Experience in Lancing Process of Steam Generator at PWR Nuclear Power Plants

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1. Introduction

Maintaining steam generator integrity for stable operation of nuclear power plants is a very important and spending a lot of money for maintenance and inspection of steam generator. In pressurized water reactor, the generation and transport of corrosion products in the feedwater, drain and condensate systems from deposits on the secondary side of the steam generator. The deposits have problems such as increasing the possibility of corrosion of the tube material and reducing the efficiency of heat transfer. Although it is the best way to prevent such deposits through water quality management, it is very difficult in reality. Therefore, chemical cleaning and mechanical cleaning are performed to remove deposits from the steam generator.

In this study, deposits and cleaning methods of steam generators and lancing processes performed at nuclear power plants are described.

2. Methodology

The steam generator deposits typically consist of a mixture of metal oxides, primarily magnetite (Fe3O4) and copper (Cu, CuO). According to the previous research report, deposits of the steam generator are as follows.

- Deposits contain >85% by weight magnetite.
- Deposits contain ~5% by weight metallic copper.
- Copper can account for as much as 50% by weight of the deposits in some PWR steam generators.
- Copper in deposits is generally found as copper metal, but minor amounts of Cu_2O and CuO have also been found.

There are chemical and mechanical methods for removing such sludge removal from steam generator.

2.1 Chemical Cleaning

The goal of chemical cleaning is to maximize the dissolution of deposits and simultaneously minimize the corrosion of steam generator materials. Chemical cleaning is different depending on each process. However, in case of EPRI method applied in domestic nuclear power plant, the temperature of ASCA is 82℃, EDTA is about 2%, the high temperature is 110~121℃, and EDTA is about 20%. In addition, a small amount of hydrazine reduces ferric ions which decrease corrosion of the base material and simultaneously dissolution of magnetite increase. And corrosion inhibitor in the solution doesn't have effect on the dissolution rate of the magnetite but decrease corrosion rate.

Although chemical cleaning is an effective technique if the steam generator needs to be completely cleaned, there are problems such as the cost of expensive cleaning, generation of undesired waste, and possibility of corrosion of the steam generator during chemical cleaning.

2.2 Mechanical Cleaning

Sludge removal from steam generators is typically uses mechanical cleaning including blowdown, gas pressure and lancing.

The blowdown method removes only sludge that exists as suspended particles and is ineffective at removing hardened sludge. This method is also used only for recirculating steam generators and uses a built-in drainage system in the steam generator.

The other mechanical cleaning processes, pressure pulse and water slap, periodically release pressurized nitrogen at the bottom of the tube bundle. The nitrogen produces upward movement of the water mass in the steam generator, thereby dislodging deposits from the tube surfaces and from the tube sheet and tube support plate regions.

Finally, lancing uses a high-pressure water jets to remove the sludge from the steam generator. This method can insert the water jet through the inspection port into the steam generator and remove the soft and some sticky sludge through high pressure jets.

2.3 Experience of Performing Lancing

At present, lancing of domestic nuclear power plant performs sludge removal the tube sheet top of the secondary side of the steam generator. The lancing equipment used in nuclear power plant depends on the steam generator type. The types are shown in Table 1.

Table 1. Types of Lancing Equipment by NPP

Type	NPP
FOLAS	Kori #2,#3,#4 Hanbit#1,#2
OLAS	ShinKori #1,#2,#3 Hanul #3,#4,#5,#6 Hanbit#3,#4,#5,#6 ShinWolsong #1,#2
CECIL-3	ShinWolsong #2,#3,#4
CECIL-4	Hanul #1,#2

Equipment used to remove deposits can be roughly classified into a robot system, control system, and process system. The schematic layout is shown in Fig. 1.

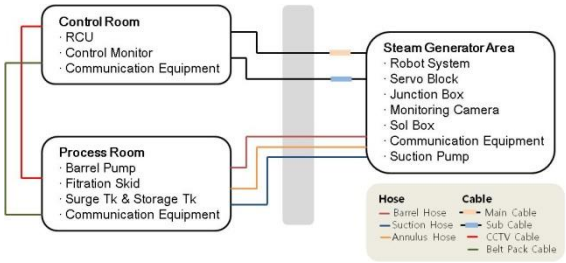

Fig. 1. Schematic of Lancing Equipment Configuration.

The robot system inserts the robot assembly through the steam generator handhold, attaches to the inner wall surface by magnetic force, and is driven and cleaned. The system performs the cleaning operation according to the input of the moving speed, the nozzle angle, the cleaning time, the number of the column to be moved, and the like through the operation program.

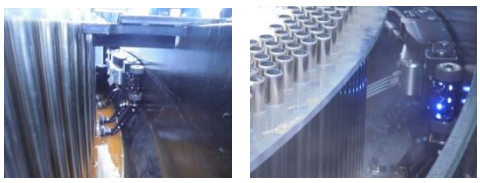

Fig. 2. Lancing Mock-up.

When the cleaning operation is performed, the cleaning waste liquid is collected by the sludge suction pump and the hose into the surge tank of the process room located in the maintenance area. The cleaning waste collected in the surge tank is collected in the storage tank after passing through the filtration system, and the sludge is removed from the filtration system, and then the cleaning operation is repeated while being supplied to the robot system. The weight of the sludge removed is the difference in filter weight generated during the cleaning operation at the initial filter weight and before the filter weight measurement; water is removed from the filter by air blowing for about 3 minutes. Lancing is preformed according to the conditions of the site, but generally, all columns are four times and terminated.

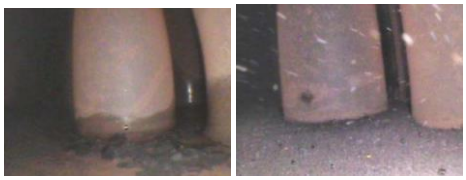

Fig. 3. Before and After performing Lancing.

3. Conclusion

The lancing process is one of important processes to secure the integrity and safety of the steam generator by removing the deposited sludge on the secondary tube sheet. Therefore, understanding of the process for the generation and removal of deposit and sludge in the steam generator is essential for the worker performing the cleaning process.

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