

Performance Analysis of Pulse Tube/³He Joule-Thomson Cryocooler for Thermometer Calibration

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Joule-Thomson (JT) cooling circuits can enhance the cooling capability of mechanical refrigerators. We have been developing JT cryocoolers for thermometer calibration for more than ten years. Owing to the nature of thermometer calibration, the cryocooler requires a wide operational temperature range with a high temperature control stability rather than a high cooling power. A pulse tube/³He JT cryocooler for precise thermometer calibration was developed. It comprises a commercial two-stage 4 K pulse tube refrigerator and JT cooling circuit, which was designed and built at National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST). The developed cryocooler uses ³He as the working fluid for the JT cooling circuit to reduce the minimum temperature below 0.5 K. This cryocooler utilizes a needle valve that can vary flow impedance for JT expansion. An oil rotary, mechanical booster pumps and a compressor were used for ³He circulation. The value of cooling power was typically 1 mW at 0.65 K. A sub-millikelvin temperature stability can be obtained at the thermometer comparison block that is installed in the cryocooler. The cryocooler has been used for the precise resistance thermometer calibration and evaluation at the temperature range from 0.65 K to 25 K. This paper describes the construction and performance of the developed cryocooler in detail.