Assessment of Capability of MARS Code for Safety Evaluation of APR+ PAFS

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1. Introduction

In South Korea, advanced power reactor plus (APR+), as a Korean specific reactor, is currently under development for the export strategy. In order to raise competitiveness of the APR+ in the world market, it is necessary to develop the original technology for the improved technology, economics, and safety features. For this purpose, a passive auxiliary feedwater system (PAFS) was adopted as an improved safety design concept of APR+; and then there have been many efforts to develop the PAFS.

According to PAFS design concept [1], PAFS can completely replace the auxiliary feedwater system. When the design basis accident, in which feedwater is not available, occurs, the PAFS can remove the residual heat in the core and then prevent the core damage.

In order to develop the safety evaluation system for APR+ PAFS, it is required to assess the calculation capability of MARS code for the passive system with the horizontal type heat exchanger. For this purpose, the main contents of this study are: 1) to simulate the TH phenomena such as natural circulation and horizontal condensation heat transfer in NOKO experiment using MARS-KS, 2) to compare the simulation results between RELAP5 and MARS for PAFS input model.

2. MARS Simulation of NOKO Experiment

2.1 NOKO experiment

It has been known that SWR1000 in Germany use the passive safety system, called as Emergency Condenser, similar to PAFS. It uses the emergency condenser which is composed of the horizontal heat exchanger and large pool. In order to investigate the emergency condenser effectiveness in SWR1000, the experimental study was performed using NOKO facility of Fig. 1.

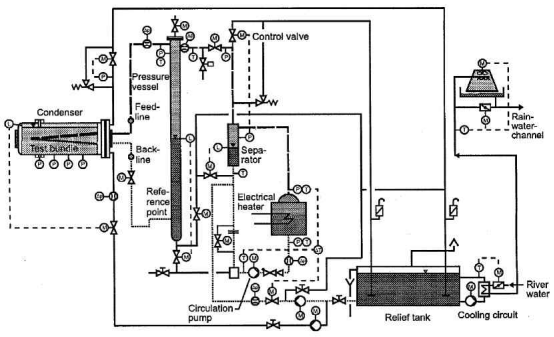


Fig. 1 NOKO Facility

2.2 MARS-KS modeling of NOKO experiment

In order to simulate the natural circulation and horizontal condensation heat transfer phenomena in the NOKO experiment using MARS-KS code, NOKO input model was developed, as shown in Fig. 2.

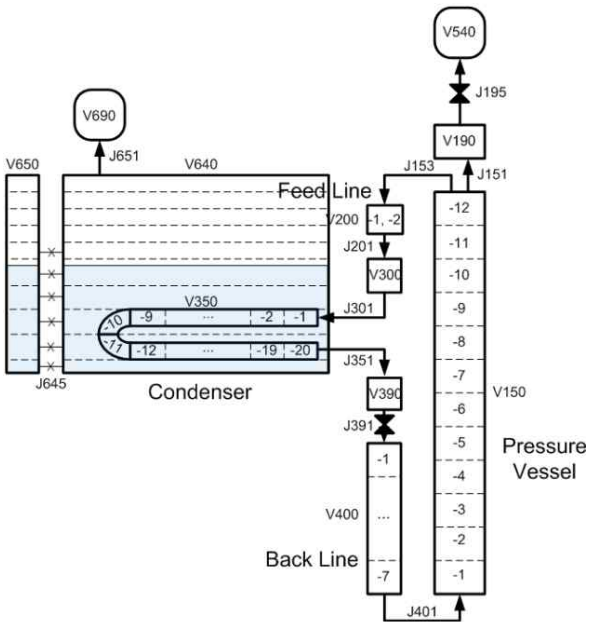


Fig. 2 MARS-KS Nodalization of NOKO Facility

2.3 Simulation results

In order to simulate the NOKO experiment, the experimental data of A7-1 case were used. From the experiment, it was found that the natural circulation flowrate, 1.6 kg/s was obtained when the pressure vessel pressure, condenser pressure and pressure vessel water level were 50 bar, 1.5 bar and 1.0 m, respectively. At this moment, the thermal power is 2.62 MW which is obtained from the hand calculation multiplying the mass flowrate and latent heat.

Figure 3 shows the MARS-KS calculation results. For the experimental condition in A7-1 case, the calculation results of natural circulation flow rate and heat removal rate are 1.5 kg/s and 2.49 MW. From the simulation results, it was found that MARS-KS somewhat under-predicts the amount of horizontal condensation heat transfer but MARS-KS could simulate properly the important TH phenomena such as natural circulation and horizontal condensation heat transfer in the NOKO experiment.

