ASSESSMENT OF THE RELAP5-3D SUBCOOLED BOILING MODELS FOR LOW-PRESSURE CONDITIONS

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ABSTRACT:

Two different low-pressure subcooled flow boiling experiments have been simulated using the thermal-hydraulic computer program RELAP5-3D. After carrying out the simulation of the cases with the original subcooled boiling model adapted in RELAP5-3D, the Savannah River subcooled boiling model (SRL) option in the code was selected and the simulations were repeated. The results of these simulations are compared against the experimental data. It is found that the axial void fraction predictions obtained using the SRL model compare better to the experimental data than the original model in RELAP5-3D. The annulus case using the SRL model gave reasonable results, however, refinements are required to reasonably predict the tube case experimental results.

INTRODUCTION:

RELAP5-3D[1] is the latest version of the RELAP series of computer programs that are used for the thermal-hydraulic safety analysis of water-moderated nuclear reactors. In this version of the code, a three-dimensional simulation of thermal-hydraulic and neutronic phenomena occuring in a reactor can be simulated.

Recently, a number of papers[2, 3, 4, 5] have appeared in the literature in which attention has been devoted to the RELAP5 code's predictions of low-pressure flow boiling experiments. These studies have been motivated by the need to use the RELAP5 code for the thermal-hydraulic safety analysis of research reactors and advanced reactors with passive safety features.

The primary objective of the present study is to study some of the experimental data on low-pressure subcooled flow boiling available in the literature, and to utilize them as validation cases, for thermal-hydraulic computer codes. Moreover, this study was also conducted to investigate the suitability of the SRL model for low-pressure subcooled flow boiling.

EXPERIMENTAL SETUP & NODALIZATION:

In this study, two subcooled flow boiling experiments, one in annular geometry, and the other, in pipe geometry, are simulated. The geometrical configuration and experimental conditions of the study are summarized in Table 1 and 2 respectively, and the reader is referred to reference 6 for more details. The experiments are discussed in references 7 and 8. The RELAP5 nodalization of the experimental setup is discussed in detail in reference 2.

In these simulations, the inlet liquid conditions were specified using the inlet time-dependent volume and time-dependent junction, and the exit conditions were specified using an exit time-dependent volume. The specified value of the experimental pressure was set at the condensing section.

Table 1. Geometrical Configuration of the Cases

CASE	GEOMETRY	ID (m)	OD (m)	LENGTH (m)
1	ANNULUS	0.0127	0.0254	0.3048
2	PIPE	0.01229	N/A	0.15

Table 2. Experimental Conditions

CASE	PRESSURE (Pa)	MASS FLUX (kg/s-m^2)	HEAT FLUX (kW-m^2)	INLET SUBCOOLING (°C)
1	1.65	367.4	714.4	29.2
2	1.65	620.2	805.0	44.3

RESULTS:

The results of the simulations are presented in Figures 1 and 2. In these figures, the axial void fraction predictions of the code are compared against the experimental data. The maximum absolute error on the void fraction was estimated to be 0.015[6]. The base code predictions are labeled as RLP-3D, those predictions with the SRL model option invoked, are labeled as RLP3D-SRL and the experimental data is denoted as EXP.

As can be seen from the results, the SRL predictions compare better to the experimental data, than the original code predictions. The SRL model gives a reasonable prediction for the annulus case but gives a low prediction for the tube case.

CONCLUSIONS:

The results of the simulation of two different subcooled boiling experiments, conducted in two different geometries using the RELAP5-3D computer code, have been presented. The SRL model option available in the code was invoked to compare its predictions and assess its suitability for low-pressure flow boiling conditions. It is found that the SRL model's axial void fraction predictions compare better to experimental data than the original RELAP5-3D's subcooled boiling model predictions. The SRL model gives a reasonable prediction for the annulus case, but gives a low prediction for the tube case.

