ODSCC flaw development procedure for a leak test of SG tubes

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1. Introduction

Ni based alloy 600 materials have been used a lot for steam generator (SG) tubes which were being installed in Pressurized Water Reactor (PWR) nuclear power plants. Recently the trend is to replace alloy 600 SG tubes with alloy 690 materials because of its excellent corrosion resistance. The installed SG tubes in the existing PWRs have experienced various types of corrosion damage, such as a pitting, wastage and Stress Corrosion Cracking (SCC) on both the primary and secondary side. It is important to establish the repair criteria for the degraded tubes to assure a reactor integrity, and yet maintain the plugging ratio within the limits needed for an efficient operation. The steam generators at Kori-1 were replaced with new ones of alloy 690 materials. The primary coolant leakage to the secondary system is likely to suffer difficulties in the radiation safety management aspects when the steam generator tubes of the currently operating power plant have occurred SCC defects. Therefore, an evaluation of a coolant leakage behavior of the tubes containing stress corrosion cracks is very important under the pressure conditions of a operating or a virtual accident. In order to perform leak tests, it is essential to develop various forms of SCC defects on the tube surface. In the study, we are introducing the development measures for the various forms of SCC tube defects.

2. Methods and Results

2.1 Specimen Preparation

High temperature thermally treated (HTMA) alloy 600 tubes were used for the purpose of the present work. The outside diameter (OD) and the wall thickness (WT) of the tubes were 19.05mm (0.75 in.) and 1.07mm (0.042 in.), respectively. The specimens were cleaned in acetone and washed with a ethyl alcohol solution. Then the specimens were heat treated at 600^{o}C for 36-48 hours to produce a microstructure that is susceptible to a cracking. The heat treatment was performed in a tube filled with an argon-nitrogen mixture gas to avoid an oxidation of the tube surfaces. The specimens should not be burst during the SCC production process. Therefore, we set the conditions of the heat treatment based on a report in which the yield strength of the materials does not drop off during the heat treatment. Chemical compositions of the alloy 600HTMA tubes are shown in Table 1.

Table 1 Chemical compositions of alloy 600MA tube (wt %)

Alloy	C	Si	Mn	P	Cr	Ni	Fe	Co	Ti	Cu	Al	B	S	N
600MA	0.025	0.05	0.22	0.07	15.67	75.21	8.24	0.005	0.39	0.011	0.15	0.001	0.001	0.01

2.2 Development ODSCC

The outside of the tube was exposed to a 1M aqueous solution of a sodium tetrathionate ($Na_2S_4O_6$) solution at room temperature by a nitrogen gas pressurization of the inside of the tube by using the device shown in Fig.1. An applied pressure to develop the SCC was between the inside and outside operational pressure of the SG. An exposed surface to the solution was designed as shown in Fig.2. When an indication of a through-wall crack was confirmed by showing a internal pressure drop, the SCC development was finished.

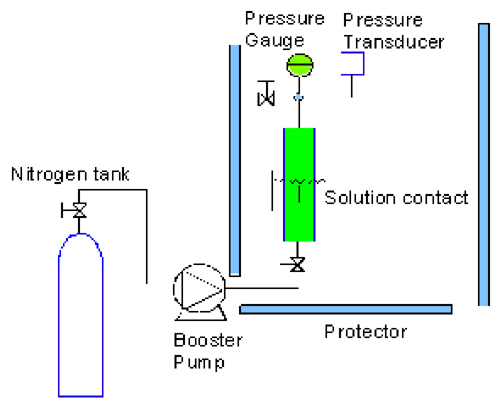

Fig.1. Schematic diagram of a pressurized device for producing stress corrosion cracks

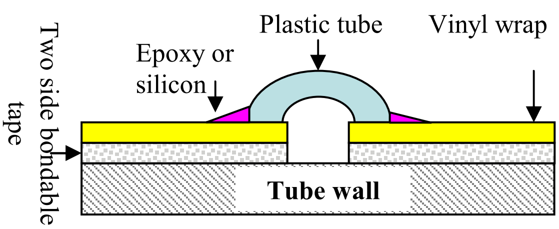

Fig.2. Taping method for continuous exposure solutions on the tube surface

2.3 Defects evaluation by non-destructive methods

The length and depth of the flawed specimens were determined by using a liquid penetration test and evaluated by a non-destructive inspection such as an Eddy current test (ECT). The ECT data was collected by using the MIZ-70 acquisition system with an

M/+point-610-MRPC probe. Table 2 shows information of the ECT. Before acquiring the ECT data for the tubes, a copper piece was attached on the tube surface to identify the position of the flaws.

Table 2 ECT Data acquisition system

	ECT data acquisition	
1	Acquisition system	MIZ-70 system, zetec
2	Flaw analysis	Eddynet Data Analysis System, zetec
3	Probe	M/+point-610-MRPC, zetec
4	Standard specimen	EDM Notch STD
5	Frequency(kHz)	400, 300, 100, 10, 700
6	Inspection rate	600 RPM, 0.2 inch/sec

2.4 Measuring the SCC flaws

The defects were observed with a zoom stereo microscope and flaw pictures were taken by using a digital camera (C-4040 ZOOM, OLYPUS). Fig. 3 shows a typical defect generated on the tube and the c-scan image analyzed with the eddy-net data analysis system. As shown in Fig.3, this specimen has a single through-wall crack and a 4.25 mm long axial crack in length. We have developed twenty axially flawed specimens having various lengths for the leak experiments.

3. Conclusions

◈ It is very important to evaluate a coolant leakage behavior of the tubes containing stress corrosion cracks.
◈ In order to create the defects on the desired location, we have developed a special SCC development technique.
◈ We have developed twenty axial ODSCC specimens having various lengths for the leak experiments.

REFERENCES

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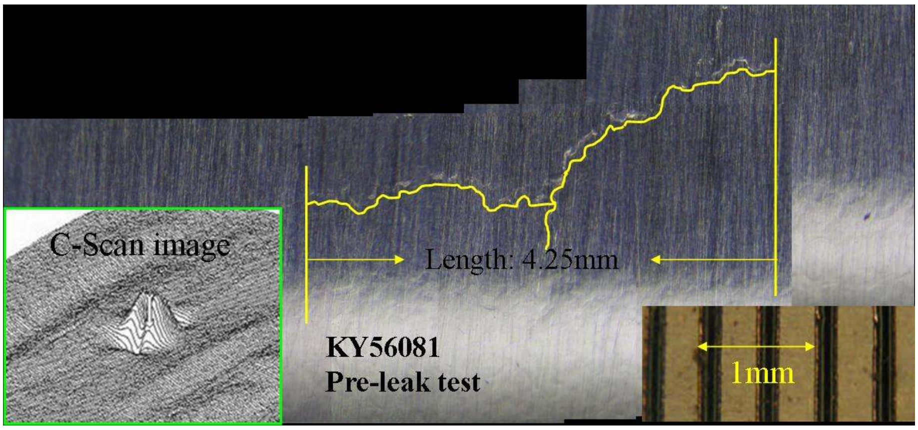

Fig.3. C-scan image (left-bottom) and feature of the crack