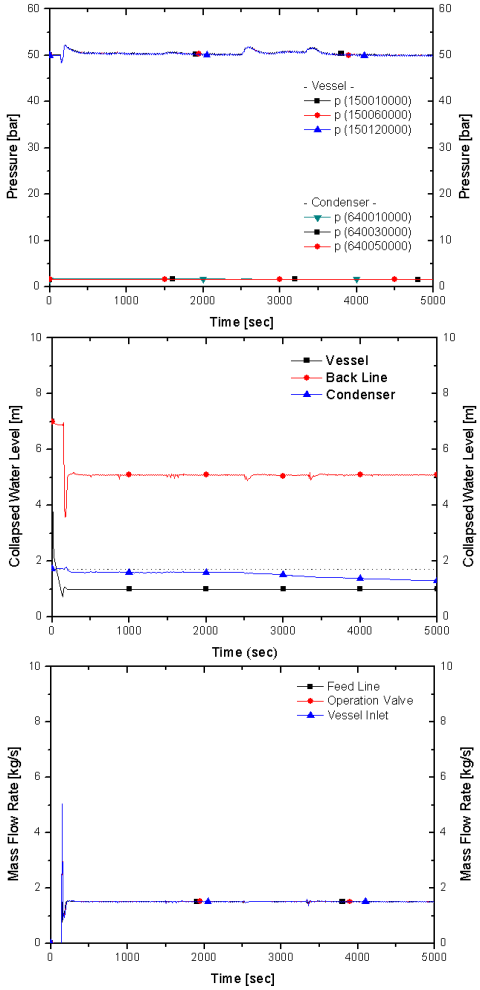


Fig. 3 Simulation Results (Pressure, Water Level, Flowrate)

3. MARS Simulation of PAFS

There have been many numerical studies to evaluate the PAFS performance using RELAP5 code. Although there are no experimental data for PAFS yet, it has been known that RELAP5 could simulate properly the important TH phenomena in PAFS.

In order to assess the calculation capability of MARS-KS for PAFS, MARS-KS and RELAP5 calculation results were compared using the same PAFS input model developed by KHNP, as shown in Fig. 4.

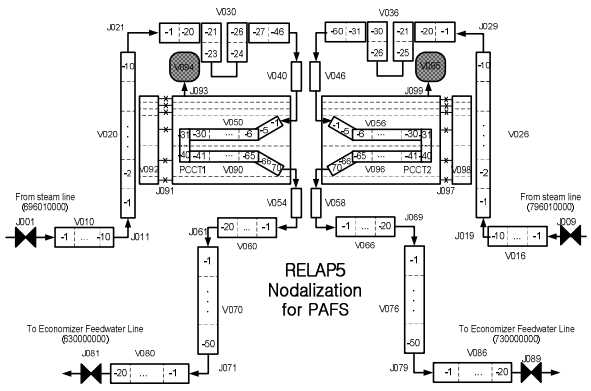
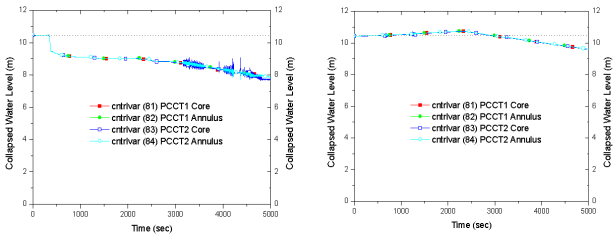


Fig. 4 PAFS nodalization

Figure 5 shows PCCT water level as representative MARS-KS simulation result. From Fig. 5(a), it was found that MARS-KS could not predict well the TH behavior in PCCT due to the numerical instability (see Fig. 6) when the initial condition on PCCT is set with NC gas. At 300s, the collapsed water level in PCCT was decreased sharply with very large pressure oscillation and void generation at 300s. However, if the initial condition on PCCT is set with steam instead of NC gas, MARS-KS predicts properly the important TH phenomena in PAFS, as shown in Fig. 5(b).



(a) MARS with NC gas (b) MARS w/o NC gas

Fig. 5 Simulation Results for PAFS

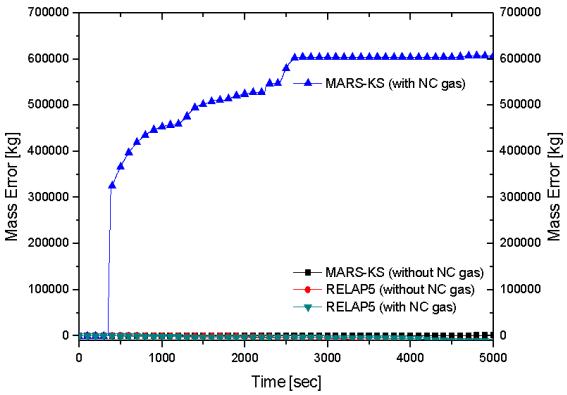


Fig. 6 Numerical Instability of MARS-KS

5. Conclusions

In this study, the calculation capability of MARS-KS was assessed using NOKO experiment and RELAP5 input model for PAFS. Present MARS-KS can predict properly the important TH phenomena such as natural circulation and horizontal condensation heat transfer in passive safety system. However, in the future, the modification of the original RELAP5 input model for PCCT is required to simulate TH phenomena in APR+ PAFS using present MARS-KS.

ACKNOWLEDGMENTS

The authors would like to acknowledge the financial support from Korean Ministry of Education, Science and Technology (MEST).

REFERENCES

[1] NETEC, The Feasibility Study Report on Development of The Core Technologies for APR+, 2008, S07NJ06-K-TR-001