Progress of the 4 K-class Vuilleumier type cryocooler and its further applications

Background

Vuilleumier cycle was first patented in 1918. It was usually regarded as the thermal-driven Stirling refrigeration cycle. The Vuilleumier cryocooler combines the low-frequency working pattern like GM type cryocooler and the compactness of Stirling-type cryocooler. With the continuous development in the past 100 years, the Vuilleumier-type (VM-type) cryocoolers have been proved to generate cooling power from ambient temperature to liquid nitrogen temperature and even to liquid helium temperature. In recent decades, some efforts were made on traditional displacer-type VM cryocooler, Vuilleumier hybrid pulse tube cryocooler (VM-HPTC) and the VM-type pulse tube cryocooler (VM-type PTC) to obtain the liquid helium temperature. Successfully, not only the 4 K was obtained, but also limit the temperature of oscillating cryocooler by He4 was hit. This paper presents the progresses of the 4 K-class VM-type cryocooler and analyzes the possible applications of 4 K-class VM-type cryocooler.

Displacer-type VM cryocooler

Matsubara et al. 1980s Japan

Matsubara et al. 1980s Japan

VM-type pulse tube cryocooler

Matsubara et al. 2000s Japan

Development process of 4 K-class Vuilleumier type cryocooler

Replaced the displacer & cylinder by pulse tube cryocooler (reducing moving parts)

Challis & Hogan 1964 USA

Zhou et al. 1970s China, CAS

Wang et al. 2018 China, TIPC, CAS

Dai et al. 2002 China, TIPC, CAS

PAN et al. 2016 China, TIPC, CAS

Further application

The future application of 4 K VM-type cryocooler mainly concentrates on the precooler source of the mill-class refrigerator like ADR or DR. Its compactness makes it more suitable to work in some mobile cooling system and even to join the cooling chain of X-ray detectors (SQUIDS, TES) in some science projects.

Conclusion

In this paper, the progress of 4 K-class Vuilleumier-type cryocooler was presented and the further applications were discussed. It could be a basic reference for the researchers to know some characteristics about this type of cryocooler.

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