Development of Visual Inspection System for Flow Distribution Plate of OPR1000 SG

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1. Introduction

In this paper, we present a development of visual inspection system for the Flow Distribution Plate (FDP) of OPR1000 SG. The inspection system is composed of the positioning sub-assembly, the *1st* guide, the *2nd* guide, and an endoscope. The *2nd* guide moves along the groove in the *1st* guide. A quartz endoscope for acquiring visual image of the FDP is inserted in the hole of the *1st* guide, and it reaches the FDP which is about 10 meters away from the man-way.

2. Visual Inspection System for FDP

2.1 System Description

There are two FDPs in OPR1000 SG as shown in Fig. 1. Visual inspection system for the FDP of the *8th* egg-crate was already developed and reported in our previous paper [1]. In this study, we developed a visual inspection system for the FDP of the *7th* egg-crate. The distance between the *7th* and *8th* egg-crate is about 100cm and there is no guide for approaching the *7th* FDP which is at the center of the *7th* egg-crate. Therefore, we chose completely different approach of two stage guiding. The first guide is composed of 160 components of 50mm long. When the 160 components are assembled by a wire rope, it becomes 8 meters long flexible guide. The *2nd* guide could reach the outer rim of the *7th* egg-crate.

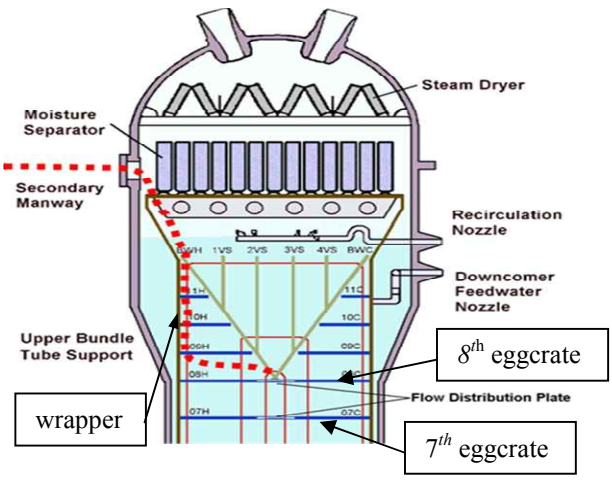

Fig.1 OPR 1000 SG and FDP Location

The *1st* guide is composed of 500 components of 25mm long. Completely assembled, it becomes a flexible strip of 10 meters long.

2.2 Design of Visual Inspection System

In designing the visual inspection system, the thickness of the assembled guides was the most important concern. Our previous experience with APR1000 steam generators showed us that the gap between the egg-crate rim and the wrapper is about 14mm. Therefore, the thickness of the *1st* and the *2nd* guide is decided to be 12 mm and 14mm respectively.

There are three holes in the *2nd* guide for twisted stainless wires as shown in Fig. 2. The wires inserted in the holes #1 and #2 are used to make all the 160 components linked together. Tension in the wire in holes #1 and #2 makes the 1st guide assembly to be rigid and flexible. Rigidity increases as the tension of wire increases. Generally, the tension of the wire in hole #1 is adjusted to be the same with the tension of the wire in hole #2.

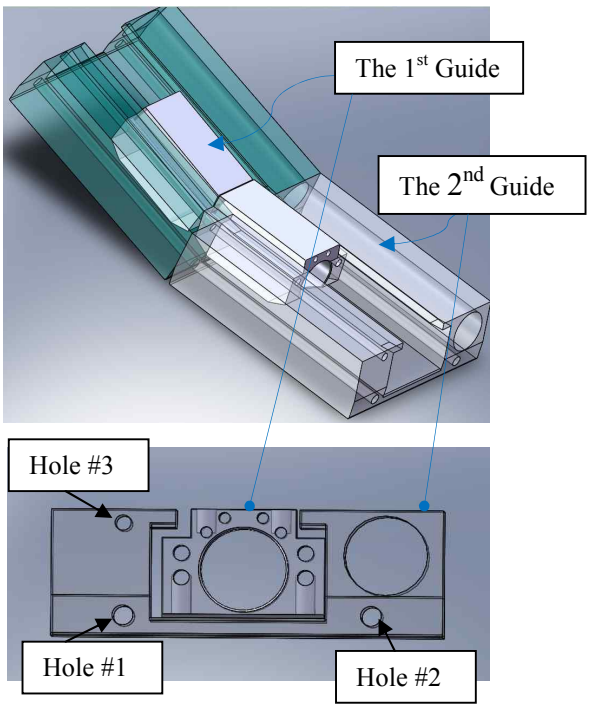

Fig.2 Two Guides Linked Together

The wire in hole #1 of the 2^{nd} guide is used to bend the tip which is shown in Fig. 3. By exerting tension to the wire in hole #1, we could bend the tip and several adjacent components to direct the center of the egg-crate where the FDP is located. Fig. 4 shows a picture of guide assemblies and a quartz endoscope.

