# In-core Flux Mapping System Retrofit for Kori Unit 2

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## 1. Introduction

In-core flux mapping system acquires 3-dimensional neutron flux distribution data into the nuclear reactor. This system, generally observed in the Westinghouse designed plants, is comprised of movable detectors, a detector drive system and a control console. As system equipment is getting order in most plants of the type, trouble occurs frequently during the operation and most spare parts for maintenance would be out of stock in the near future. So, the system retrofit project for Kori unit 2 in order to remedy the increasing defect had been performed. This paper presents overall description of the project achievement. An advanced detector drive system and a control console were designed, built and tested. The system was installed and test-operated during the 19$^{th}$ plant outage of Kori unit 2 in 2004.

## 2. Flux mapping system description

In-core Flux Mapping System is integrated with the movable detectors, a detector drive system and a control console [1]. The detector drive system is assembled with four detector drive units and a detector path selector assembly. The drive units move detectors into the reactor through the guide thimbles installed into the 36 dedicated fuel assemblies for Kori unit 2. The path selector assembly transfers detector routes as each detector in each time gets a path out of 36 by selecting a certain thimble. Each detector measures flux at 8 to 10 locations of each group and changes group according to the operation modes. The control console is prepared for providing operation means, controlling detector drive system to move detectors into the reactor, acquiring flux data with a given form.

## 3. Detector drive system design

New system was designed to get better performance of efficiency, reliability and maintainability.

### *3.1 Drive unit design*

The drive unit was built with lots of components as a drive motor, a torque limiter, a drive wheel, two idle pulleys for guiding detector with optimum efficiency, and a motor driving storage reel for convenient maintenance. The system design objectives are derived from the inherent system technical manual [2, 3, 4]. Keeping the objectives, new design was proceeded mainly to increase driving efficiency, to upgrade maintainability. Precise drive gear and double idle pulleys contributed on driving efficiency or reliability enhancement. Convenient maintenance features were considered like electric motor driving storage wheel, local control box, local sound pick-up, and one touch clamps.

Figure 1. New drive unit

### *3.2 Path selector assembly design*

The path selector assembly enables each detector to get a path out of multiple thimbles with indexing mechanism. The old path selectors were installed separately on the two layers. Four path selectors for selecting a group are arranged on the upper layer and other four for selecting a path of the group on the lower. This design produced such a large curvature of the detector guide tubes, that it causes high friction on the surface of the detector and tubes.

Figure 2. Outer and inner path selectors

So, single layer path selecting architecture using double indexing mechanism was considered. The

double indexing path selector is assembled for four inner path selectors and an outer path selector. The inner path selectors are evenly allocated in a circular manner on the rotating table of the outer path selector which can be rotated from $0^o$ to $270^o$ at $90^o$ intervals. The outer path selector is responsible for selecting a group and inner for a path of the group. Single layer architecture reduced the curvature and friction of the detector guide tube. As a result, the system reliability was improved.

## 4. Control console design

The control console provides operation means, control functions of the detector drive system, and storing functions of the flux data. The new control console gives fully automated operation functions for the flux mapping, and various operation modes and supporting function enhances system operability.

### *4.1 Hardware design*

The designed control console aims for digital architecture. The programmable logic controllers and industrial computers were adopted. The control and information equipment of the console are hierarchically arranged, and all control nodes are able to exchange operation data through Ethernet. In addition, control console prepares detector power supply modules, manual drive control boxes, and a local sound drive box for operation support.

### *4.2 Software design*

Most functions are implemented to software programs replacing relay logic board of the old system. Detector drive unit control, path selector control, detector power supply control, and common control programs were developed for control functions, and various system diagnostic programs were also made up for providing system alarms and interlocks. For building operation interface, a set of graphic panes like control panes, parameter configuration panes, operation support panes and maintenance support panes were prepared for Kori unit 2.


Figure 3. Main control pane

## 5. Test, install and operation

The new detector drive system and the control console were integrated on the flux mapping system mockup in KEPRI to test the integrated system functions, before shipped to the Kori site. The new system was installed during the 19th planed outage of Kori unit 2. The replacement schedule was tightly observed without addition. After the replacement a series of integration tests were conducted as the same manner at the mockup. The initial operation of the new flux mapping system was performed on the 5% reactor power. The neutron flux distribution data were achieved successfully using the new system.

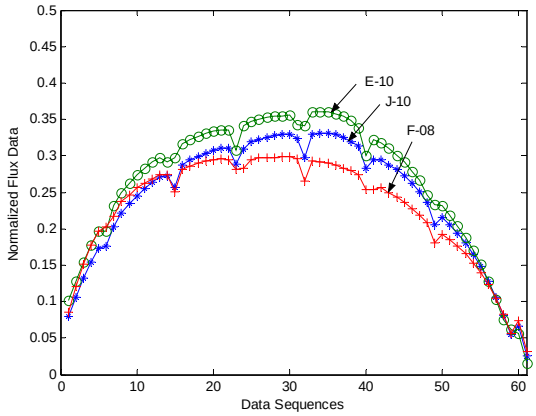


Figure 4. In-core flux map data at 5% of reactor power

## 6. Conclusion

In order to cope with aging sign of the in-core flux mapping system of Kori unit 2, the system retrofit project had been performed and completed including system analysis, design, manufacture, test, installation, and test-operation. An advanced detector drive system equipped with an innovative detector driving and path selecting mechanisms enhances system efficiency and reliability dramatically. The digital control console also provides various kinds of automatic control functions and increases system maintainability and operability of Kori unit 2.

## REFERENCES

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