Development of S/G Lancing System for Upper Bundle Hydraulic Cleaning

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1. Introduction

Steam generators of nuclear power plants are recommended to be cleaned during plant outages. Various lancing equipments are developed for the cleaning of tube sheet area of nuclear steam generators. However, no lancing system has been developed in Korea for cleaning upper bundle area of steam generators. Therefore, we developed an upper bundle cleaning system for removing sludge deposited on the tube support plates of nuclear steam generators.

2. Upper Bundle Hydraulic Cleaning

In this section, various lancing systems in Korea are introduced briefly. Design criteria and conceptual design of upper bundle cleaning system are described. Finally, the development of sludge processing system is outlined.

2.1 Steam Generator Cleaning

Sludge accumulation in the secondary side of nuclear steam generators may cause tube degradation. Soft sludge may be hardened when it is baked by hot temperature of primary coolant. Therefore, steam generator makers recommend that the secondary side of tube sheet and tube support plates should be cleaned during each outage cycle.

There are several ways for cleaning nuclear steam generators. High pressure water jet is often used to remove sludge. Ultrasonic transducers are used to soften hard scale. Chemical agents for selectively dissolve sludge without damaging internal components of steam generator are also already developed. Bulk cleaning is a way to remove sludge piled up on the tube support plates.

2.2 Lancing System in Korea

KHNP, the only nuclear power utility in Korea, has several water jet lancing system. Kori NPP#1 has KALANS®-I(**K**epco **A**dvanced **Lan**cing **S**ystem) and Kori NPP#2 has CECIL unit #1 for lancing and KALANS®-IV for FOSAR(Foreign Objective Search And Retrieval). Ulchin NPP#1 has CECIL unit #2 and Ulchin NPP#2 has KALANS®-II. Younggwang NPP#1 has KALANS®-III and Younggwang NPP#2 has ABB-CENO. KALANS® is registered trademark of KEPRI steam generator cleaning system.

Model	Supplier	First Field Application
KALANS®-I	KEPRI	Jan. 2000, Kori #1
KALANS®-II	KEPRI	April 2004, Ulchin #2
KALANS®-III	KEPRI	June 2004, Younggwang #1
KALANS®-IV	KEPRI	July 2004, Kori #2
CECIL®-I	FMI	April 1996, Kori #2
CECIL®-II	FMI	February 2001,Ulchin #1
ABB-CENO	ABB-CE	December 1996, Younggwang #2

Fig. 1 Steam generator lancing system of KHNP(Korea Hydro and Nuclear Power Co.)

2.3 Design of Upper Bundle Cleaning System

Accumulation of soft sludge on the tube support plates often blocks the broach holes. Blocked broach holes may prevent steam flow from bottom to top. We developed the upper bundle cleaning system to remove sludge accumulated on tube support plates and in broach holes.

The upper bundle cleaning system is composed of nozzle head, hydraulic cylinder, support rail, sludge processing system, and control system. Support rail is installed through a hand hole of steam generator. Hydraulic cylinder moves upward through flow slot on each tube support plate. On the top of the hydraulic cylinder, nozzle head is attached. When the nozzle head is reached at the cleaning position, it is disengaged from the hydraulic cylinder. Hydraulic cylinder and nozzle head are temporarily joined together by an electromagnet.

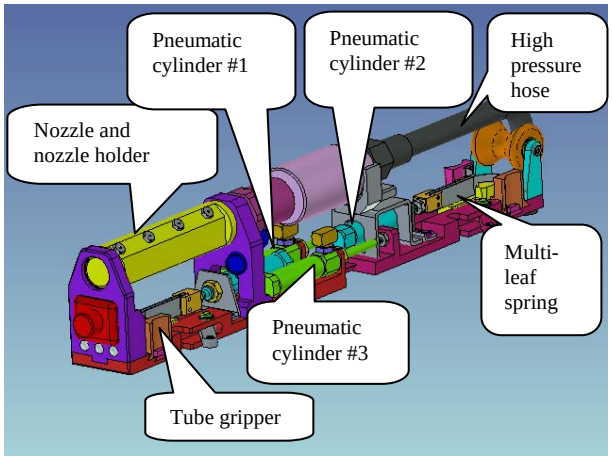

Fig. 2 Nozzle Head Assembly

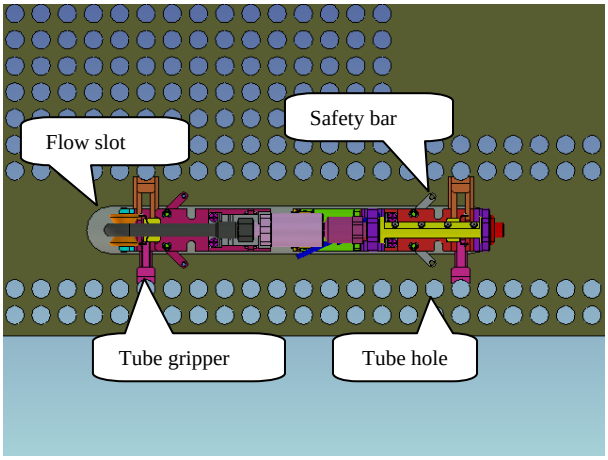

Fig. 3 Nozzle Head Assembly on Tube Support Plate

When the nozzle head assembly is placed on a desired tube support plate, it is separated from the hydraulic cylinder by turning off electricity of electromagnet. Two pairs of tube grippers are sequentially activated by pneumatic cylinders #1 and #2. When a tube gripper of the two is inactivated, the nozzle head assembly moves along no tube lane by activation of pneumatic cylinder #3. Pressurized water is supplied through high pressure hose. Water jet is ejected through multiple nozzles on nozzle holder when two tube grippers firmly hold tubes of a steam generator.

2.4 Sludge Processing System

We designed and manufactured sludge processing system for upper bundle hydraulic cleaning. The system is composed of suction pump, surge tank, storage tank, transfer pump, filtering system, and high pressure pump. Suction pump absorbs sludge and water from inside of steam generator. Sludge and water is stored temporarily in a surge tank. Transfer pump send sludge to filtering system. Filtering system is composed of two stages of filters of one and ten micron in mesh size.

Fig. 4 Sludge Processing System

Fig. 5 Sludge Processing System

High pressure pump pressurizes water up to 260 bar and sends it to nozzle head assembly. Figure 4 and 5 shows sludge processing for upper bundle hydraulic cleaning.

3. Conclusion

We developed a lancing system designed to clean upper bundle area for Model-F steam generator. The developed lancing system was designed to clean tube support plates and tubes in upper bundle area. The nozzle head assembly is installed at the bottom of tube support plate by a hydraulic cylinder. To remove the possibility of contaminating inside of steam generator, water is used instead of oil as a pressure medium of hydraulic cylinder.

We designed and fabricated sludge processing system for filtering sludge. Sludge filtering system is designed to enable operation without stopping during filter change.

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