A study on the Stress Corrosion Cracking reduction method of Steam Generator secondary side of KSNP

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1. Introduction

Integrity preservation of Steam Generator (SG) is very important for stable operation and efficiency improvement of nuclear power plant (NPP). Due to growing operation years of NPPs, corrosive products which is flowed to SG is fixed and accumulated secondary side with sludge form. Because of this, sludge can have a significant impact to NPPs safe operation by causing not only corrosion of the SG tubes, but also water level instability because of flow blockage. [1,2]

In order to avoid sludge accumulation affecting the life of the steam generator, the best way is to prevent the sludge inflow in advance by optimization of water quality management through chemical concentration and pH control etc. However it is very difficult to prevent sludge accumulation under the weak condition of corrosion, such as condensation, boiling and high temperature of feed-water in NPPs.[3,4] Particularly stress corrosion cracking occurs in a top-of-tube sheet area of steam generator with an increase in number of operation years of Korea Standard Nuclear Plant(KSNP).

The purpose of this study is to improve suppression of stress corrosion cracking and life extension for steam generator and improve plant efficiency by performing full length bulk high chemical cleaning in order to remove iron oxide of steam generator secondary side in KSNP Hanbit Unit 6.

2. Methods and Results

2.1 Needs and the type of chemical cleaning.

In the result of performing eddy current test (ECT), Hanbit Unit 3 among KSNP, SCC was not found at the TSP region. However 67th stress corrosion cracking were generated TSP region in Hanbit unit 4 and preceded rapidly to defects occurrences in the TSP region of Hanwul unit 4. In order to remove sludge at TTS, lancing process has performed per every operation cycle, but it is impossible to remove all sludge on the top of TSP. Also it is difficult to remove accumulated and hardened sludge by physical methods. Thus it is necessary sludge removal methods for the entire steam generator.

Chemical cleaning is the one among sludge removal methods for steam generator secondary side. There are three different ways, Advanced Scale Conditioning Agent (ASCA) for low concentration chemical cleaning , top of tube sheet chemical cleaning-only for cleaning TTS, full length bulk high temperature chemical cleaning for TSP, TTS, full legnth bulk iron deposit etc.

2.2 Full length high temperature chemical cleaning procedure.

Full length high temperature chemical cleaning is composed of Checkout Rinse Step, Iron Removal Step, TSP Crevice Cleaning, Low Volume Rinse, and Full Volume Rinse. Following is in detail for each process.

1) Checkout Rinse Step

Determine functional operation state of cleaning device prior to injecting the washing water to the steam generator, and check whether or not a leak, such as piping connected to the cleaning device via through the heating and cooling

2) TTS Crevice Cleaning

Circulate and inject the cleaning fluid that prepare in advance about 1m from the top of the tub plate and been heated to about 95℃. Drain partially to about 0.5m and heat to 121±5 ℃. Dissolute the deposited sludge between the upper TSP and tubes by opening main steam atmosphere dump valve and main steam atmosphere dump isolation valve.

3) Iron Removal Step

Inject the cleaning fluid inject about 15cm from top of tube bottom (TTB). Maintain about 93±5 ℃ and circulate the cleaning fluid. This step dissolves the deposited sludge on TTS, free span and TSP.

4) TTS Crevice Cleaning

Maintain and heat to about 121±5 ℃ the cleaning fluid injected the steam generator. Vent and lower the water level in the steam generator for each TSP 11 single stage to the first stage to conduct the venting. It removes harden sludge and collar type sludge.

5) Low Volume Rinse

Inject demineralized water (demi-water) to about 1m from steam generator and drain after some hours. This step emits remaining cleaning fluid of the top of TTS.

6) Full Volume Rinse

Inject demi-water to about TTB 20cm, heat to about 121℃ and circulate (including venting 6 times). This step removes entirely remaining cleaning fluid in device pipes and inner steam generator.

2.3 Free EDTA and Fe concentration change

During carrying out chemical cleaning in Hanbit unit 6, Free EDTA concentration decreased in accordance with increasing Fe concentration as Fig. 1.

