MARS-KS Assessment of TRACE Fundamental Problems

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1. Introduction

MARS(Multi-dimensional Analysis of Reactor Safety) code has been developed for the realistic multi-dimensional thermal-hydraulic system analysis of light water reactor transients. In this study, the phenomenological problems were used to determine whether the code produces qualitatively correct results [1]. The main objectives of this study were to offer the additional validation data of MARS code by solving TRACE fundamental test problems. A total of five simple problems were used to evaluate the MARS code. This study is to investigate base capabilities of MARS for predicting the behavior of nuclear power plant. For this investigation, comparing code predictions against experimental data and the physics were conducted.

2. Methods and Results

2.1. Oscillating Manometer

The oscillating manometer, selected for the assessment, consists of the U-tube shaped frictionless pipe of constant cross-sectional area, 0.01 m^2 containing a water column of length L. The total length of the manometer is 20 m and its cross-sectional area is 0.01 m^2. The system is filled with water and air so that both arms of manometer, which is 5 m from the bottom. Initial conditions are an initial water level of 5.0 m and an initial velocity of 2.1 m/s. With these initial conditions, the analytical solution and MARS results are following.

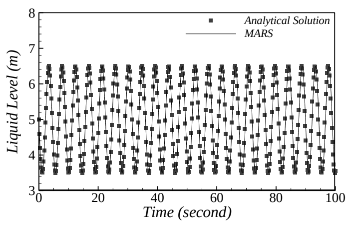

Figure 1. Variation of liquid level for the manometer problem

2.2. ANL Vertical Two-phase Flow Tests

Next topic is about the assessment of ANL vertical two-phase flow tests. As seen from figure2, almost data points were obtained scatter within 0.1 void fraction differences. However, the predicted void fractions with the test series A (in the case of the liquid superficial velocity is equal to zero) and the highly voided two-phase conditions were exhibited significant differences.

In figure3, it shows that TRACE results were good agreement within 0.05 void fraction differences. But it is needed to check the predictions with the highly voided two-phase conditions, and compare to MARS results.

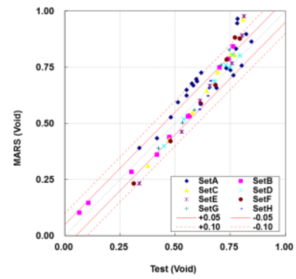

Figure 2. Comparison of MARS predicted and measured void fractions

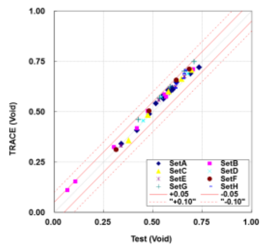

Figure 3. Comparison of TRACE predicted and measured void fractions

2.3. TPTF Horizontal Flow Tests

Next assessment is for two phase horizontal flow tests.

These two figures show the results of calculated void fraction at both MARS and TRACE. The prediction point was saturated temperature at high pressure. Void fraction is very sensitive to predicted pressure value inside pipe flow. So, there could be large errors in void fraction if the pressure loss across the pipe flow was not exactly predicted.

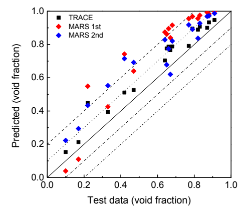

Figure 4. Bubbly flow type mixer

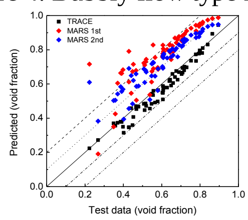

Figure 5. Separated flow type mixer

2.4. Test of MARS CCFL Model

This assessment show the prediction of CCFL phenomena compared with bank-off experimental data. Small diameter results and Wallis correlation were compared. Large diameter results and Kutateladze correlation were compared. Below results were from the MARS transient results.

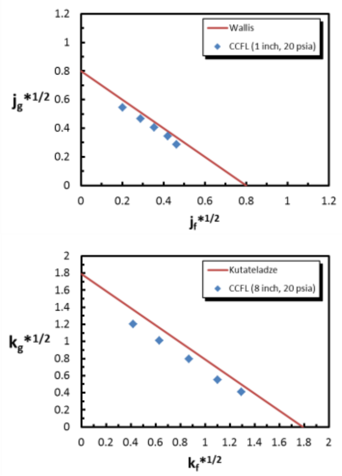

Figure 6. Gas versus liquid dimensionless superficial velocity

2.5. CISE Adiabatic Tube

Last item is CISE adiabatic tube test. As shown in below figure, MARS-KS assessment has a good result. However, void fraction prediction was over-predicted under the high quality condition. It means that the interfacial drag force model may be supplemented especially about slug and annular condition. But overall void fraction prediction of MARS-KS is satisfied.

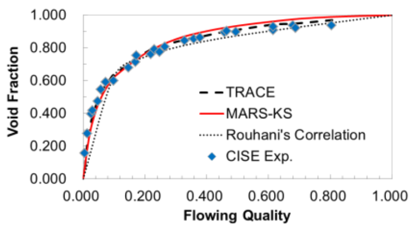

Figure 7. Results of void fraction

3. Conclusions

MARS-KS has been developed for a realistic analysis of thermal hydraulic transients in nuclear power plants. This study is intended to provide additional validation of the MARS-KS code by solving TRACE fundamental test problems. A total of five simple problems are used to evaluate the MARS code: Oscillating manometer for liquid motion in a frictionless U-tube manometer, ANL vertical two-phase flow tests for adiabatic two-phase upward-flow in a simple vertical pipe, TPTF horizontal flow tests for horizontal two-phase flow in a relatively large-diameter pipe, single tube flooding (test of CCFL model) for comparison of code void fraction predictions against experimental data, and CISE adiabatic tube for vertical upward two phase flow. Each assessment includes examined whether unphysical deviation exists, and in case where analytical solution exists, the accuracy of the code were evaluated. MARS results agree fairly accurately with the analytical solutions and TRACE results, which demonstrate that the predictions of the thermal-hydraulic behavior in MARS-KS are accurate.

4. Recommendation & Further Study

The assessment results of ANL vertical two-phase flow tests showed only three patterns were identified despite the fact that four flow regimes were classified in Mishima-Ishii criterion. It seems to us that are caused by flow regime model in MARS code. These tentative conclusions await further refinement and correction in the light of further research.

Large scale systems tests were not included in this assessment. Henceforward, it is also hoped that this work will serve as a platform from which studies of demonstrating the MARS code's ability to simulate nuclear power plant performance.

5. Acknowledgement

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