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Sensitivity Research on Design Parameter of Reactor Power Cutback System in Westinghouse type plant

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1. Introduction

Korea hydro & nuclear power co.(LHNP) performed 4.5% power uprate for Westinghouse type 3-loop plants in Korea several years ago. As the design modification, the main steam flow in full turbine load increased and the steam pressure decreased. The steam dump capacity decreased from 70% to 64%. Therefore, these plants do not have house load operation capabilities in full load rejection transients after power uprate. This paper performed a feasibility research on plant modification to recover these house load operation capabilities in full load transients by introducing reactor power cutback system in Westinghouse type plant.

2. Steam Dump System Capability

UCN nuclear power plants 1&2 can be transferred from full power to house load operation without reactor trip after full load rejection transients because steam dump capacity is sufficiently equipped with 85% of the rated main steam flow. Westinghouse type 3-loop plant has the 64% dump capacity and is not sufficient to accommodate excess heat after large load rejection. Therefore, operational experience data in this plant showed that the reactor trip occurred by trip signal such as over temperature DT (OTDT), pressurizer (PZR) high pressure and steam generator water level.

3. Reactor Power Cutback System (RPCS)

RPCS of OPR1000 type plant has been not installed in Westinghouse type plant. If the RPCS is installed the reactor power reduces abruptly by RPCS signal from steam bypass control system after large load rejection transients. The control rods selected by program are dropped and reactor power remained in an equilibrium state between 20~80% of the rated reactor power. OPR1000 type plant is designed to accommodate the unbalanced equilibrium state resulting from excessive reactor residual heat after large load rejection transients by using steam bypass control system and reactor power cutback system mainly. OPR1000 type plant has 55% steam dump capacity and is equipped with reactor power cutback system to remove the excess residual heat. Although the steam dump capability in the plant is small as compared with other type plants, it is possible to transfer from full load operation to house load operation in large load rejection transients (LLRT) because the plant has RPCS.

4. Results and Discussions

Transients with/without RPCS are shown in Figures 1 and 7. The transient are analyzed using assumption that feedwater flow and control do not control automatically with some conservatism. Large load rejection transient occurs at 10 sec and reactor power initiates to decrease at 15.5 sec and arrive in 5% of the rated power at 110 sec in transient case without RPCS as shown in Fig. 1. On the other hand, reactor power initiates to decrease at 12.3 sec and arrive in 45% of the rated power at 14.4 sec in transient case with RPCS. Reactor temperature decrease after increases early in transient case without RPCS but directly decrease in transient case with RPCS. PZR pressure increase to 2350 psia at 14.7sec in transient case without RPCS but do not arrive 2350 psia (PORV setpoint) in transient case with RPCS. SG pressure fluctuates in early stage of the transient and remains in a steady state after 150 sec in both cases. Steam dump valve position is more opened in transient case without RPCS. OTDT reactor trip occurs at 20.7sec in the case without RPCS but does not occur in the case with RPCS.

