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Automatic Inspection System for the Stay Cylinder Weld of the Steam Generator

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1. Introduction

ASME Section XI Division 1 provides requirements for in-service inspection of Class 1 pressure retaining components and their welded attachments in light-water cooled plants and specifies volumetric examination on the stay cylinder weld of steam generator [1]. Manual inspection on this weld involves various difficulties on account of limited accessibility and moreover high radiation in this area. Thus automatic inspection system and technology were required to examine the weld efficiently.

Recently new automatic ultrasonic inspection system for stay cylinder welds has been developed. The inspection system is basically consisted of a mechanical driving equipment, data acquisition device and signal processing units [2]. The mechanical driving equipment is classified by (1) the scanner for inspection and buffing of the weld, (2) pillars for guiding the scanner and (3) the base frame for loading and supporting pillars. These components can be inserted into the skirt of the stay cylinder through the manway hole and assembled easily by one-touch in the skirt. Data acquisition device and signal processing units developed in previous works are also newly upgraded for better processing of data analysis and evaluation [3-4]. The system has been successfully demonstrated not only in the mock-up but also in the field.

In this paper, newly developed inspection system for the stay cylinder weld of the steam generator is introduced and their field applications are discussed.

2. Examination Target

KSNP(Korean Standard Nuclear Plant) is consisted of reactor, 4 pumps and 2 steam generators. The stay cylinder mounted on center of the bottom head of the steam generator is welded with the tubesheet which the cylinder supports as shown in Figure 1. This weld is required volumetric inspection such as ultrasonic testing.

The accessibility for target weld is very difficult due to high radiation and narrow work space. Manway hole, the only access to the weld is about 300 mm widths and the cylinder inside diameter is about 594 mm [5]. Thus human error may be occurred during manual inspection.

The inner surface buffing step of the cylinder is necessary to improve the inspection reliability. During this step, operator can be exposed to internal contamination by contaminated dust as well.

Thus automatic inspection system and technology were required to examine the weld efficiently and with safety.

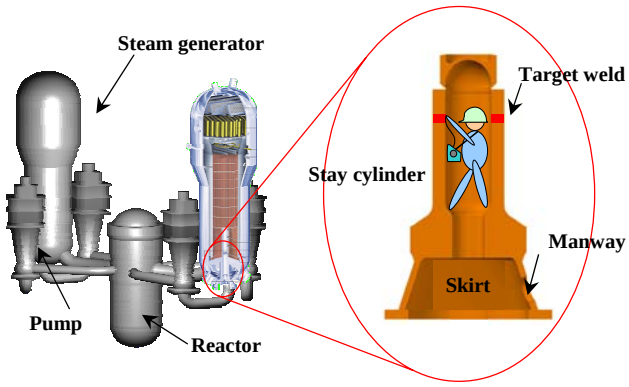

Figure 1. Geometries of KSNP and the stay cylinder

3. Automatic Inspection System

Figure 2 shows the outline of the automatic inspection system. Mechanical driving equipment inspecting in the stay cylinder is remotely controlled by the main control part in a safe zone. Mechanical driving equipment is consisted of 3 parts: the scanner for inspection and buffing an inner surface of the cylinder; pillar assembly for guiding the scanner to the weld; and base frame for not only centering the equipment on the skirt but loading and supporting pillars.

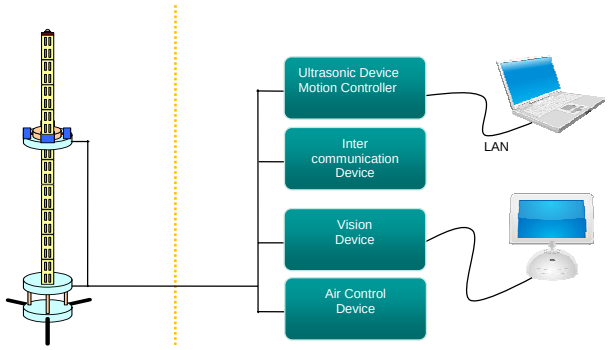

Figure 2. Outline of the automatic inspection system

These components can be inserted into the skirt of the stay cylinder through the manway hole and assembled easily by one-touch in the skirt by an operator who can communicate with an operator on the main control part. The main control part is 50 m distance from the stay

cylinder and controls the mechanical driving equipment by a vision system.

Figure 3 shows the scanner associated with the inspection system. This scanner includes 4 assembles: (1) 4 air-driven inspection arms mounted with all-in one ultrasonic sensor modules; (2) 2 air-driven buffing brush tools; (3) 2 lighting fixtures; (4) and 2 CCD cameras for monitoring in vertical and horizontal directions. The ultrasonic sensor modules are consisted of 3 angle beam modules and 1 normal module. 3 angle beam modules with different incident angle are mounted with 4 direction (up, down, CW and CCW) unit sensors.

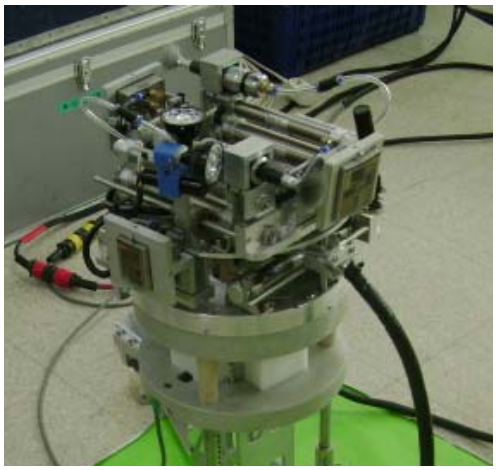

Figure 3. Automatic Ultrasonic Scanner

Data acquisition device with 100 MHz sampling and signal processing software developed in previous works are upgraded for better processing of data analysis and evaluation.

The system has been successfully demonstrated not only in the mock-up but also in the field.

4. Conclusion

Automated ultrasonic inspection system is developed to exam the stay cylinder welds of steam generator. The mechanical driving equipment consisted of the scanner, the base frame and pillars can be inserted into the skirt of the stay cylinder through the manway hole and assembled by one-touch in the skirt. This equipment is remotely controlled. Demonstration of the system in the mock-up and field shows very good results.

ACKNOWLEDGEMENT

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