Development of Kori #1 Simulation System

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1. Introduction

A general NPA (Nuclear Plant Analyzer) for Kori #1, which does not have a full scope simulator, was developed to improve the operator's actual training effects, and it can be used for the accident analysis. KSIM developed by KEPRI was used as simulation environments, ARTS (Advanced Real-time T/H Simulation model) was used for the NSSS thermal-hydraulics modeling, and RAST-K was used for the core kinetics modeling. The results of steady state validation are described compared with Kori #1 design steady state data.

2. Simulation Environment

The program for real-time system variables and module databases controls the shared memory on internal variables that are used at each system composing simulator. Figure 1 shows the function diagram for real-time system variable and module database.

KSIM developed by KEPRI was used as real-time simulation environments. It has the following functions:

- Assignment of execution per CPU for each system
- Real-time control between executing modules of each system (executing 12 times per sec)
- Displaying and changing current value for internal variable of system model
- Providing real-time graph for variable of major system
- Offering mimic screen
- Three-dimensional core actuation screen
- Snapshot/Reset
- Operator action

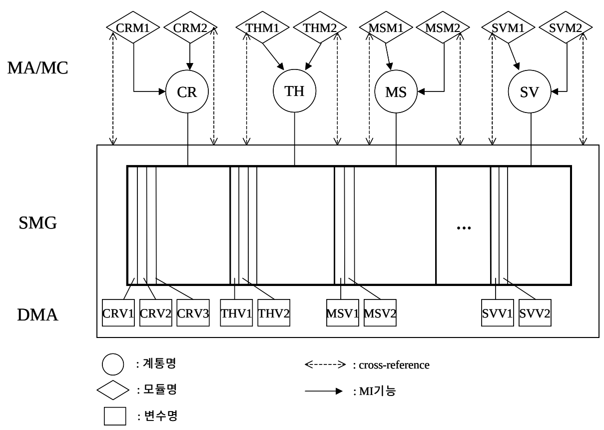

Figure 1. Function diagram for real-time system variable and module database

3. System Modeling and Results

ARTS was used for the NSSS thermal-hydraulics modeling, and RAST-K was used for the core kinetics modeling. The calculated results are displayed on MMI screen.

3.1 NSSS Thermal-hydraulics Modeling

The input model for ARTS was based on RETRAN input model. The geometric model of core, steam generator and pressurizer was modified using Kori #1 RELAP5/MOD3 input model that was verified by various safety analysis. Figure 2 shows the ART nodalization for Kori #1.

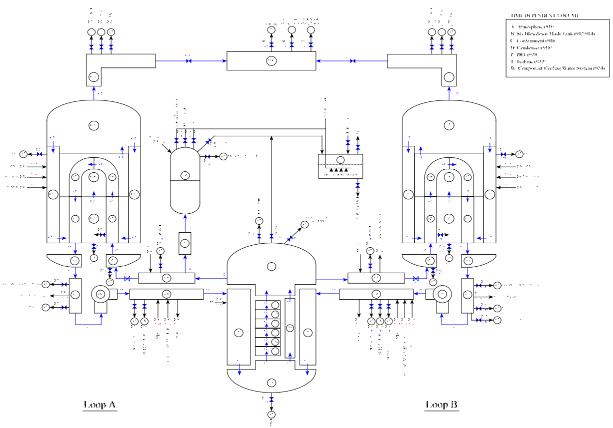

Figure 2. Kori Unit 1 Nodalization

3.2 Core Kinetics Modeling

The control rods were modeled in core kinetics modeling. The control rod control system is used to make the average coolant temperature as programmed by controlling reactivity. RAST-K, the kinetics modeling code, has the following features:

- Implicit time-dependent 3-D, 2-group diffusion equation solver
- Non-linear coarse-mesh finite difference method
- Preconditioned BICGSTAB
- Generalized core-reflector B.C instead of Albedo condition
- Generate excore detector signals using 3-D weighing factors given by DORT or TORT
- Control rod worth measurement (41 cases)
- Benchmarked with several problems

3.3 Development of MMI

To provide user friendly screen, the MMI was developed similar to the real plant panel. Figure 3 shows the MMI for the RCS, and figure 4 shows the soft panel. As shown in figure 3 and 4, the NPA screens have the functions and forms like a real plant panel.

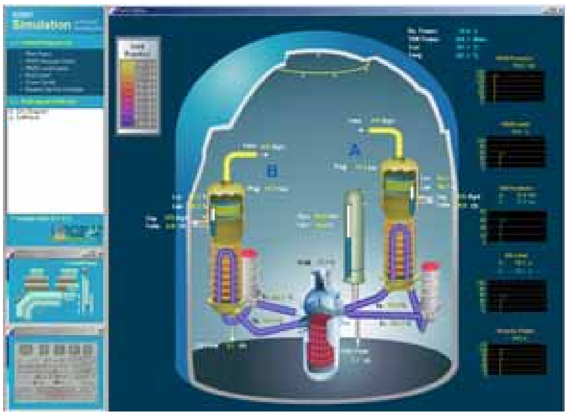

Figure 3. MMI for the RCS

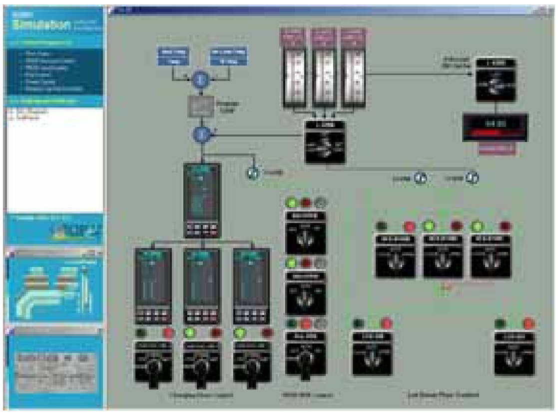

Figure 4. Soft Panel

3.4 Steady State Result

The steady state tests were performed to verify the functions, and the results were compared with Kori #1 design steady state data. As shown in table 1, the calculated parameters are in a good agreement with design ones.

Table 1. Comparison of steady state parameters

Parameter	unit	variable value		
		design	NPA	error (%)
Rx power	%	100.00	100.00	0.00
PRZ P	bar	154.12	153.95	0.11
PRZ level	%	55.00	55.40	-0.73
S/G P	bar	57.00	57.35	-0.61
S/G level	%	56.20	56.19	0.02
MF flow	kg/s	473.75	478.82	-1.07
S/G STM flow	kg/s	473.75	479.13	-1.14

4. Conclusion

A general NPA for Kori #1 was developed to improve the operator's actual training effects, and to cope with the accident analysis. KSIM was used as simulation environments, ARTS was used for the NSSS thermal-hydraulics modeling, and RAST-K was used for the core kinetics modeling. The results of steady state calculation were in a good agreement with design ones. A transient validation of the NPA is in progress. By using best-estimate code, RETRAN, at the real-time NPA, the flexibility to predict accurate results under all modes of plant operation can be provided.

REFERENCES

[1] "Operator Education Virtual Simulator Developing and KSNP Transplantation", Final Report, KHNP, 2002.
[2] "Development of Ulchin KNSP Simulator", Intermediate Report, KEPRI , 2001
[3] " Performance Improvement of Nuclear Power Education Institute #2 Simulator ", Final Report, KEPRI, 2001.
[4] "Development of KSNP Computer Support Education Training System", KEPRI, 2002.
[5] "ANSI/ANS 3.5 Nuclear Power Plant Simulators for Use in Operator Training and License Examination", USNRC, 1998.