Improvement of Steam Generator Level Difference in OPR1000 Simulator

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1. Introduction

OPR1000 simulator based on the design data of ShinKori-Unit 1, which will be used for training operators of ShinKori-Unit 1&2 and ShinWolsung-Unit 1&2, has been developed. OPR1000 simulator adopted RELAP5 R/T code for the modeling of NSSS (Nuclear Steam Supply System) TH (Thermal-Hydraulics) and Reactor Core, and selected 3KEYMASTER^{TM}, a commercial plant simulation tool for NSSS auxiliary systems modeling, BOP(Balance of Plant) modeling and simulator environment.

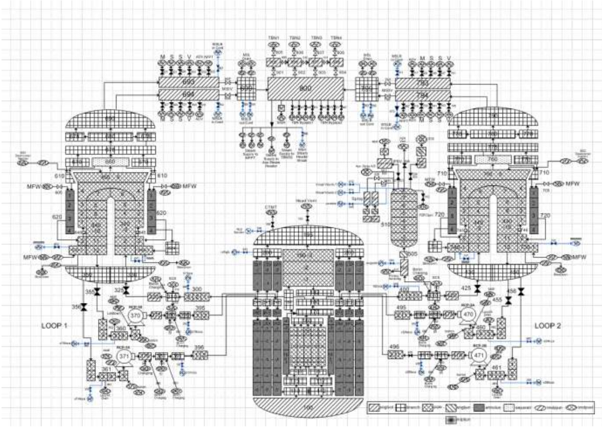

Fig. 1. RELAP5 R/T Nodalization for OPR1000

For V&V (Verification and Validation) of the integration, a lot of tests have been carried out through GOP (General Operating Procedure), AOP (Abnormal Operating Procedure), and EOP (Emergency Operating Procedure) during FAT(Factory Acceptance Test) and SAT (Site Acceptance Test) period. After the test, KHNP instructors or operators usally issue DRs (Discrepancy Report) about some mismatching results or phenomena in simulator while using it in class or test. One of the DRs is a Steam Generator(Steam Generator) level difference between two loops in case of feedwater loss malfunction. it will be reviewed in this paper.

2. Current Status of SG Level Difference

The SG level difference between two loops, occurs while SG levels sweep out to the bottom(0% level) and recover after feedwater was not available in feedwater-related malfunctions such as feedwater head rupture and feedwater control system failure. For comparison of SG levels between before and after countermeasures are applied, 45 tests are carried out and the average maximum SG level difference in case of feedwater head rupture is measured as 18.62%.

Fig. 2. SG level at feedwater head rupture(before)

3. Analysis of related parameters for SG Level

3.1 Analysis of Auxiliary Feedwater Temperature and SG Node Temperature

Auxiliary feedwater temperature and SG downcomer node temperature are compared each other with the same period in Fig. 3 & Fig 4. Although auxiliary feedwater temperatures are constant for two loops, Each range of SG downcomer node temperatures varies so much and the node temperatures of Loop B are relatively lower than those of Loop A. It seems that relatively lower SG downcomer node temperatures cause tardiness in speed of SG level recovery due to condensation.

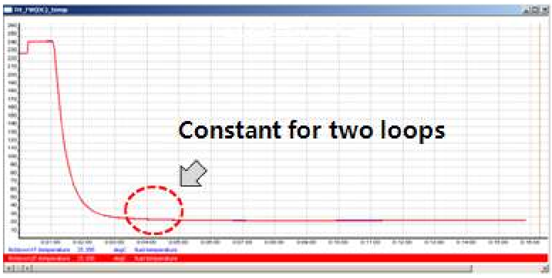

Fig. 3. Auxiliary Feedwater Temperature

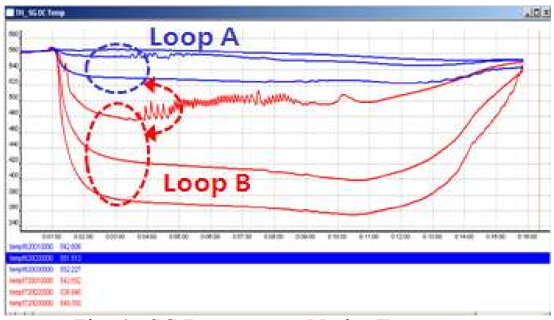

Fig. 4. SG Downcomer Nodes Temperature

3.2 Analysis of SG level and Auxiliary Feedwater Flowrate

SG level and auxiliary feed water flowrate are compared each other with the same period in Fig. 5. Auxiliary feedwater flowrates are being injected constantly when the level difference occurs and there is a time delay between the point of SG level difference occurrence and the point of auxiliary feedwaters controlled according to the SG level difference. It shows that auxiliary flowrates are not being controlled timley based on the SG level difference.

