

Experience in Application of Calandria Internal Inspection System to Wolsung NPP#1

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1. Introduction

Calandria is a PHWR Reactor and a horizontal cylindrical vessel of eight by eight meter in size. Calandria's internal structure and parts cannot be inspected during the normal operation or overhaul period. Accordingly, this inspection is only allowed when the pressure tubes are replaced for the lifetime extension activity. For the purpose of this inspection, we have developed an expeditious NDE System for Calandria's internal and successfully applied the system to the field inspection during the period of pressure tube replacement of Wolsung Nuclear Power Plant Unit 1 on February 2010.

2. Tooling & Operation Programs

For this project, firstly we defined the technical elements required for the Calandria inspection, such as remote controlled robotic system, mock-up training, synchronization & robot operation software and specific operation procedures. In this section, we will introduce the Robot system and operation software.

2.1 Robot system

The Robot system is composed of a movement body, a controller and a computer for system operation. Also, it is equipped with main and sub cameras. System configurations are as follows.

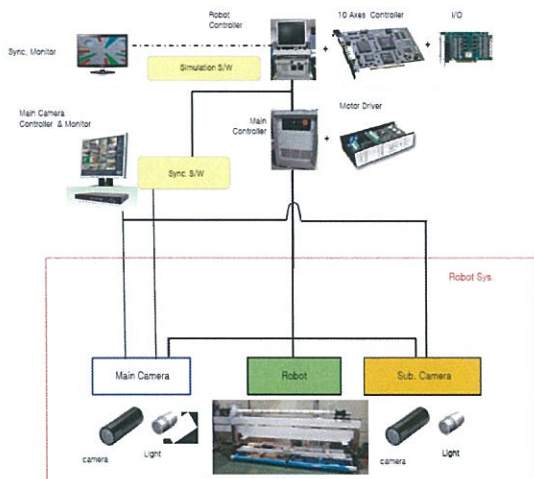


Fig. 1. Robot system configurations

* Key specifications & Features

Robot dimensions are 6m(L)x1.2m(W)x1.6m(H) and weight is approximately 2 tons. Robot's specification & Features are as follows.

9-axes joints and automatic control system

Synchronization program (applying virtual reality)

- provide with 3-D virtualization in real time
- provide the screens of the point of camera and the 3rd view
- Aid of operation and evaluation

Cameras

- 1×10^7 Gy anti-radiation(main)
- General purpose lens(sub)

13cm(5.11") Diameter of inserting parts (Robot Arms)

2.2 Synchronization program

The purpose of this program is to avoid contacting of the inserting parts with internal parts of Calandria and aid the robot operator and Visual Testing examiner. Also, this program provides Camera/3rd part views. Camera view provides the means to compare with the recorded image. 3rd part view provides the information of contact with robot and internal parts according to the operation such as rotating, withdrawing or inserting the robot.

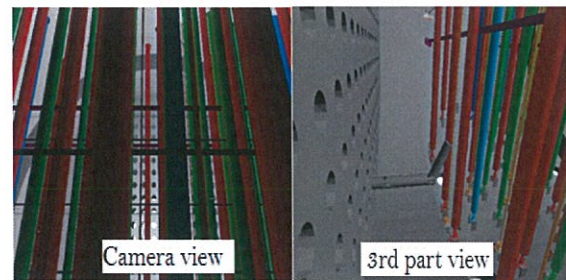


Fig. 2. Two points of view(camera/3rd)

2.3 Safety functions

Synchronization program displays the robot's position and status on 3D CAD virtual reality. Also, robot's arms can be manually controlled and pulled out straight out without damage of Calandria. In addition, Robot's controller remembers its coordinates and provides the function of withdrawal or continual inspection when power recovers. In addition, Robot system has safety zone function. That means when robot is in the high risk



zone, it restrains operation to avoid collision with internal structures.

2.4 Automated alignment system

Automated alignment system is prevent the contact with protective sleeves and reducing inspection time. This system is equipped with contact sensors on the alignment jig and measure the center of the protective sleeves. Automated alignment system is performed to the robot axes with the calandria tubes(maximum error : 0.5mm)



Fig. 3. Automated alignment system

3. Inspection case of Wolsung NPP#1

3.1 Mock-up training

For mock-up training, we made a quarter of full scale calandria and then perform to verification of the inspection procedure and verification of robot system including operating programs.



Fig. 4. Mock-up for calandria inspection

3.2 Inspection procedure

Calandria inspection procedure includes inspector requirement, inspection scope, drawings, objects, sequence of inspection, evaluation criteria and reports.

3.3 Inspection results

The inspection results are “No Recordable Indication(NRI)” and not found foreign materials. Exam period is 4.5 days and 7 inspectors/2 shift(12 hours) to inspections. This is the results of Wolsung NPP#1 site inspections.

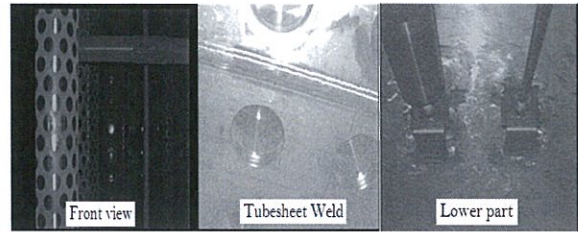


Fig. 5. Photos imaged the internals of calandria

Table 1. Inspection results

Examined area	Method	Result
Moderator Inlet Nozzles	Remote VT	NRI
Calandria Tube Sheet weld	Remote VT	NRI
Calandria Vessel Interior	Remote VT	NRI
Flux Detector Guide Tubes	Remote VT	NRI
LISS Nozzles	Remote VT	NRI
Shutoff Rod, Control Absorber Adjuster Guide Tubes Absorber Elements	Remote VT	NRI
Calandria Manhole cover to Nozzle Weld	Remote VT	NRI

4. Conclusions

For the purpose of this inspection, we have developed the Calandria Internal Inspection System(CIIS) and then completed the field inspection to apply this system to Wolsung Nuclear Power Plant Unit 1 on February 2010.

The inspection results are “No Recordable Indication(NRI)” and not found foreign materials. Especially, we reduced inspection time to 20 days compare to overseas company. In the future, we are plan to export this system and technology to overseas plant.

REFERENCES

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