Simulation of MIT Pressurizer Experiment using SPACE Code

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1. Introduction

The Korea nuclear industry has been developing a thermal-hydraulic analysis code for safety analysis of PWR(pressurized water reactor). The new code is named SPACE(Safety and Performance Analysis Code for Nuclear Power Plant). In this paper, the pressurizer model for SPACE code is tested using MIT pressurizer experiment data. The SPACE code input for MIT pressurizer experiment is developed and simulations are performed. The calculation results are compared with measured data from the experiment.

2. MIT Pressurizer Experiment

In early 1980s, MIT performed a series of pressurizer experiments. The transients considered include insurges to a partially-full tank, outsurges, insurges to a tank with hot walls, empty tank insurges, and combined insurges and outsurges. The initial pressure for the pressurizer ranges from 0.7~0.9MPa. A schematic diagram of the experimental apparatus is shown in Fig. 1. The primary tanks models the pressurizer and storage tank is used to store insurge/outsurge fluid. The primary tank is 1.143m high and has 0.203m inner diameter. More detailed information on MIT pressurizer tests can be found in references [1,2,3].

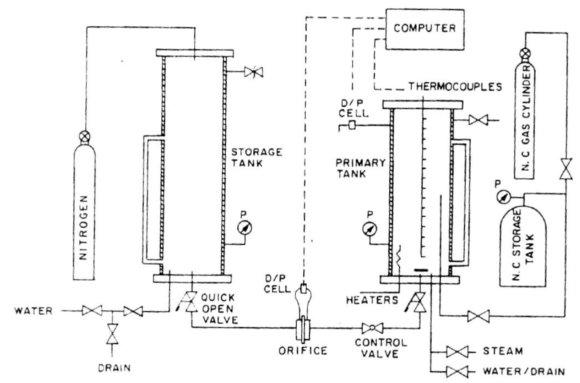

Fig. 1. Schematic of the experimental apparatus.

Table I: List of Conditions for MIT Pressurizer Test

Case / Parameter	A	B	C	D	E
Initial pressure [MPa]	0.696	0.867	0.784	0.698	0.869
Initial water level [m]	0.35	0.75	0.28	0.52	0.24
Final water level [m]	0.86	0.24	0.89	0.20	0.71
Final Pressure[MPa]	-	0.817	0.852	-	0.376

3. SPACE Calculation

3.1 Computer Code

The SPACE thermal hydraulic analysis code is used for simulation of MIT Pressurizer experiments. The SPACE code is an advanced system thermal hydraulic analysis code with two-fluid, three-field analysis capability. The SPACE code has many component models required for modeling a PWR, such as reactor coolant pump, safety injection tank, etc. The programming language used in the new code is C++, for new generation of engineers who are more comfortable with C/C++ than old FORTRAN language. The SPACE code is still under development, but now mature enough to simulate simple experiments.

3.2 SPACE Nodalization

The MIT Pressurizer is modeled using one pressurizer component, one heat structure group and one pipe component and one TFBC(Temporal Face Boundary Condition) component as shown in Fig.2. The pressurizer component(c110) with 10 cells is used to model the primary tank. The initial water level was modeled by changing vapor void fraction of each cell in the pressurizer. The heat structure(h110-1) and pipe(c770) is used to model heat loss to the environment. The TFBC component is used to model flow boundary condition to the pressurizer.

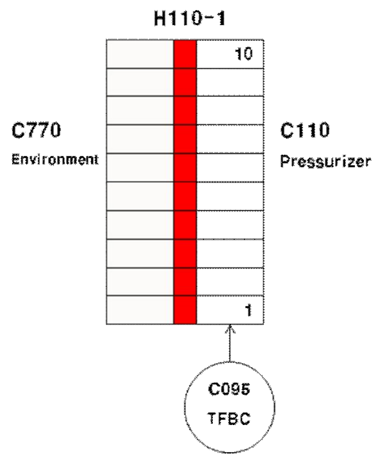

Fig. 2. SPACE Nodalization diagram for MIT Pressurizer.

3.3 Calculation results

The SPACE calculation for case A (insurges to a partially-full tank) and case B (outsurge) were performed. For case A, the initial pressurizer water level is 0.35m (1/3 of the primary tank). The initial water level is modeled by setting vapor void fraction to 0.0 for lower 3 cells for C110 and 0.6666 for 4th cell. The rest of the cells are set to void fraction 1.0. The insurge begins at t=20sec and stops at about t=86sec. The insurge water is subcooled. However, the insurge water does not immediately mix with saturated liquid already present in the pressurizer. Therefore the pressurizer pressure increases rapidly during insurge. The pressure decreases after insurge stops. This pressure decrease is due to heat loss to the pressurizer wall and mixing of cool insurge water and saturated water initially present in the pressurizer. The SPACE overpredict pressure rise during insurge and pressure decrease after insurge stops. However, the general trend is the same as the experiment.

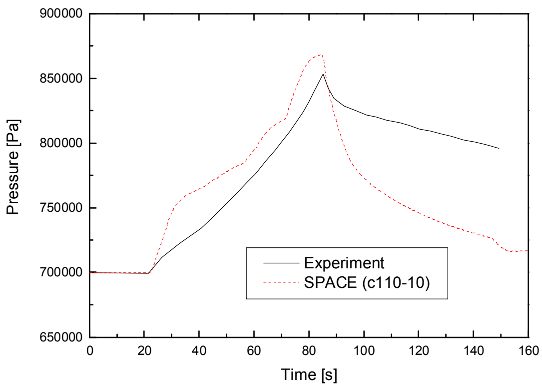

Fig. 3. Pressure vs. time for case A : insurge into partially filled pressurizer.

For case B, the initial pressurizer water level is 0.75m (2/3 of the primary tank). The initial water level is modeled by setting vapor void fraction to 0.0 for lower 6 cells for C110 and 0.3333 for 7th cell. The rest of the cells are set to void cells are set to void fraction 1.0. The outsurge begins at about t=6sec and stops at about t=65sec. At the beginning of the outsurge the pressure drops rapidly. After the initial pressure drop, liquid is vaporized and pressure changes slowly. SPACE code calculation predicts more pressure drop than the experimental results. However, the general trend is the same as the experiment.

For both case A and case B, SPACE code predicts larger pressure change compared to experimental results. The possible causes are 1) under prediction of phase change, 2) under prediction of heat transfer between vapor and liquid phase and 3) under prediction of wall heat transfer. As SPACE code becomes more mature, we expect better prediction of experimental results.

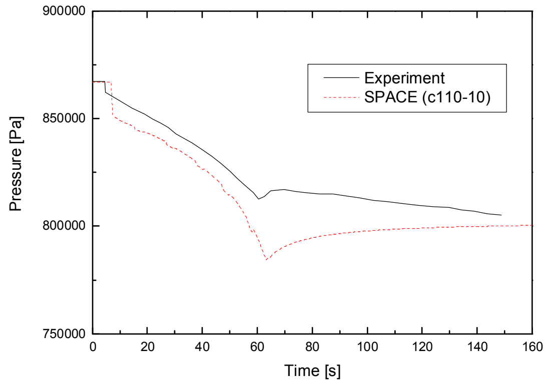

Fig. 4. Pressure vs. time for case B : outsurge

4. Conclusions

The MIT Pressurizer experiment was simulated with SPACE thermal hydraulic code. Two cases were analyzed : insurge into partially filled pressurizer and outsurge from pressurizer. The results show that general trend agree with experiment results. However, the amount of pressure change is larger for the SPACE code compared with the experiment. We expect better agreement as SPACE code development continues.

Acknowledgement

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