rate was higher at the part where the fluid first contacts the pipe before the low-alloy steel, and the thinning rate of low-alloy steel was lower than that of carbon steel, about less than 1/3 of carbon steel thinng rate.

3. Conclusions

FAC demonstration tests were performed on welded pipe of carbon steel (SA106 Gr.B) and low alloy steel (SA335 P22) using a high-temperature and high-pressure flow rate test facility to demonstrate the wall thinning in the nuclear power plant secondary system.

In the pipe thickness measurement, a high-temperature UT device of a KAERI developed transducer and a commercial product model was installed at the same time to accurately measure the monitoring accuracy during the test period, and the measurement results were compared with each other to confirm that the precision of the KAERI developed wave guide method high-temperature UT measurement was higher

ACKNOWLEDGMENTS

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