

PROCEEDINGS

Numerical Simulation Research on the Entire Process of a Cryostat Based on J-T Refrigeration Machine

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ABSTRACT

The pre-cooled J-T refrigerator is an important device for achieving low temperatures in the 2K temperature zone through mechanical refrigeration. It provides a stable and reliable low-temperature environment in the 2K-5K temperature range and ensures the accuracy of the low-temperature thermostat in the reference temperature measuring device. In this paper, the SAGE model and ESS model were established to determine the cooling capacity at 2K using the pre-cooling J-T cycle of a two-stage G-M refrigerator, which is utilized in the low-temperature thermostat of a 2-5K reference temperature measuring device. Thermodynamic analysis of the J-T throttling process was conducted, and experimental data from the literature were employed to validate the models. Using this model, key operating parameters such as the high-pressure pressure (P_H) and pre-cooling temperature (T_{pre}) in the J-T cycle are analyzed and optimized. The results of the J-T refrigerator cycle were integrated with the low-temperature thermostat, and the cooling process and stability of the entire low-temperature thermostat system were simulated. It is found that when the final pre-cooling temperature T_{pre} remains constant, the cooling capacity Q_c first increases and then decreases with the high pressure PH. To meet specific cooling capacity requirements, optimal values for the final pre-cooling temperature T_{pre} and high pressure PH can be chosen to minimize the total power consumption of the J-T refrigerator. Considering the lower cooling temperature of the cryostat, the J-T refrigerator is capable of providing an 11mW cooling capacity for the cryostat at 2.2K, with a minimum no-load temperature reaching 2.13K. These research findings offer optimization strategies and theoretical insights for the refrigeration cycle process of the low-temperature thermostat in the reference temperature measuring device.

KEYWORDS

Cryostat; J-T refrigerator; pre-cooling temperature

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