Measurement of Coolant Leakage from Lab Grown Axial Crack of SG Tubes

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1. Introduction

Steam generator(SG) tubes of a pressurized water reactor(PWR) have suffered from various types of corrosion, such as pitting, wastage and stress corrosion cracking (SCC) on both the primary and secondary side[1]. It is important to establish the repair criteria to assure a reactor integrity and yet maintain the plugging ratio within the limits needed for an efficient operation.

The objective of this work is to evaluate of coolant leakage from axial SCC cracks of SG tubes at room temperature.

2. Experimental

Laboratory induced stress corrosion cracks were developed in steam generator tube specimens. High temperature thermally treated(HTMA) alloy 600 tubes of which outer diameter is 19.05 mm and wall thickness is 1.07 mm were used in this work. The alloy 600 tubings were sensitized at 600 ^{o}C for 48 hours in a vacuum tube furnace. In order to avoid any oxidizing on the surface of the tubes, the furnace was vacuumed and back filled with helium and hydrogen mixture gas three times. The heat treated tube specimens were exposed to 1 M sodium tetrathionate solution at room temperature and pressurized with nitrogen gas. The pressure holding to develop cracks was stopped when a pressure drop on the tube was observed which indicates a development of a throughwall crack.

Leak rates in the degraded tubes were measured at room-temperature. The room temperature test facility as shown in Fig. 1 is equipped with a water pressurizing pump, a test specimen section, a control unit and it has the same feature as described in NUREG/CR-6511[2].

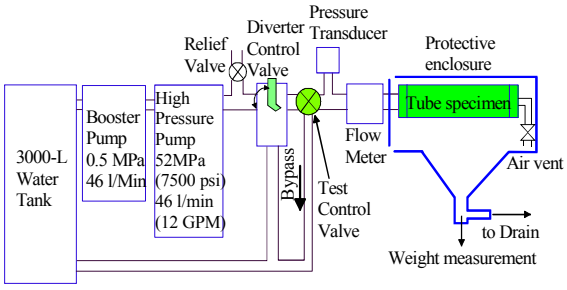

Fig. 1 High pressure leak and burst test facility

In this facility, the first leak from the tube can be detected by eye through the transparent plastic window, and the leak rate at a given pressure can be measured by weighing the water from the leak. The pressure was held at a certain value for a designated time to measure a time dependent leak rate.

The measured leak rates were compared with those of estimated based on the leak rate model developed by Argonne National Laboratory [3].

3. Results and Discussion

Fig. 2 is a typical behavior of the pressure and leak rate during the water pressurization on a SCC degraded tube. In the case of KY56065 specimen, the main crack opened at 42 MPa and leakage was begun to be recorded. As the pressure increased, the crack opening increased also. It was torn largely at 48 MPa, the water pressure decreased while the flow rate increased. A further increase of water pressure at the test time of 670 seconds enabled the crack to open largely. Consequently, the leak rate rapidly increased.

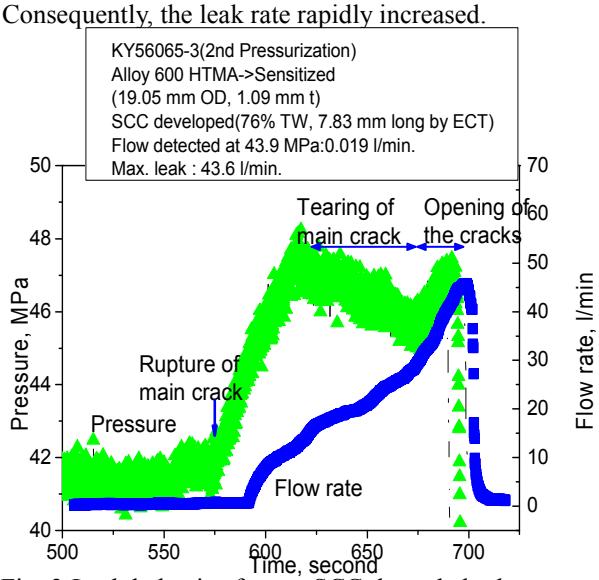

Fig. 2 Leak behavior from a SCC degraded tube at room temperature.

