Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Performance Evaluation for GOTHIC and RELAP Coupling Code

Choong Sup Byun, Dong Soo Song, Hwang Yong Jun

Korea Electric Power Research Institute
103-16, Munji-Dong, Yusung- Gu, Daejeon, 305-380, KOREA
Tel:82-42-865-5585 , Fax: 82-42-865-5504, Email:csbyun@kepri.re.kr

1. Introduction

The containment code, GOTHIC 7.2, is coupled with the system code, RELAP, via interprocessing communication method. In the coupled code, RELAP transfer the mass and energy release data to GOTHIC and GOTHIC transfer the calculated containment pressure simultaneously. The coupling simulation can give the best estimated results in the main parameters such as the containment pressure and the cladding temperatures. In addition, the operation of Engineered Safety Features (ESFs) can be simulated exactly in the coupling code in compared with the separated RELAP code.

2. Coupling Method

GOTHIC 7.2 includes the capacity to run simultaneously with other codes and to communicate information back and forth as the calculations proceed. This allows GOTHIC to calculate the containment response to the mass and energy injection from a loss of coolant accident (LOCA) calculated by a primary system code, RELAP5 Mod 3.3[1], as that code runs. At the same time, the primary system code could use the containment pressure, sump temperature and other parameters calculated by GOTHIC to establish boundary conditions needed for the transient on the primary side. Dynamic code coupling is accomplished Interprocess Communication (IPC) method [2].

RELAP5 modifications include the addition of a source file, ipc.c, which contains the functions necessary for communicating with GOTHIC. Additional minor modifications to RELAP5 are included in source file tran.f, which controls the time advancement of transient problems.

Figure 1 show the coupling concept. RELAP transfer mass and energy release data and safety injection flow rate to GOTHIC. GOTHIC calculates the containment pressure and temperature from the mass and energy release data from RELAP and feed back those to RELAP. In addition, GOTHIC calculates the recirculation times for the safety injection and the containment spray with safety injection flows from RELAP. These recirculation times are used for controlling the safety injection system and containment spray system in RELAP and GOTHIC.

Figure 2 show the GOTHIC modeling for coupling run. The boundary conditions, 1F and 2F, represent mass and energy release from RELAP. Residual Heat Removal (RHR) heat exchanger primary outlet temperature transfer to RELAP and the temperatures of safety injection water source are replaced with it after the safety injection recirculation. These data transfer can be accomplished easily by the control variables in GOTHIC.

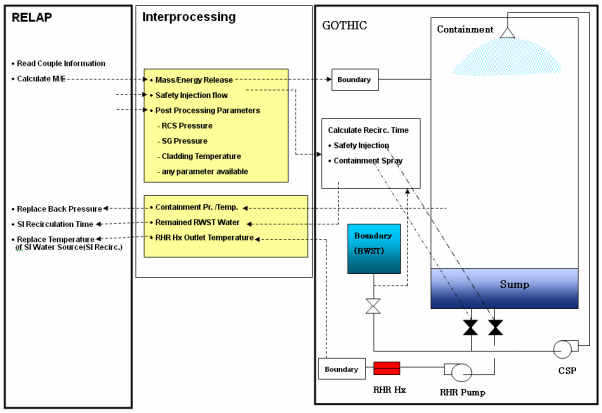

Figure 1 Concept of GOTHIC/RELAP Coupling Calculation

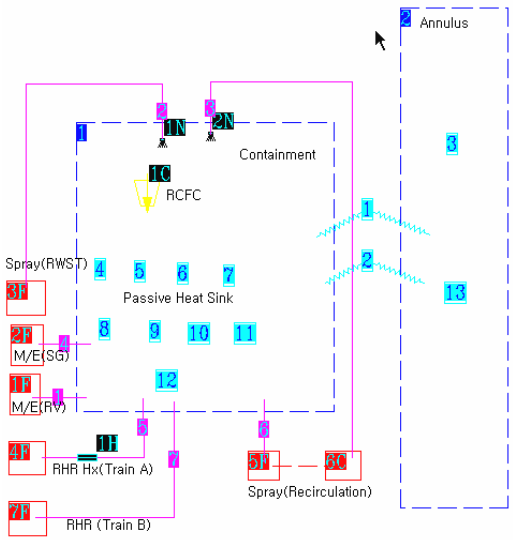

Figure 2 GOTHIC Modeling for Coupling Calculation

3. Evaluation

A large break loss of coolant accident scenario in the reactor coolant pump suction for Kori 2 nuclear power plant is used for performance evaluation of the coupling calculation. The maximum safety injection flow is assumed.

