A Study on the Application of the Reactor Power Cutback System to WH 1000 Type Nuclear Power Plant

Beyongho Yi and Jongsoon Song*
Chosun University, 309 Pilmun-daero, Dong-gu, Gwangju, Republic of Korea
godot21@naver.com

1. Introduction

The reactor shutdown of WH1000 type NPPs is inevitable during the secondary system transients, such as the loss of the total load, while OPR1000 NPPs are designed to prevent shutdown the reactor by the operation of the reactor power cutback system(RPCS). In this study, it is proved that the NPPs can be improved economically through preventing the unnecessary reactor shutdown by applying RPCS to the WH1000 type NPPs.

2. Main title

2.1 Analysis on cause of shutdown for NPP type

The analysis on the causes of unplanned shutdown of the nuclear reactor at the Hanbit1 power plant(WH1000 type), 55% of the cases were caused by the secondary system, whereas in the case of the OPR1000 type was 27%, about half of WH1000 type.

2.2 Necessity of R & D

To prevent the reactor shutdown of WH1000 NPPs in case of a secondary abnormal such as loss of total load, it is necessary to secure enough main steam dump capacity such as Hanul1 power plant or to apply RPCS like OPR1000 type. If a reactor shutdown occurs due to a failure or an accident, the NPPs will take a long time to analyze the cause of the shutdown and perform the safety assessment in order to obtain approval for restarting the reactor due to conservative decision making. As a result, the utilization rate is lowered and economic costs are increased according to the inspection. Therefore, reducing the number of reactor shutdowns in NPP operation is essential not only for economic improvement, but also for securing public confidence.

2.3 Steam dump system by NPP type

Comparison of characteristics and operating mechanisms of the WH1000 type and OPR1000 type power plant for the steam dump system used in the event of high power output from the reactor system caused by sudden loss of loads with the secondary system.

2.3.1 The steam dump system of WH1000 is designed to remove 64% of steam via the condenser and atmospheric in order to eliminate surplus thermal energy generated by the reactor when the turbine load is rapidly reduced or lost. But reactor shutdown cannot be avoided even if the steam dump system is operated when the turbine load is rapidly reduced or lost at 100% power operation.

2.3.2 The steam dump capacity of OPR1000 type is 55%, which is rather smaller than that of WH1000 type. The remaining surplus output is controlled by RPCS and the reactor control system. The plant maintains equilibrium energy and the reactor does not shutdown.

2.4 Application of WH1000 type RPCS

In the case of the WH1000 type NPPs, if two main feedwater pumps are lost, a turbine runback occurs and turbine power is maintained at 45%. Because the reactor output cannot be reduced quickly, the turbine-reactor output is mismatched, and the low level of the steam generator causes the reactor shutdown due to the shortage of water supply. Otherwise reactor shutdown occurs by primary system overheating (pressurizer high pressure, OTΔT). In order to prevent the reactor shutdown according to the above mechanism, it is necessary to apply RPCS to the WH1000 NPPs. The RPCS drops the selected control rods into the core to reduce reactor power and through the steam dump system quickly stabilizing the reactor output and turbine output.

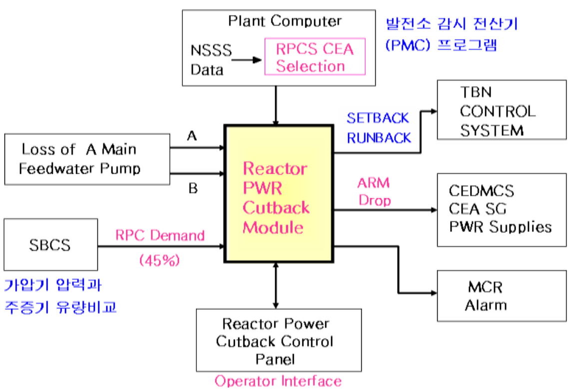

Fig. 1. Diagram of OPR1000 RPCS.

2.5 Simulation of the RPCS WH1000

A simulation model of the Hanbit 1 power plant was developed using the performance analysis code based on the Advanced Continuous Simulation Language (ACSL). Assuming that the secondary system has lost at the full loads. The comparative variables are reactor power, etc. When not applying the RPCS, the reactor coolant temperature was continuously increased from 588°F to 596°F due to the inability to properly cool the reactor coolant. The pressurizer pressure was increased and the reactor shutdown by the OTDT occurred at about 21 seconds after the total load loss. On the other hand, in the case of the RPCS applying model, part of the control rod was inserted into the core by the RPCS actuating and the reactor output was rapidly reduced to 40% and stabilized.

3. Conclusion

This study conceptually introduced the application of RPCS to the WH1000 NPPs to prevent reactor shutdown by the turbine stop or large secondary system transients. Applying this concept to the field, this will drastically reduce the frequency of unexpected shutdown at the existing Westinghouse1000 type NPPs.

REFERENCES

[1] CRI, KHNP(2012), Improvement of success rate for WH type full load dropout

[2] KHNP(2016), Hanbit unit 5,6 system manual