Fig. 3 shows crack features after the burst test. An initial leakage came from the circumferential cracks and following leak was originated from axial ones. This is because the depth and length of

the circumferential crack are much deeper and longer than those of axial ones.

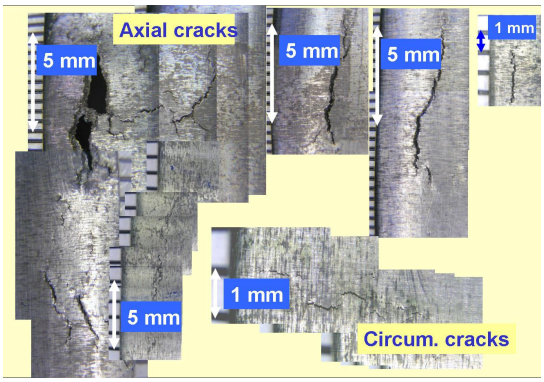

Fig. 3 Feature of the cracks after the burst test on KY56065 specimen

A leak rate measured and estimated based on the leak rate model[4] is shown in the Fig. 4. In this test, a measured leak rate of 25.72 l/min at 31 MPa corresponds to an equivalent crack length of 6.7 mm which is calculated from the leak rate model. Then the length of main crack after the burst is 5 mm, and there are multiple cracks, of which lengths are 1 mm to 5 mm as shown in Fig. 3. Since the cracks are not single manner, it is hard to compare the measured crack length with the estimated one.

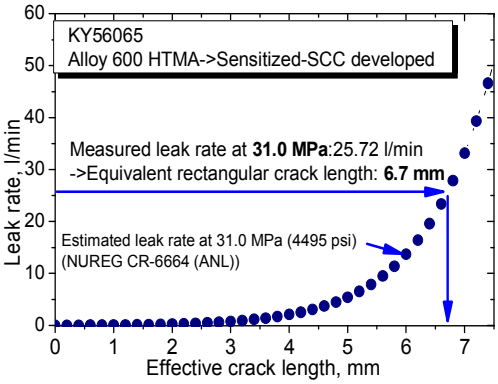

Fig. 4 Comparison on leak rate measure and estimated based on the leak rate model

The tube showed different leak rates depending on the internal water pressure as depicted in Fig. 5. When considering a pressure difference of 8.5 MPa between primary and secondary side of the SG tubes, the leak rate of 0.81 l/min at 26 MPa is not so big. It can be said that multiple cracks of over 5 mm long on a tube do not show the EPRI leakage guide line action level 1(78.85 l/min)

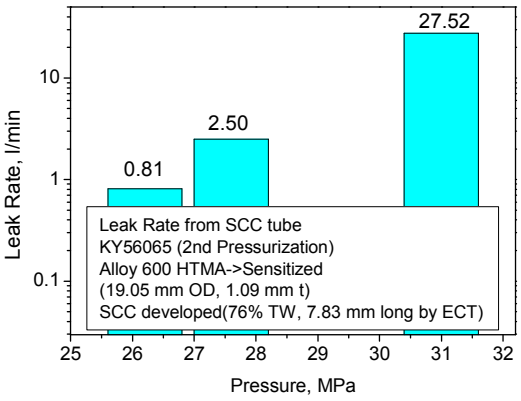

Fig. 5 Dependence of leak rate on pressure of a SCC degraded SG tube

4. Conclusions

1) SCC crack shows a ligament rupture at the first stage of the pressure test and a tearing of the main crack and an opening of the crack follow it.

2) Since the cracks are not single manner, it is hard to compare the measured crack length with the estimated one.

3) Multiple cracks of over 5 mm long on a tube do not show the EPRI leakage guide line action level 1(78.85 l/min).

REFERENCES

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