Simulations of Two-Phase Flows in Adiabatic Pipes Using SPACE Code

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1. Introduction

The SPACE code is a system code for predicting the thermal-hydraulic behaviors of PWR nuclear power plants. This paper is dedicated for the validation of the interphase drag module in SPACE code. Two experiments were employed for the comparison, for which no wall heat is applied.

2. TPTF horizontal test

2.1 Experiment description

Kawaji et al. (1987) and Nakamura (1996) reported a large number of experimental data for cocurrent-horizontal flow at saturated conditions. The system pressure ranges between 3.0~8.6MPa, and the mass flux between 300~1500kg/m^{2}s. Schematics are depicted in Figs. 1 and 2. The same facility is used except the mixer. The gamma-densitometers are placed at L/D=17, 21, 40, and 48 to measure the void fraction.

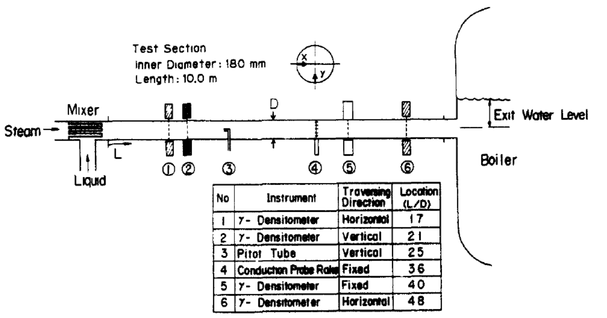

Fig. 1. Kawaji et al. (1987) apparatus (taken from reference)

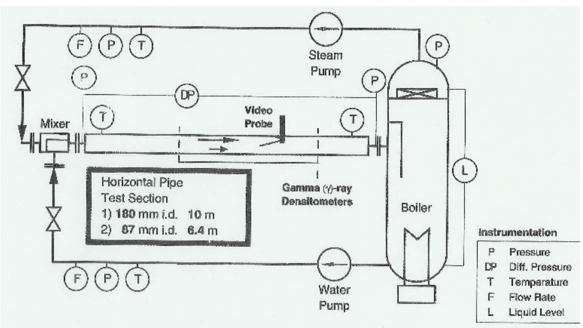

Fig. 2. Nakamura (1996) apparatus (taken from reference)

In Kawaji et al. (1987), the experiment were performed under two different water levels. For high exit level, the water level in the boiler is higher than the horizontal pipe, but for low exit level, the water level lower than the horizontal pipe. In Nakamura (1996), only high exit level data are provided.

2.2 SPACE model description

The SPACE models for Kawaji`s TPTF experiments are illustrated in Fig. 3. The models depend on the water level. The models for Nakamura`s experiment are quite similar to Fig. 3. A total of 46 data for Kawaji and a total of 64 data for Nakamura were simulated, respectively.

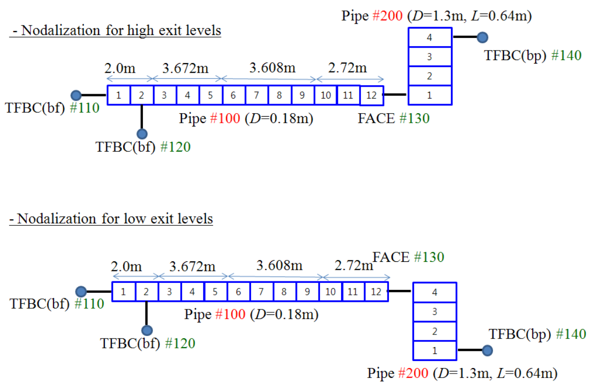

Fig. 3. Nodding diagram for Kawaji et al. (1987) experiment

2.3 Results

For the high exit level in Kawaji, the predicted void fractions at Cell 5 and Cell 11 are compared in Fig. 4. Though horizontal flow is difficult to be predicted due to stratification, Fig. 4 shows relatively good prediction. In particular, the predicted values at Cell 5 are better. The water level was designed to be kept in the boiler by using a simple vertical pipe. Hence, the farther from the boiler, the less the error induced by simple modeling.