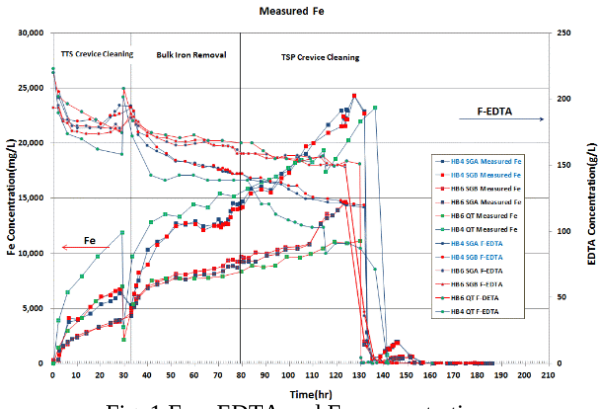

Fig. 1 Free EDTA and Fe concentration

The peak of Fe concentration was confirmed by SG1 14,556ppm, SG2 14,668ppm from TTS Crevice Cleaning Process to Crevice Cleaning process. In case of chemical cleaning of Hanbit unit 4, it was by SG1 24,335ppm, SG2 24,265ppm. The reason why sludge amount of Hanbit unit 6 is less than Hanbit unit 4 is considered by sludge loading amount. This is the reason that Hanbit 6 operation years are shorter than Hanbit unit 4.

And Iron removal cleaning was performed 13 hours after heating cleaning fluid to 121 ℃ reflecting to the experience the Hanbit unit 4. This is believed to contribute to minimize the phenomenon stacked sludge on the TTS of steam generator by minimizing to generate the non-dissolved sludge

2.4 Sludge Removal

As a result of qualification test of the Full Length Bulk high Temperature on Hanbit unit 6, most of sludge (75.7%) was dissolved in the iron removal step, and about 20.2% of sludge was removed on TTS Crevice Cleaning and TTS Crevice Cleaning step. And 100% of sludge was verified to be dissolved through the qualification test, sludge removal by calculated the sludge weight loss method of the built-in-pressure vessels was calculated 100%.

The level of sludge removal observed at the qualification test of Hanbit unit 6 was consistent with qualification test of EPRI/SGOG process performed in the past, especially sludge deposited at simulated TSP crevice was removed also to 100%. It is judged to be effective in TSP crevice by performing the Full length bulk high temperature chemical cleaning.

The dissolution of Collar type sludge at the upper tube plate was in the range of 68% to 100%, on average 92% was removed. Sludge removal after carrying out full length bulk high temperature chemical cleaning on the steam generator secondary side during 9th planned maintenance of Hanbit unit 6 was 3001kg, it was 200.1kg by lancing additionally as Fig.2. This is 30 times increased amount compared with 8th planned maintenance of it.

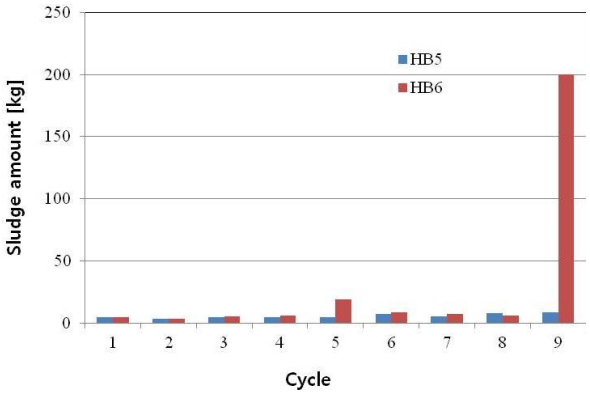

Fig. 2 Sludge removal of SG

3. Conclusions

This study analyzed the Free EDTA and Fe concentrations and sludge removal after performed full length bulk high temperature chemical cleaning for removing the iron oxide of steam generator secondary side, which of Hanbit unit 6 of KSNP.

1) It showed a typical pattern that Fe concentration increased in accordance with to decrease Free EDTA(Ethylene Diamine Tetea acetic Acid) concentration.

2) Sludge removal based on iron oxide after performing the full length bulk high temperature chemical cleaning was 3001kg and sludge removal by lancing additionally was 200.1kg.

As this study, the full length bulk high temperature chemical cleaning for steam generator secondary side showed an excellent effect on the sludge removal and this is expected to help to improve the suppression of stress corrosion cracking and steam generator life extension and efficiency.

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