Database development on SCC from a retired steam generator

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1. Introduction

Stress corrosion cracking (SCC) in Korean Steam generator(SG) tubings had been serious problems because the tubes were made of low temperature mill annealed alloy 600, which is known as relatively SCC susceptible in PWR environment. After experiencing various corrosion problems such as pitting, wastage, denting, primary side stress corrosion cracking (PWSCC), out side diameter stress corrosion cracking(ODSCC), the SGs were replaced in 1998 with a new one. A metallographic examination on the defected tubes could be utilized for setting up a guide line for a safe operation of the SG. A destructive analysis on 91 tube sections was carried out, and a database was developed during a 5 year research work.

The objective of the present paper is to demonstrate the SCC location in terms of top of tube sheet(TTS) or tube support plate(TSP), and to seek a relationship between the crack location and corrosion environment at the TTS or TSP regions.

2. Experimental

91 tube sections from a retired steam generator were pulled out and transferred to a hot laboratory of KAERI. Detailed nondestructive analysis examinations for a marking of the defects were taken, and metallographic examinations were carried out in the hot cell. Types and sizes of the defects were characterized by using a high magnification contact camera and a scanning electron microscope(SEM), and the chemical compositions out side the tubes was also measured by using EDS. All the crack information was compiled in a database, and a relationship among the SCC defect location, defect depth, and sludge height was obtained.

3. Results and discussion

PWSCC and ODSCC were found at the TTS or near TSP. Some cracks were observed at a free span region. Axial cracks of TTS were believed to be located within the sludge pile before a chemical cleaning as shown in Fig. 1.

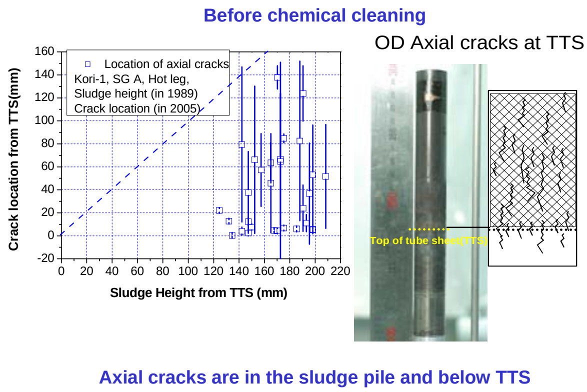

Fig. 1 Axial Crack location at TTS region

On the other hand, circumferential cracks were found below the TTS as shown in Fig. 2. According to A. McIlree[1], circumferential cracks are caused by residual stress and operating pressure difference at the TTS region. The confined location of the circumferential cracks below TTS means that a residual stress by sludge pile is high enough to invoke the cracking.

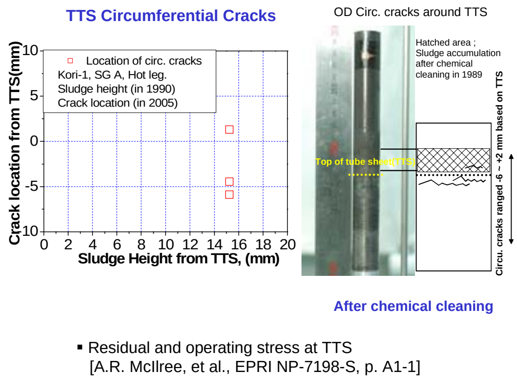

Fig. 2 Location of the circumferential cracks at TTS region

A depth of the ID axial cracks was 90 % of the tube wall when the lengths of the cracks are over 4 mm as shown in Fig. 3-(a).

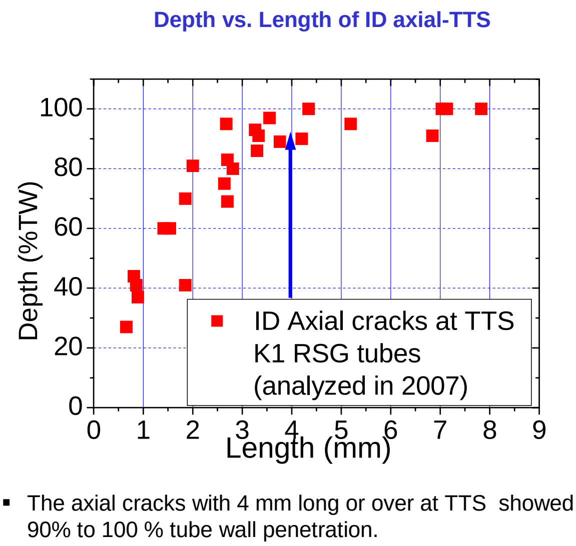

Fig. 3-(a) Relationship between depth and length of ID axial cracks at TTS.

