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The Best-Estimate Analysis of Kori Units 3 & 4 for the Verification of Upgraded KNPEC#2 Simulator

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1. Introduction

Korea Electric Power Research Institute (KEPRI) upgraded the KNPEC #2 simulator to implement the changes caused by the power uprating project of Kori units 3 & 4. The simulator was validated through the system integrated test and verified through the comparison with the data sets generated by the computational analysis of the object plants or collected from the operational transients. In the case of the computational analysis, the best-estimate code systems and the nominal conditions were used to analyze the target plants. In this paper, the detail description of approaches to the analysis and the results were presented.

2. Plant Modeling

Prior to analysis, the reactor coolant system (RCS) of object plants, Kori Units 3 & 4, was modeled with volumes and junctions to simulate the accident for the RETRAN-3D and RELAP-5 codes. The 3 loops were modeled separately to reflect the non-symmetry effects which could be caused by asymmetric transients, such as the main steam line break (MSLB), the partial loss of flow, *etc*.[Figs. 1 & 2]. The control systems, such as rod control system, level or pressure control systems, *etc*., were modeled to simulate the normal operation of the plants. The results of steady-state analysis of the models are as mentioned in Table 1. The results show good agreement to the target values with negligible deviation.

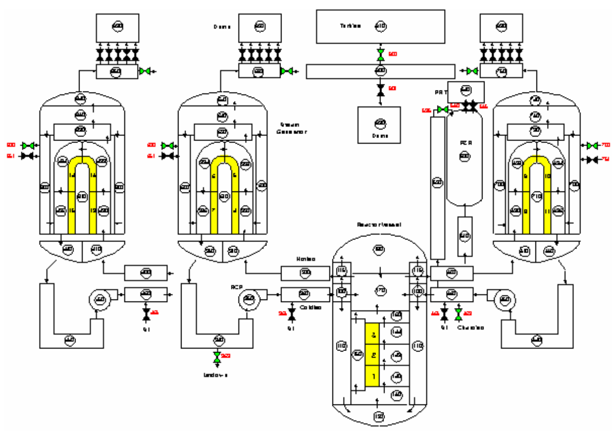

Fig. 1 RETRAN nodal diagram for Kori Units 3 & 4

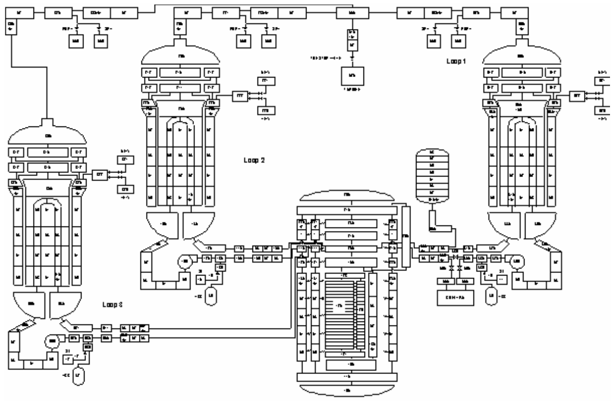

Fig. 2 RELAP5 nodal diagram for Kori Units 3 & 4

Table 1. Results of the Steady-State Analysis

Description	Target	RETRAN	REALP5
Core Power, MW	2,900	2,900	2,900
RCS Flow, lb/s	10,249	10,018	9,795
PZR Press., psia	2,250	2,250	2,250
Vessel Tout, F	620.0	619.0	620.9
Vessel Tavg, F	586.0	586.0	587.0
Vessel Tin, F	552.0	553.0	553.1
STM Press., psia	927	927	912
STM Flow, lb/s	1,196	1,198	1,193
Feed Temp., F	445.9	445.9	445.9
Zero Load Temp., F	557.0	557.0	557.0

3. Transient Analysis

3.1 Scenario Selection

In fact, to verify the simulator, the best suitable data sets would be the records of the plant operational transients. The records, however, could not cover all ranges of the transients required to verify the simulator. And the arbitrary transients in the plants actually could not be expected due to the safety issues. So the best-estimate analysis approach using the computational code systems has been used to compensate the lacks of data sets.