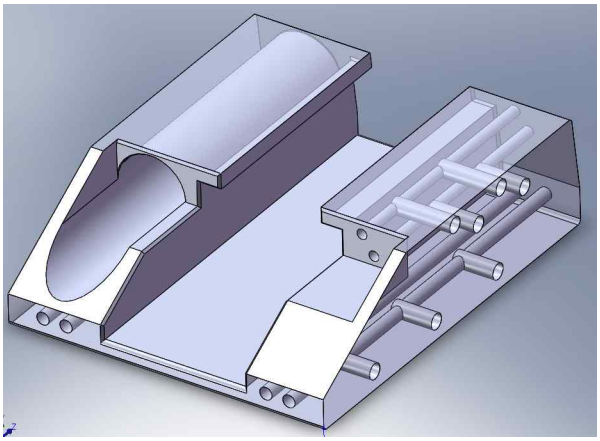

Fig.3 Tip of the 2^{nd} guide

2.3 Visual Inspection Procedure

The procedure to visually inspect the 7^{th} FDP is summarized as follows:

Step 1) Transport the positioning sub-assembly [1], the guide assemblies, and quartz endoscope to the working platform near the steam generator secondary man-way.

Step 2) Attach and fix the positioning sub-assembly to the flange on secondary man-way by two bolts. Man-way cover also could be mounted if necessary.

Step 3) Install the 2^{nd} guide assembly along the groove in the positioning sub-assembly. Stop inserting the 2^{nd} guide assembly just before it reaches the 7^{th} egg-crate rim. To check the position of the tip, use endoscope if necessary.

Step 4) Exert tension on the wire in hole #3 of the 2^{nd} guide assembly to bend the tip.

Step 5) Insert the 1^{st} guide assembly along the groove in the 2^{nd} guide assembly. When inserting the 1^{st} guide assembly, endoscope is recommended to be inside of the hole in the 2^{nd} guide assembly. Stop inserting the 1^{st} guide assembly when the tip leaves about 20 cm from the tip of the 2^{nd} guide assembly.

Step 6) Exert tension and maintain it on the wire of the 1^{st} guide assembly to bend the tip. It will make further insertion of the 1^{st} guide assembly along the egg-crate easier.

Step 7) Connect endoscope probe assembly to controller and turn power switch on. Insert the 1^{st} guide assembly further toward the center of the FDP if necessary.

Step 8) Inspect the FDP and bolts and record it.

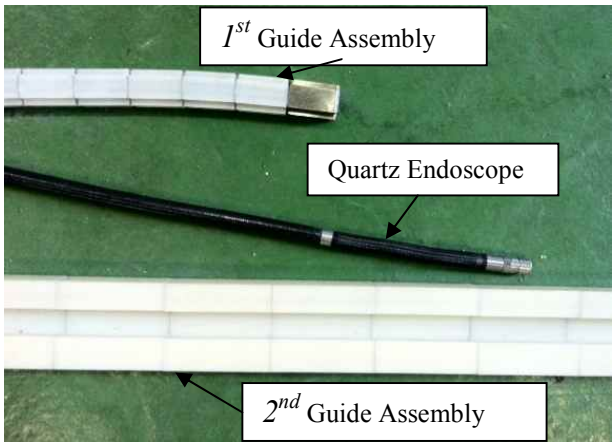

Fig.4 Guide Assemblies and Quartz Endoscope

3. Conclusions

We designed and manufactured a visual inspection system for the FDP of the 7^{th} egg-crate of nuclear steam generator using endoscope and the two guide assemblies.

Test using steam generator mockup showed us that we could approach to the FDP of the 7^{th} egg-crate, and successfully inspect bolts on the FDP. Inspection and recording of the image of the FDP and joining bolts were also possible.

However, we found that several improvements are necessary as follows:

1) A device to adjust tension of the wires used in the guide assemblies is necessary. Excessive tension of the wires prevented smooth moving along the bent region.
2) A wire tensioning and a locking device should be additionally developed. Using a set screw and wrench to lock tensioning wire was not easy in actual hot environment.

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