Fig. 3-(b) represents the depth of the OD axial cracks with increasing crack length. These OD axial cracks show shallower wall thickness penetration than ID axial cracks even the crack length is 15 mm. This means a corrosive environment was severer in OD side of the tube by sludge accumulation than in tube ID surface condition of a cracking.

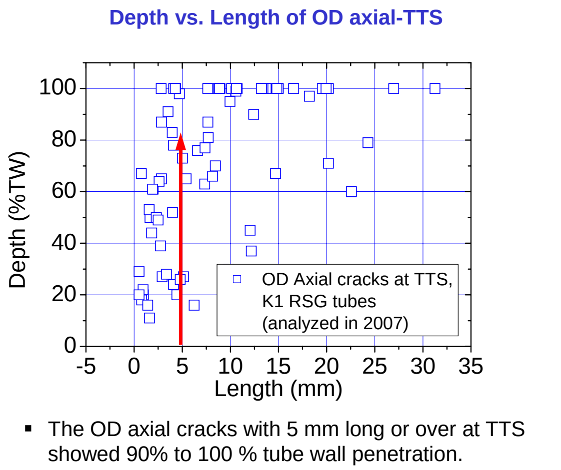

Fig. 3-(b) Relationship between depth and length of the OD axial cracks at TTS

Based on the metallographic examination on the 91 sections of the tubes, a database was developed as shown in Fig. 4.[2]

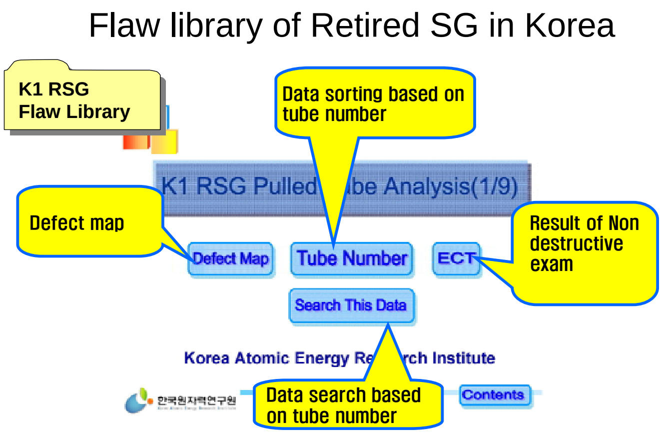

Fig. 4 Main frame of the SCC flaw database library

Detail flaw information can be searched based on a tube number, tube location or based on ECT results. Crack length and location can be compared with ECT results. The detail crack information was transferred to the other group in order to develop a better in service inspection technology.

Fig. 6 shows an example of detail information of a tube which has circumferential cracks. There were deeper cracks in ECT indicated area (196°~ 272°) in a multiple circumferential mode, some shallow cracks were also detected all around the tube circumference. The depth of the cracks, however, was 48% in maximum of the tube wall. So those shallow cracks might not be detected by a normal ECT.

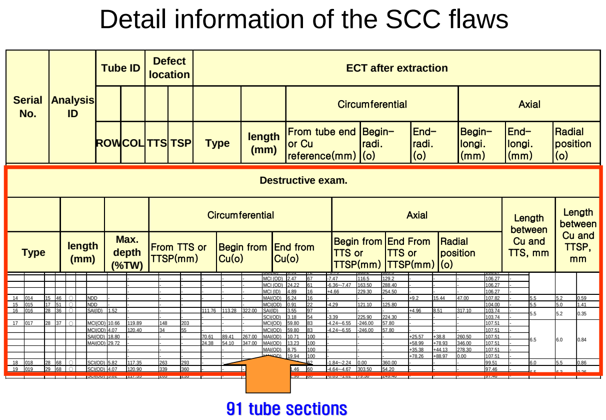

Fig. 5 Detail information of the SCC flaws

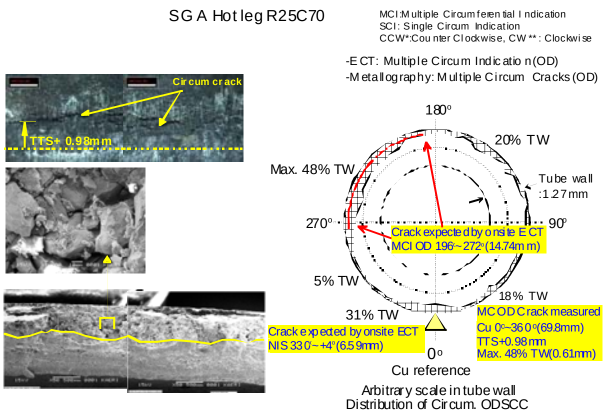

Fig. 6 Detail crack information of a tube having circumferential cracks.

REFERENCES

[1] A.R. McIlree, et al., EPRI NP-7198-S, p. A1-1.
[2] S.S. Hwang et. al., KAERI/RR-2903/2007, Final report on Failure Analysis of Retired Steam Generator Tubings.