In this study, some transient scenarios were selected to meet the V&V requirements for the simulator and analyzed using the nominal conditions based on the same viewpoints mentioned before [Table 2].

Table 2. Selected Transient Scenarios

No.	Transient Scenarios
1	Reactor Manual Trip
2	All Feedwater Pumps Trip
3	All MSIVs Closure
4	Complete Loss of Flow
5	Partial Loss of Flow
6	Turbine Trip
7	Power Change (100 → 75 → 100%)
8	Large Break Loss of Coolant Accident
9	Main Steam Line Break
10	Pressurizer PORV Stuck Open
11	Loss of Load

3.2 Analysis

The selected transients were analyzed using the high fidelity best-estimate codes, RETRAN-3D and RELAP, using the models mentioned in section 2. For the analysis, some trip cards or setpoints were modified to implement the scenarios. The results of the analysis were as mentioned in references 1 and 2. In this paper, only the results of MSLB analysis are presented.

To implement the MSLB scenario, the 100% guillotine break on the main steam line has been modeled through the opening of control valves. To consider the two-phase flow effect in the line the dynamic slip model was used. The pressurizer level and pressure control system, steam generator level control systems were also considered to be in the normal operation.

The variation of the power and loop average temperatures show similar trends compared with those calculated for old simulator [Figs. 3 & 4].

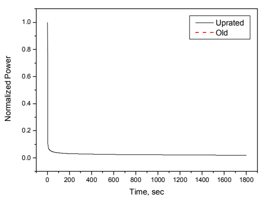

Figure 3. Power Trends

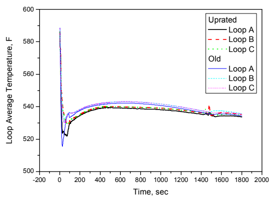

Figure 4. Loop Tavg Trends

In the case of the RCS pressure, the pressures of the pressurizer and steam generator shell-side dome also show similar trends except for some deviation [Figs. 5 & 6].

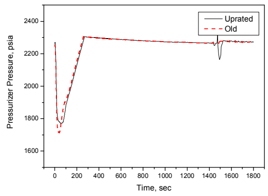

Figure 5. PZR Press.

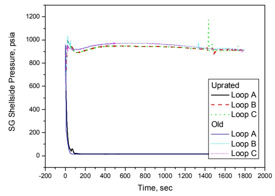

Figure 6. SG Dome Press.

Figure 7 & 8 compare the steam flow and inventory of the steam generators with those calculated for the original simulator. In spite of the similar trends, however, the uprated plants show lower mass inventory in steam generators due to slightly larger break flow caused by the uprated power level.

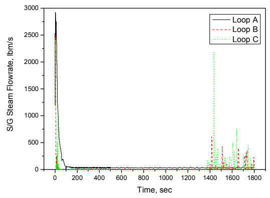

Figure 7. Steam Flow

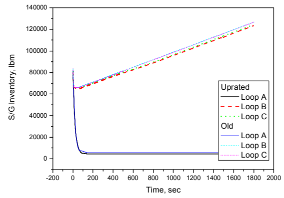

Figure 8. SG Inventory

4. Conclusion

The eleven transients were selected and analyzed to compensate the lacks of data sets to verify the upgraded simulator, KNPEC#2. For the analysis, the RCS and control systems were modeled with the best-estimate codes, RETRAN-3D and RELAP5. And the transients were analyzed according to the transient scenarios with the nominal operation conditions to generate the verification data sets.

Acknowledgements

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REFERENCES

[1] J. H. Hong, *et al.*, Upgrade of KNPEC#2 Simulator for Kori Unit 3 Power Uprating - Final Report, TR.S02.S2006.897, Korea Electric Power Research Institute, 2006.
[2] Y. H. Kim, *et al.*, The Generation of Reference Data for KNPEC#2 Simulator Verification, TM.R06NH16.P2006.661, Korea Electric Power Research Institute, 2006.
[3] Y. H. Kim, *et al.*, UNICORN-TM User's Manual, TM.S05. R2006.933, Korea Electric Power Research Institute, 2006.
[4] D. S. Choi, *et al.*, RELAP5/MOD3.1/K User's Manual, KNF-TR-SGA-06005, Korea Nuclear Fuel Co. Ltd., 2006.