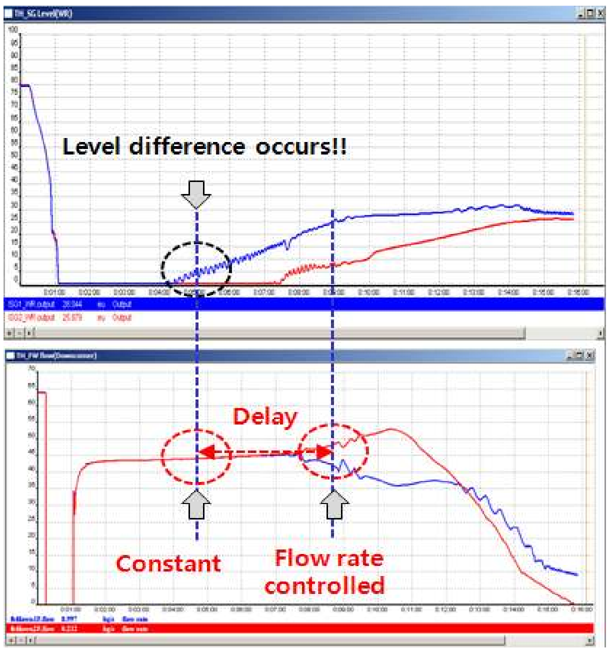

Fig. 5. SG level(above) and Auxiliary Feedwater Flowrate

4. Improvement of SG Level Difference

4.1 Change of SG level calculation method

The SG level calculation is embodied through the RELAP5-R/T code inputdeck. Current SG level is calculated by means of void fraction for each SG downcomer node volume which is affected much by node volume temperature. Therefore, it seeams that SG level calculation method should be changed into other method which is affected less by node temperature. Finally, pressure in SG downcomer node is adopted in stead of void fraction for SG level calculation.

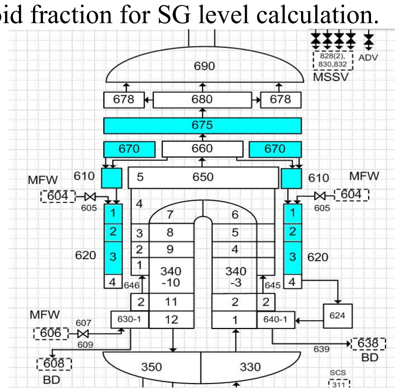

Fig. 6. SG Downcomer nodes for level calculation

4.2 Adjustment of PI Constant for Auxiliary Feedwater Control Valves

At low reactor power (less than 15~20%), feedwater for SG level is controlled by SG level only while at high reactor power, feedwater is controlled by SG level, feedwater and steam flowrate. It means that current feedwater control can't reflect SG level difference at low reactor power. Therfore, it seeams that PI constatnt for auxiliary feedwater control valves should be adjusted in consideration of SG level difference empirically. Adjusted are PI constants of two auxiliary feedwater control valves in Loop A because SG level of Loop A recovers more rapidly after SG level drys up to the bottom.

5. Result

After two improvement methods are applied, 30 tests are carried out repetitively. The average maximum SG level difference in case of feedwater head rupture is measured as 7.72%.

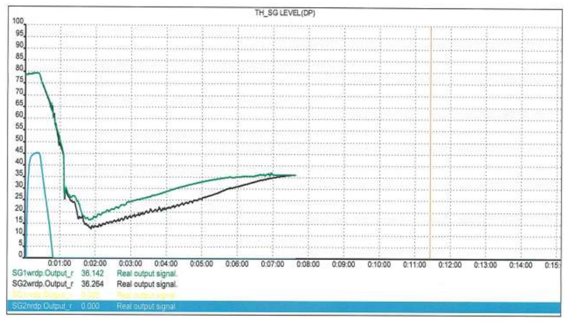

Fig. 7. SG level at feedwater head rupture(after)

6. Conclusions

It has been improved SG level difference in OPR1000 simulator in case of feedwater loss malfunctions. Two methods are suggested through analysis of related parameters for SG level. adopted and applied are two methods of level calculation and auxiliary feedwater control for SG level. By applying two presented methods, SG level difference has been improved from 18.62% to 7.72% by 59%.

REFERENCES

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[2] D. H. Hwang, M. S. Lee, J. H. Hong, S. H. Lee, J. K. Suh, "Interface between Core/TH Model and Simulator for OPR1000, Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May. 22, 2009.