Figure 3 shows convergence test results for containment pressure. As seen in Figure 3, the calculation results converge on the coupled code results after several iterations. Figure 4 shows the containment pressure responses between the constant back pressure of 14.7psia and the coupled back pressure. After the blowdown stage, the containment pressure in case of the coupling calculation is higher than that in the constant back pressure case. This can be explained by the higher release enthalpy in case of the coupled back pressure.

Figure 5 shows the cladding temperature. As seen in Figure 5, the cladding in the coupled run is quenched earlier than that in case of using the constant back pressure of 14.7 psia.

Figure 6 shows good simulation of the safety injection system operation in the coupled code running. During cold leg injection, the low head safety injection (LHSI) pump and high head safety injection pump (HHSI) take suction from refueling water storage tank (RWST) and inject into the reactor coolant system. The LHSI pump injects the low head flow directly into the vessel downcomer. The HHSI pump initially inject only into the accumulator lines connected to the cold legs. After a three minute delay, some of the high head flow divert into the low head injection line. After draining the RWST the system aligns to the cold leg recirculation phase of operation. The LHSI pumps take suction from the containment sump. After the recirculation, the RWST temperature in RELAP is replaced with the outlet temperature of LHSI heat exchanger.

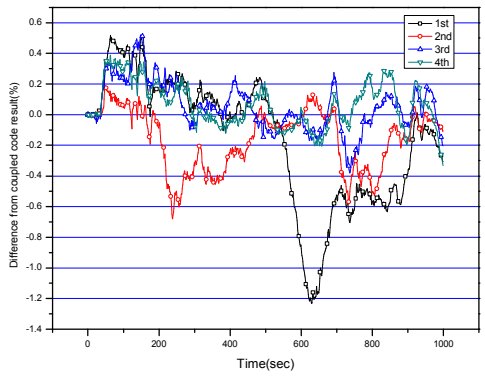

Figure 3 Convergence test for the containment pressure

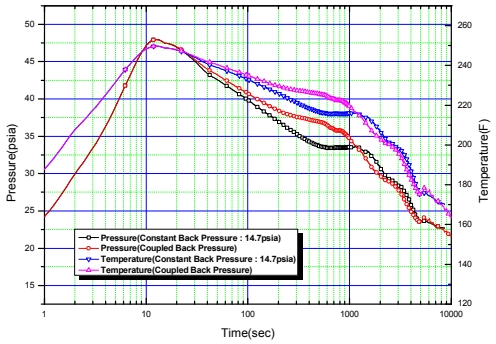

Figure 4 Containment Pressure and Temperature

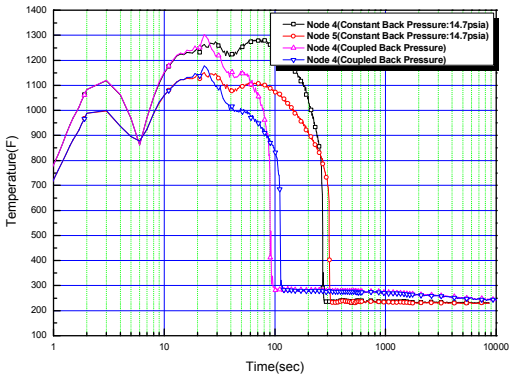

Figure 5 Cladding Temperature

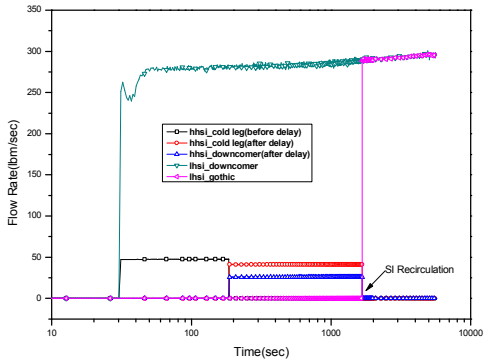

Figure 6 Safety Injection Flow

4. Conclusion

In this paper, the coupling between GOTHIC and RELAP is constructed and the performance is evaluated. The couple run can be easily accomplished by the minor change of RELAP source. The coupling run can give the best estimated results in the containment pressure and the peak cladding temperature and the additional margin in those predictions. In addition, ESF operation can be simulated easily in the GOTHIC/RELAP coupling code.

REFERENCES

[1] "RELAP5/MOD 3.3 Code Manual", Information Systems Laboratories, Inc., Jan. 2003.

[2] T.L. George, et. al., "GOTHIC Containment Analysis Program, Version 7.2, Volume 1and 2", NAI 8907-02, Rev. 16, Numerical Applications, Inc, Sept. 2004.