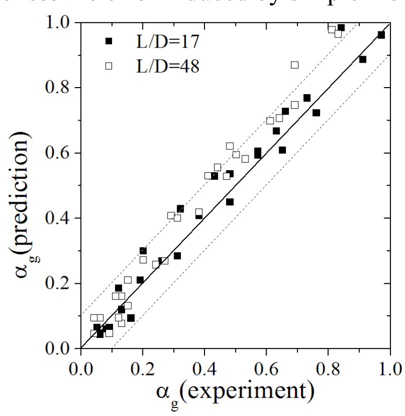

Fig. 4. Compaison of the prediction to the experiment (Kawaji et al. 1987).

3. ANL vertical test

3.1 Experiment description

Smissaert (1963) made experiments of cocurrent air-water flows in a vertical pipe, under the atmosphere pressure. The superficial velocities of water and gas are 0.0~0.305m/s and 0.032~4.676m/s, respectively. The apparatus consists of a downcomer, riser and separator. Details can be found in the reference.

3.2 SPACE models

In the model, the downcomer and separator are excluded. Air and water are injected from the lower inlet. The center of Cell 7 corresponds to the experimental measurement point. A total of 47 experimental data selected to be simulated.

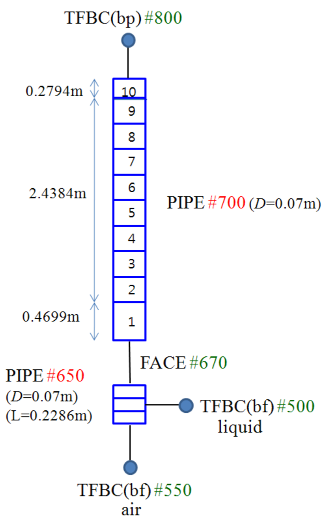

Fig. 5. SPACE model for Smissaert`s experiments.

3.3 Results

The following figure compares the prediction abilities of two interphase drag approaches. As can be seen, the drift-flux approach shows smaller errors.

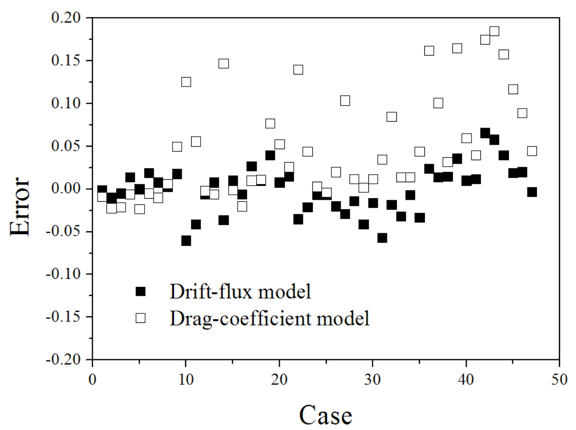

Fig. 6. Comparison of two interphase drag approaches

A comparison with the experimental data are shown in Fig. 7. The predicted values using the drift-flux correlations are considerably close to the experimental data, which demonstrates that the interphase drag module in SPACE code is excellent for upward air-water flow. For reference, no special correlations for noncondensable-water drag are used in SPACE code. In other words, SPACE code uses the nearly same correlations when calculating the interphase drags for steam-water and for noncondensable-water.

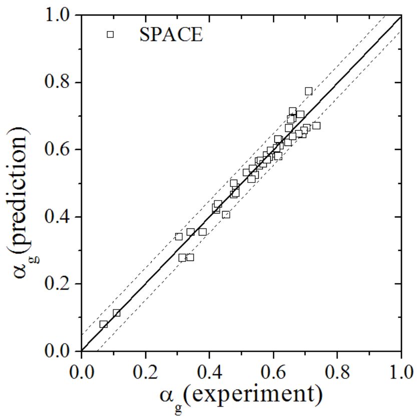

Fig. 7. Comparison of the predictions with the experimental data

3. Conclusions

The interphase drag module has shown to excellent for cocurrent and adiabatic flows.

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