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An Improved RELAP4 BWR
Jet Pump Model

by

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SUMMARY

A RELAP4 Boiling Water Reactor (BWR) jet pump model development effort is being conducted to develop a new RELAP4 BWR jet pump model from test data. Results from the Jet Pump Test and Model Development Program[a] conducted at the Idaho National Engineering Laboratory (INEL) are being used. The overall program consisted of three phases, subscale testing, model development, and model evaluation. This paper includes a program description, a model description, and a model evaluation.

Since little off-design jet pump behavior data was available for model development and evaluation, 1/6 scale tests were performed in the LOFT Test Support Facility at INEL. Both subcooled steady state and two-phase transient tests were performed for a wide range of environmental conditions. During steady state tests the jet pump was exercised extensively for on- and off-design flow patterns. The transient tests approximated flow patterns found in BWR jet pumps during a loss-of-coolant accident. Model development consisted of using the steady state data to improve the original RELAP4 model when necessary. Model evaluation was performed using data from this program, the General Electric Company Two-Loop Test Apparatus, and full scale on-design data.

[a] E. E. Ross, "Jet Pump Test and Model Development Program Requirements and Plan," EG&G Idaho, Inc, Interim Report, March 1978.

For two-stream mixing as in a jet pump, a momentum exchange term is used in the RELAP4 momentum equation. The model development goal is to rectify the two-stream momentum exchange term using knowledge gained from the steady state test data. In as much as possible, the original form of these terms is to be retained thereby maintaining RELAP4 two-phase and scaling calculational capabilities. Briefly, the procedure is to compare the original exchange term with an analogous value calculated from the data and then correct discrepancies as required. Although these calculated values are biased by wall effects, turbulence and other phenomena, trends and approximate magnitudes can be determined.

Although numerous flow patterns and associated exchange terms occur, only the suction terms with positive drive flow are presented. Both RELAP4 and data values are presented in Figure 1. For normal positive flow, the exchange term is fairly well understood and in general the original model represents the data. However, for reversed suction flow there is little similarity between the RELAP4 equation and the calculated value. Better agreement is achieved by extending the positive suction flow equation into the negative flow region as shown in Figure 1. By including the multiplicative factor shown below in the negative flow region even better agreement is achieved.

$$\left(1.0 + \left|\frac{\text{Suction flow}}{\text{Drive flow}}\right|\right)$$

This product is the final form of the new model. Not only does this model give better agreement, but it is also continuous and retains the original form of the RELAP4 equations.

The performance of the new model is evaluated by performing RELAP4 jet pump calculations with the model and comparing the results to data. This comparison is shown in Figure 2 as a four-quadrant jet pump characteristic curve. Plotted are the new model, the original model, and data from this program. The improvements are particularly evident in the second quadrant, which is the case presented in this paper.

A new RELAP4 BWR jet pump momentum exchange model has been developed. The model is based on pump behavior observed in subscale tests. Although the new model is of the same form as the original model, discrepancies between the original model and data have been rectified. Jet pump calculations with the new model show substantial improvements over the original model.

