Ultimate Temperature of Pulse Tube Cryocoolers

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Abstract - An ideal pulse tube cryocooler using an ideal gas can operate at any temperature. This is not true for real gasses. The enthalpy flow resulting from the real gas effects of ^{3}He, ^{4}He, and their mixtures in ideal pulse tube cryocoolers puts limits on the operating temperature of pulse tube cryocoolers. The discussion of these effects follows a previous description of the real gas effects in ideal pulse tube cryocoolers and makes use of models of the thermophysical properties of ^{3}He and ^{4}He. Published data is used to extend the analysis to mixtures of ^{3}He and ^{4}He. The analysis was done for pressures below 2 MPa and temperatures below 2.5 K. Both gasses and their mixtures show low temperature limits for pulse tube cryocoolers. These limits are in the 0.5-2.2 K range and depend on pressure and mixture. In some circumstances, even lower temperatures may be possible. Pulse tube cryocoolers using the two-fluid properties of dilute ^{3}He in superfluid ^{4}He appear to have no limit.

Keywords - Cryocoolers, Real gas effects, Pulse tube theory

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