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Description and validation of the Little correlation for boiling zeotropic mixtures in horizontal tubes from cryogenic to room temperature

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The use of mixed gas working fluids has become common in Joule–Thomson (JT) type cryocoolers for a variety of applications in the cooling temperature range from 80 to 230 K. The thermal efficiency of mixed gas JT cryocoolers is dependent on the optimization of the gas mixture composition. Most optimization methodologies focus on thermodynamic criteria of the cycle because there are very little data or theory currently available regarding the heat transfer coefficient associated with these two-phase, multi-component mixtures at cryogenic temperatures. There is not a general and accurate correlation to predict the local heat transfer coefficient (htc) for mixtures during the boiling process. Little (2008) proposed a correlation to be used on horizontal tubes that shows good agreement with Nellis (2004) experimental data of nitrogen-hydrocarbon mixtures. However, it is not clearly shown how the correlation is obtained and how it should be applied. This paper provides a more complete description of the Little correlation and also expands its validation using the experimental data provided by Barraza et al. (2015). The new experimental data include local heat transfer coefficient for 2 components (binary) up to 5 components mixtures in the temperature range between 100 K and room temperature. These mixtures are formed from nitrogen-hydrocarbon and argon-fluorocarbon mixtures and evaporate in horizontal tubes with diameters from 0.5 to 3.0 mm for different heat flux, mass flux, evaporating pressure, and composition.

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