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Transient Performance Tests of a NSSS Thermal-Hydraulic Model for the APR1400 Simulator

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1. Introduction

The APR1400 Simulator, which is developing by KEPRI, uses a RELAP5 R/T code to simulate the NSSS thermal hydraulic phenomena. The RELAP5 R/T code is based on a RELAP5 Mod3.2 code, and was modified for real-time calculation. The reactor protection systems, control systems and BOP systems for the APR1400 Simulator were modeled using a simulation environment program named 3KEYMASTER.

Transient performance tests provided by ANSI/ANS-3.5[1] were performed using the APR1400 Simulator, and the results were compared with those of RELAP5 Mod3.3. In this paper, the results of large break LOCA tests are discussed as the phenomena could tell the characteristics of each code well.

2. APR1400 Simulator

The integrated simulation environment for the APR1400 is shown in figure 1. The steady state parameters which should be monitored and compared with design data are presented. The details for steady state values at 100% full power operation are described in reference 2.

2.1 Simulation Environment

The various transient tests are performed at simulation environment which was developed using 3KEYMASTER. The 3KEYMASTER program provides following functions:

- Windows-based graphical simulation environment for the development, execution, and control of simulation models
- Objects can be picked, dropped, dragged, connected, and configured to form models (dynamics, logics, and controls) in graphic format
- Graphical engineering station for developing graphical simulation tools library and model
- Instructor station and softpanels to control and monitor the simulator
- Dynamic-link library processing
- Object linking and embedding
- Dynamic data exchange
- Miscellaneous simulator functions such as run, freeze, snap, reset, backtrack, etc.

2.2 System Description

The simulation models are composed as follows.

- Core neutronics/NSSS thermal-hydraulics model
- Reactor protection/control systems model
- Dynamic/electric/MMI systems model

The reactor core neutronics model is embedded in the RELAP5 R/T code as a package, and details are described in previous study [2]. To model the reactor protection/control systems and dynamic/electric/MMI systems, following simulation tools were used.

- Flowbase network modeling tool
- Component modeling tool
- Logic modeling tool
- Transmitter modeling tool
- Electrical network modeling tool
- Relay modeling tool

The systems and components which are monitored and controlled at the Main Control Room(MCR) and Remote Shutdown Room(RSR) are all included in the simulation scope. As shown in figure 1, all system models are integrated in simulation environment, and could be tested by the transient analysis.

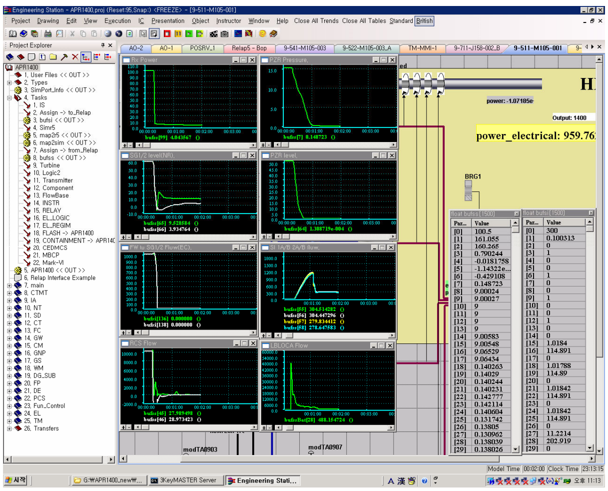

Figure 1. Integrated simulation environment for the APR1400

3. Transient Performance Tests

Transient performance tests have been performed and compared with the results of RELAP5 Mod3.3. In this paper, the results of large break LOCA tests are presented.

The major differences between calculations of RELAP5 R/T at simulator environment and RELAP5

Mod3.3 are the calculation cycles and limitations related real-time. The RELAP5 R/T at simulator environment executes 12 times per second, however the RELAP5 Mod3.3 has no real-time limitation.

Figure 2 to 5 show the reactor power, pressurizer pressure, break flow, and SIT flow when a large break LOCA happens at loop1b cold leg under the operation of 100% full power. The reactor power, pressurizer pressure, and break flow are similar in RELAP5 R/T at simulator environment and RELAP5 Mod3.3 calculations.

However, the SIT flow is somewhat different as the APR1400 simulator uses valves modeled by simulation tools. The motor operated valves are opened fully with the time lag of 60 seconds after the safety injection signals are actuated. So the results of APR1400 simulator are more realistic than those of the RELAP5 Mod3.3 calculations.

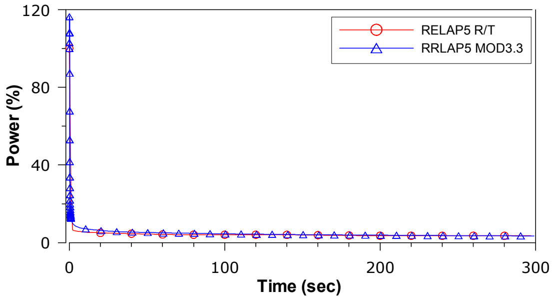

Figure 2. Reactor power (LBLOCA)

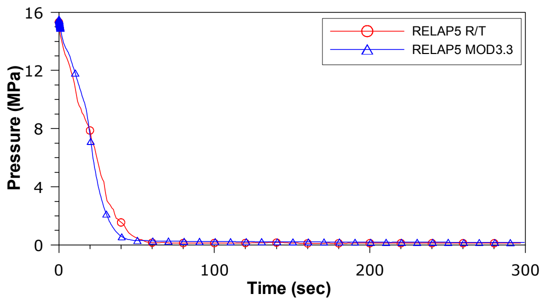

Figure 3. Pressurizer pressure

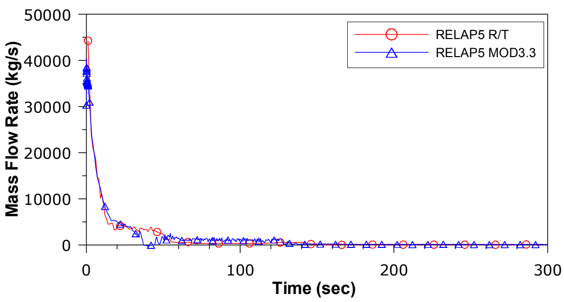

Figure 4. Break flow from loop1B cold leg

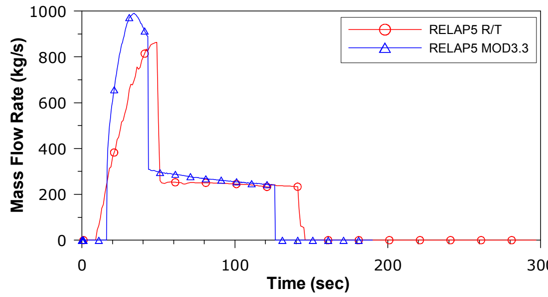

Figure 5. SIT flow

4. Conclusion

Transient performance tests of a NSSS thermal-hydraulic model for the APR1400 Simulator were performed. The transient test results by a large break LOCA at cold leg show reasonable plant thermal hydraulic responses compared with the results of RELAP5 Mod3.3 calculations. By testing the NSSS thermal-hydraulic model for the APR1400 using RELAP5 R/T, the fidelity of the APR1400 Simulator thermal hydraulic model could be certified.

ACKNOWLEDGMENT

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