REFERENCES:

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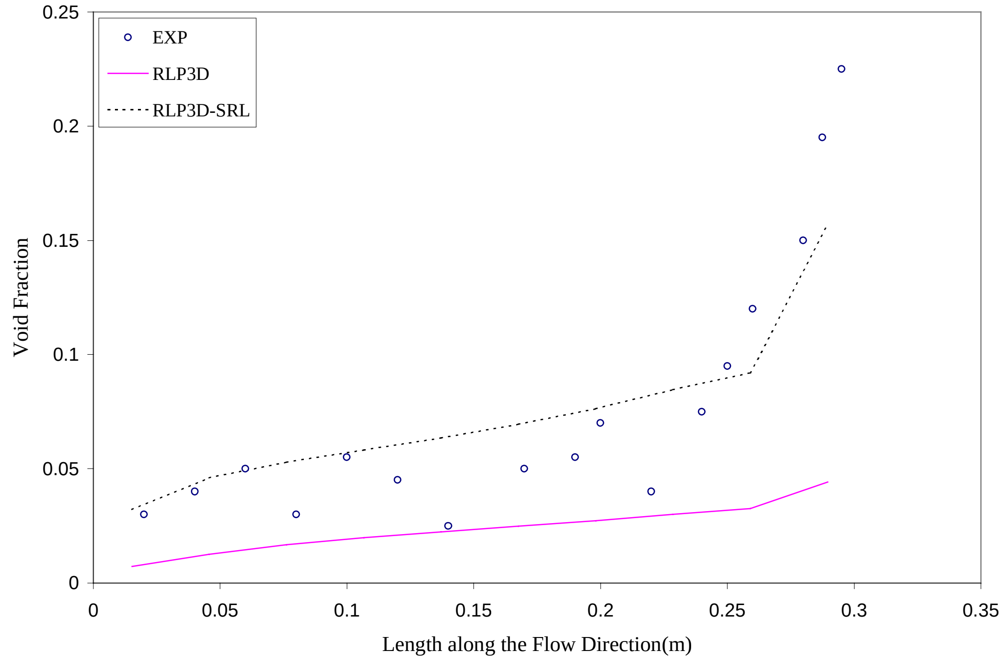

(9)

Figure1. Void Fraction Profile along the Flow Direction for Case 1 (Annulus)

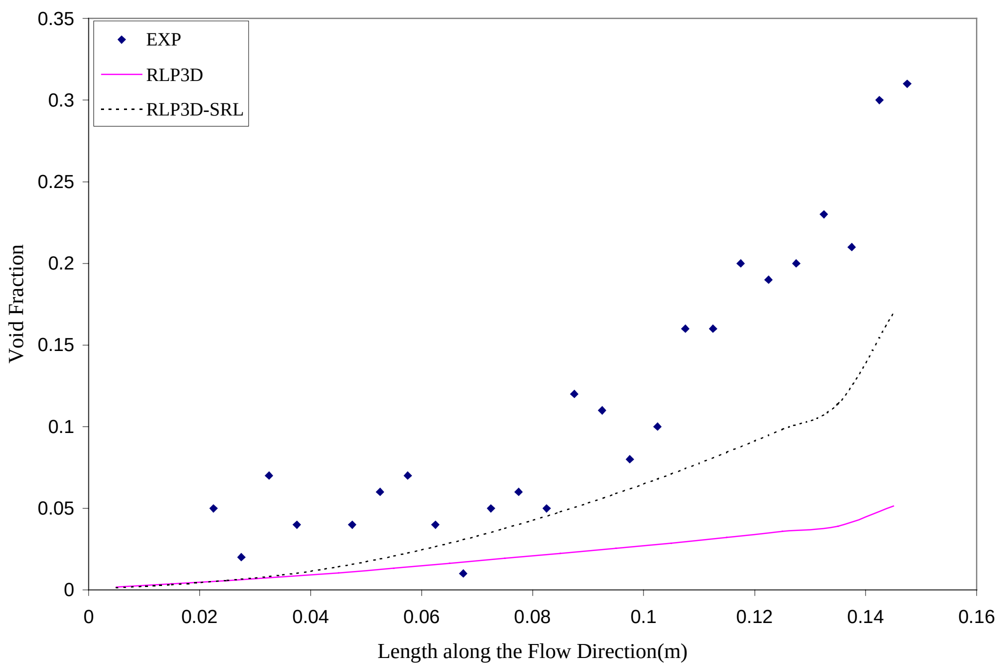

Figure 2. Void Fraction Profile along the Flow Direction for Case 2 (Tube)