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Prediction of two-phase pressure drop in heat exchanger for mixed refrigerant Joule–Thomson cryocooler

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The overall efficiency of mixed refrigerant Joule–Thomson (MR J–T) cryocooler is governed by the performance of recuperative heat exchanger which precools the refrigerant mixture prior to expansion in a J-T valve. In the heat exchanger, the hot stream of the mixed refrigerant undergoes condensation at high pressure while the cold stream gets evaporated at low pressure. The pressure drop in the low pressure stream is crucial since it directly influences the achievable refrigeration temperature. However, experimental and theoretical studies related to two-phase pressure drop in multi-component mixtures at cryogenic temperatures, are limited. Therefore, design of efficient MR J–T cryocooler is a challenging task due to lack of predictive tools.

In the present work, the existing empirical correlations, which are commonly used for prediction of pressure drop in the case of pure refrigerants, evaporating at near ambient conditions, are assessed for the mixed refrigerants. Experiments are carried out to measure the overall pressure drop in the evaporating cold stream of the heat exchanger. The various mixture compositions of nitrogen and hydrocarbons are used to study the pressure drop variations. Several tests are conducted on simple tube-in-tube and multi tubes-in-tube helically coiled heat exchangers for the same mixture compositions. The predicted overall pressure drop in the heat exchanger is compared with the experimental data for both the heat exchangers. The suggested empirical correlations can be used to predict the hydraulic performance of the heat exchanger.

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