Forecasting of Two-Phase Flow Patterns in Upward Inclined Pipes via Deep Learning

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Abstract

Conventionally, the boundaries of gas-liquid flow regime transition are extremely sensitive to the inclination of flow channels. However, traditional two-dimensional flow regime maps have difficulties to reflect this fact as it can only accommodate two independent variables, which are often the gas and liquid superficial velocities. Few investigators have been able to propose a single model with accessible inputs under the considerations of the whole range of upward inclined angels. In this paper, we developed a novel approach by applying a typical machine learning (ML) method, artificial neural network (ANN), to predict flow pattern along upward inclined pipe (0 ~ 90°) using easily accessible parameters as inputs, namely, superficial velocities of individual phase and inclination angles. TensorFlow, a new generation and popular open-source foundation for ML programming, was used for building the ANN model, which was trained and tested by experimental data (1952 data points) that were reported in the literature. The predicting results show that ANN identifications have a satisfying agreement with experimental observations. The predicting accuracies of stratified smooth, stratified wavy, annular, intermittent, bubble flow are all above 90%, with the only exception of dispersed bubble flow (73%). In addition, the validation of the model was extended by comparing the ANN's performance with well-established two-phase transition boundary models among different flow regimes. Comparing against conventional methods based on either correlation or flow regime map, the developed ANN model is expected to be a more efficient tool in flow pattern prediction. Furthermore, the impact of inclination angles on final ANN outputs was evaluated quantitatively. Results showed, given flow conditions fixed, variations of inclination angles have a significant influence on gas-liquid flow patterns in channels of conventional sizes.