Predicting Microscale Bubble to Slug Transition Boundary using an Artificial Neural Network

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Abstract

Microchannel heat sinks have potential applications in, for example, miniature refrigeration systems, the cooling of computer chips and power electronics and the cooling of fuel cells[1]. Implementing flow boiling in microchannel heat sinks promises to provide significantly greater heat transfer rates than single-phase flows due to the utilisation of latent heat. However, general predictive tools for heat transfer rates and pressure drops in microchannels must be derived and agreed to facilitate extensive adoption by industry. Microscale heat transfer rates and pressure drops are fundamentally dependent upon the prevailing flow patterns, which describe the geometry of the liquid-vapour interface.

A recent review found that there are no current flow pattern transition boundary correlations capable of accurately predicting microscale flow patterns for a large, varied data set[2]. Most present transition boundary correlations have been developed using statistical analysis to empirically fit boundary lines from a data set. The inability to universally predict prevailing microscale flow patterns may be due to the complex interdependencies of between thermophysical properties and operating parameters. The use of machine learning algorithms presents a potential solution to the prediction of microscale flow pattern transition boundaries, as is attempts to find general predictive patterns, as opposed to drawing inferences from a data sample[3].

An Artificial Neural Network was developed to predict the bubble to slug transition boundary in the microscale, for both tubes and channels, using 2885 data points. The performance of the algorithm was then tested using an existing data set for water in a single microchannel that was previously unseen during the training and testing of the algorithm. The results were comparted to existing correlations and it was found that the present algorithm performed significantly better and provided greater insight into the physical reasons for the transition from bubble to slug flows.

References

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