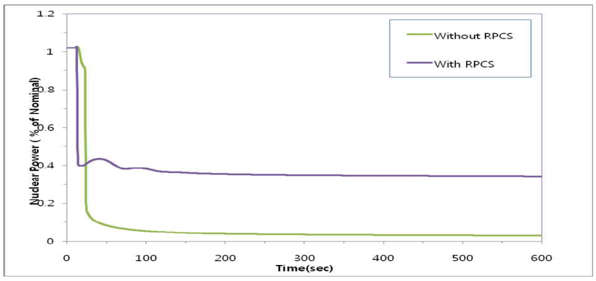

Fig. 1 Nuclear Power in LLRT

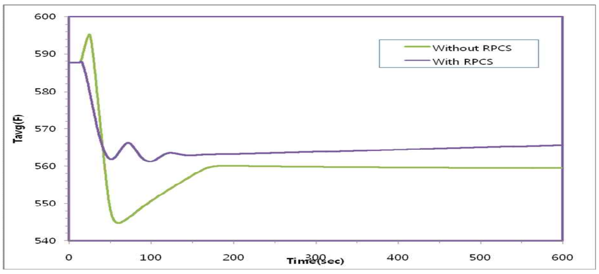

Fig. 2 RCS Average Temperature in LLRT

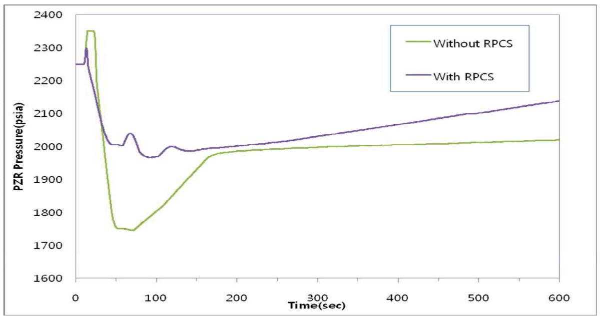

Fig. 3 PZR Pressure in LLRT

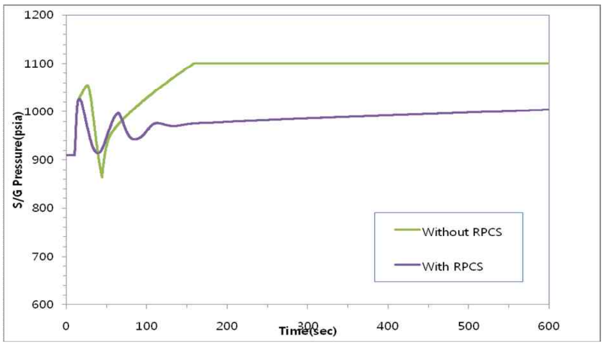

Fig. 4 SG Pressure in LLRT

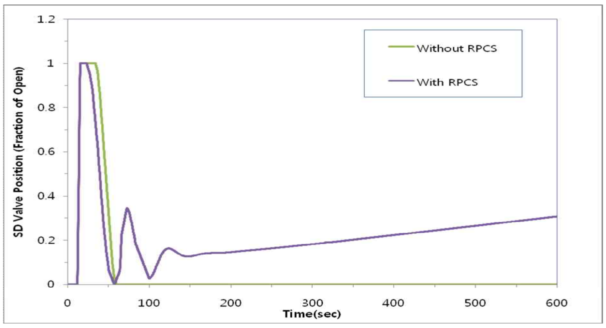

Fig. 5 SD Valve Position in LLRT

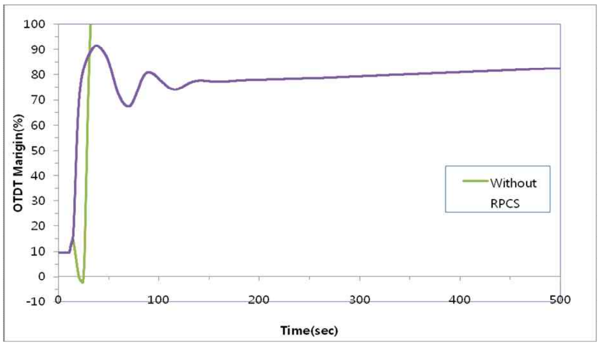

Fig. 6 OTDT Margin in LLRT

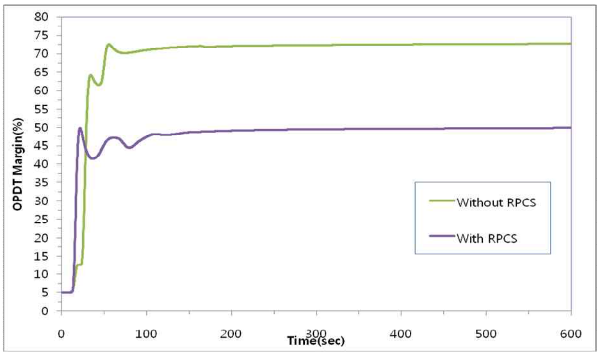

Fig. 7 OPDT Margin in LLRT

5. Sensitivity Analysis of Design Parameter

Significant design parameter of RPCS on reactor trip is delay time of the signal and target value of reactor power cutback. Reactor power cutback system signal should be initiated early to prevent reactor trip before OTDT reactor trip signal occurs. Target value of reactor power cutback should be optimized to prevent the safety injection signal and reactor trip. The safety injection signal can be occurred from excessive cooling and excessive heat removal if the value is too small. The reactor trip can be occurred from over pressure and over temperature by excessive residual heat if the value is too large.

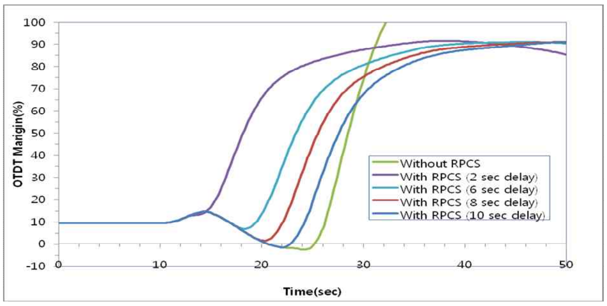

Fig. 8 Sensitivity study of OTDT Margin in LLRT

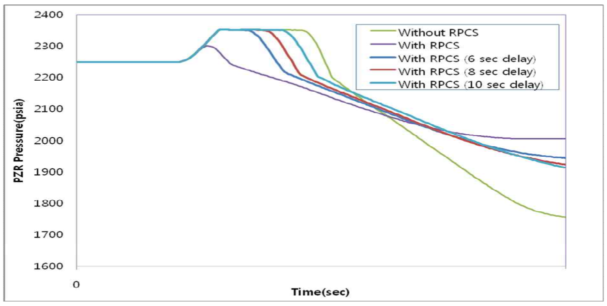

Fig. 9 Sensitivity study of PZR Pressure in LLRT

6. Conclusions

Westinghouse type plant has not reactor power cutback system. Steam dump capacity is not sufficient to accommodate the residual excess heat in full load rejection transients. Therefore, this paper performed feasibility study to install the RPCS in Westinghouse type plant. The results showed that the RPCS could prevent the reactor trip in large load rejection transients. Reactor trip occurred by OTDT and PZR pressure signal because the steam dump system could not remove excess heat after the large load rejection transients if the plant is not equipped with RPCS. However, the steam dump system and RPCS could remove excess residual heat if the plant is equipped with RPCS. RPCS should have response delay time within 8 seconds because OTDT reactor trip occurs at 10.7sec after large load rejection transient. Also, response delay time of RPCS should be limited within 4 seconds to prevent PORV open. It is appropriate to prevent reactor trip if target value of reactor power cutback has 45% after large load rejection transient.

REFERENCES

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[3] Kori 3&4 PCWG Parameters to support a 4.5% Power Uprate, 2002