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Thermodynamic analysis of a intermediate cooled heat exchanger working in high temperature ratio for Joule-Thomson cooler

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Heat exchangers of high efficiency are critical components in cryocoolers, whose performance influences the overall performance of the cryocoolers to a large extent. The entropy generation in heat exchangers primarily is a result of heat transfer across finite temperature difference. The traditional approach is to increase the heat transfer area and heat transfer coefficient so as to reduce the entropy generation. But it is limited by economic consideration and size restriction. Besides, entropy generation within heat exchangers increases owing to property variations at low temperature, and the enhancement of heat transfer has limited effects. A novel approach, based on the minimization of entropy generation, is adopted to optimize heat exchangers in the paper. The temperature difference is redistributed by intermediate cooling the hot stream. As a result, the entropy generation is reduced. The approch is especially applicable when the ratio of temperatures at two ends is high. A model is built to analyse the temperature difference distribution and entropy generation when the hot stream is cooled in different ways. The property variations including changes in specific heat capacity and heat transfer coefficients at low temperature, axial conduction, as well as parasitic heat loads, increase entropy generation greatly, which are considered in the model.

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