Analysis of MIT Pressurizer Experiment Using RETRAN Code

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1. Introduction

The MIT pressurizer experiment is a simplified experiment for assessment of pressurizer response during water insurge and outsurge transients. In this paper, RETRAN code is used to analyze MIT pressurizer experiment. The RETRAN 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 fluid in pressurizer is at saturation temperature and fluid in the storage tank is at room temperature. The primary tank is 1.143m high and has 0.194m inner diameter. In this paper, case A (insurge to a partially-full tank) and case B (outsurge) cases are analyzed. More detailed information on MIT pressurizer tests can be found in references [1,2,3].

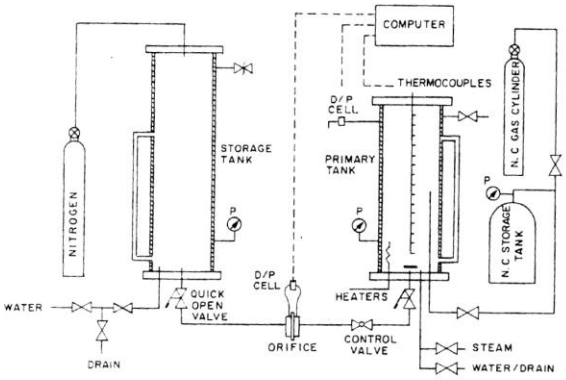

Fig. 1. Schematic of the experimental apparatus.

3. RETRAN Calculation

3.1 Computer Code

In this paper, RETRAN-3D code is used for simulation of MIT Pressurizer experiments. The RETRAN code is a thermal hydraulic system analysis code for Non-LOCA safety analysis, developed by EPRI. The version used is RETRAN-3D MOD 3.1k. The RETRAN code basically uses 3 or 4 equation model for thermal hydraulic analysis. The 3 or 4 equation model assumes homogenous volume properties. When a volume contains both vapor and liquid, saturation pressure and temperature are assumed. However, the pressurizer contains both vapor and liquid, and each region may have different temperatures. The RETRAN code provides pressurizer model which allows non-equilibrium thermodynamic conditions.

3.2 RETRAN Input Model

To find optimum input modeling, several types of modeling methods were tested to model the MIT pressurizer experiment. The pressurizer was modeled with a single volume. Sensitivity analyses were performed, turning on and off the non-equilibrium pressurizer option to see the effectiveness of pressurizer model. Pressurizer wall heat transfer was modelled with 10 conductors with local condition heat transfer model. Due to limitations of RETRAN, conductors connected to non-equilibrium must be insulated on one side. Therefore heat loss to the environment could not be properly modeled. Only the effect of wall heat capacity is considered. The insurge and outsurge flow is modeled using fill junction. The flowrates from the experiment were used.

3.3 Calculation results

The RETRAN 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 1.2625ft (1/3 of the primary tank). The initial water level is modeled by setting the mixture level of bubble rise model. The insurge begins at t=20sec and stops at about t=86sec. The insurge water is subcooled. However, in the experiment, 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.

When RETRAN pressurizer model is not used, the pressurizer volume assumes thermal equilibrium between vapor and liquid phase. The subcooled insurge fluid is immediately mixed with saturated fluid within the pressurizer. Therefore the pressurizer pressure decreases with insurge of subcooled liquid. When pressurizer model is used, the volume assumes non-equilibrium thermodynamic conditions. This allows the vapor region to become superheated as it is compressed due to insurge liquid. The results with the pressurizer model show pressure increase with insurge and pressure decrease with stopping of insurge, showing similar trends with the experiment[Fig.2]. In RETRAN, the user can supply inter-region heat transfer coefficient. By changing inter-region heat transfer coefficient, the RETRAN results during insurge can match the experiment value. However, after insuge stops, the pressure decrease is much steeper than experiment[Fig.3].

For case B, the initial pressurizer water level is 2.5625ft (2/3 of the primary tank). The initial water level is modeled by setting the mixture level of bubble rise model. 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. The RETRAN code calculation predicts less pressure drop than the experimental results. However, the general trend is the same as the experiment[Fig 4].

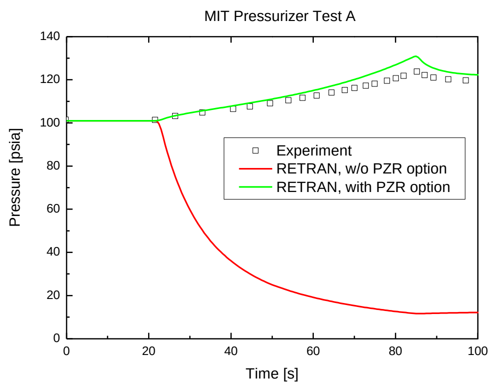

Fig. 2. Effect of pressurizer option for case A(Insurge)

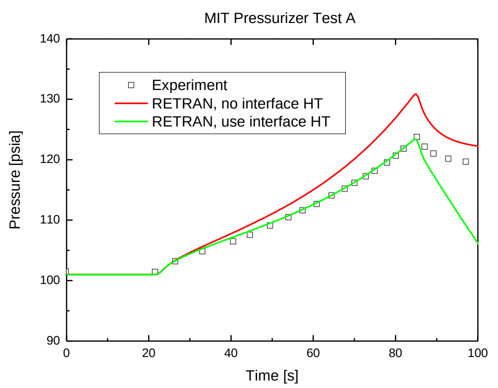

Fig. 3. Effect of inter-region heat transfer coefficient for case A(Insurge)

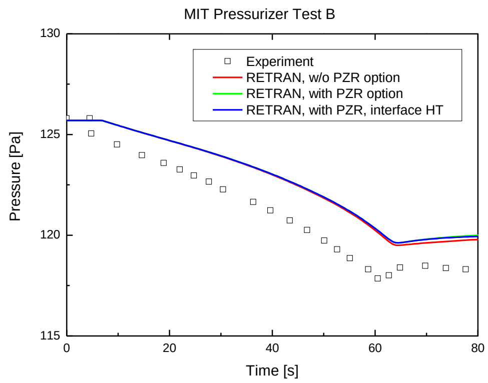

Fig. 4. Time vs. Pressure for case B(Outsurge)

4. Conclusions

The MIT Pressurizer experiment was simulated with RETRAN 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.

Acknowledgement

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