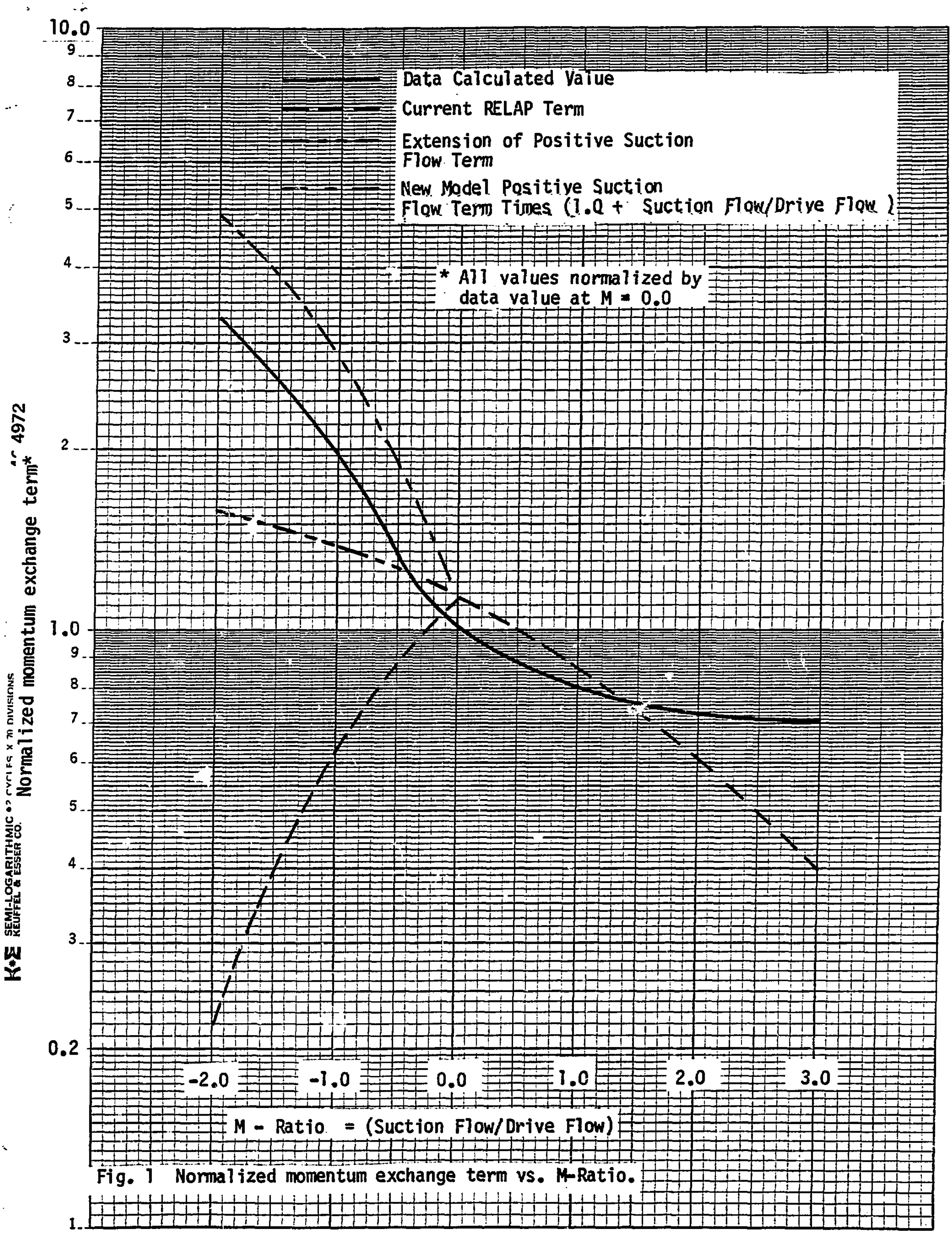

Fig. 1 Normalized momentum exchange term vs. M-Ratio.

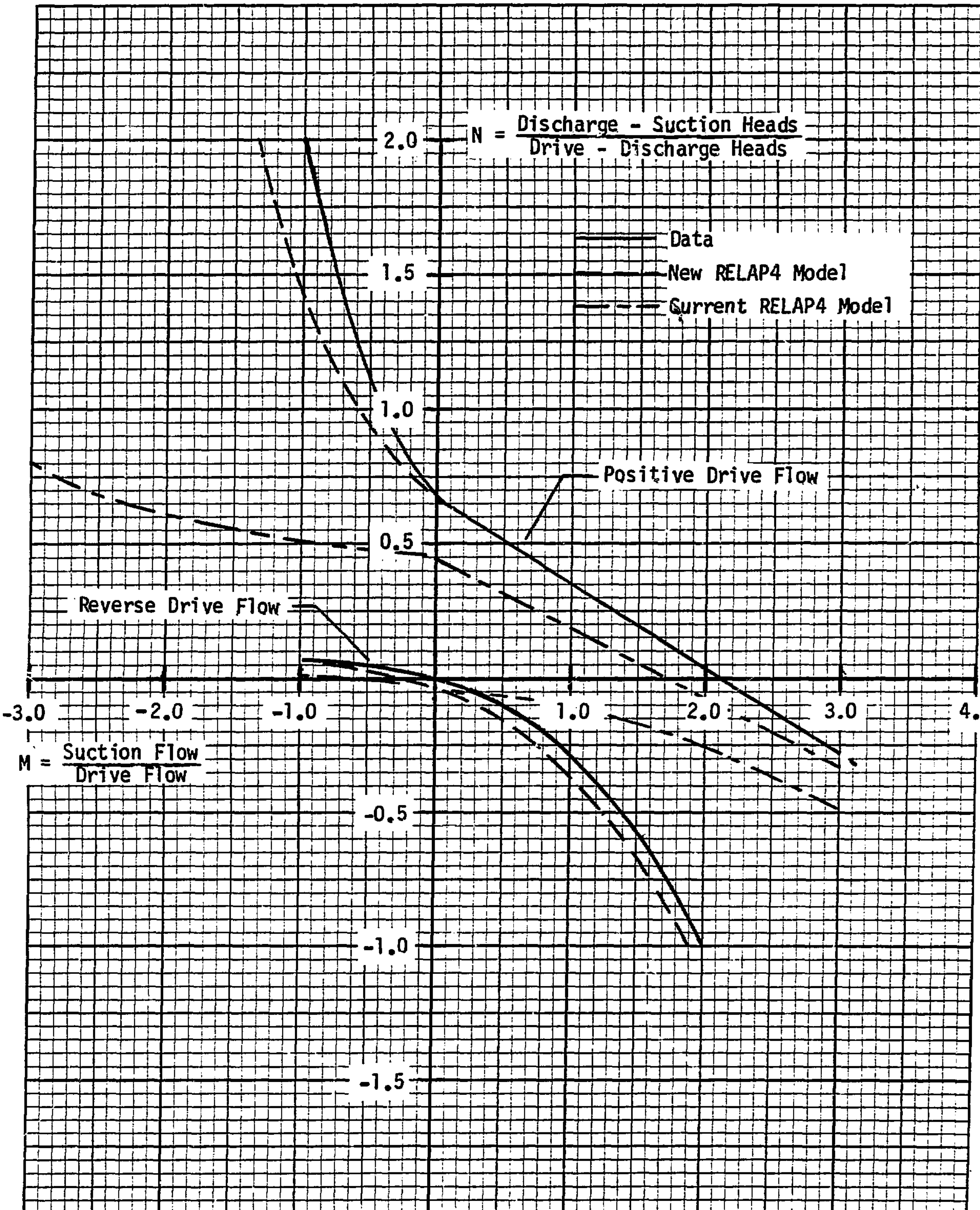

Fig. 2 Model evaluation - Jet Pump characteristic curve.