Contribution ID: **171** Type: **Poster**

C1Po1C-01: Experimental demonstration on a bellows-sealed displacer for two-stage Stirling cooler

Monday 19 May 2025 09:15 (1h 45m)

The displacer in a two-stage Stirling cooler should prevent gas leakage between the compression space at room temperature, the first stage expansion space, and the second stage expansion space. To achieve this, clearance seals are usually required at two locations between the displacer and the cylinder. Through the geometric analysis, we discovered that if the displacer operates with a very small angular tilting, undesirable sliding with friction between the displacer and the cylinder occurs at the cryogenic temperature region. In a simple single-stage Stirling cooler, clearance seals can be installed only at the room-temperature side of the displacer, and an appendix gap with a relatively large clearance is placed on the cryogenic part of the displacer to prevent friction at the cold end even if the friction occurs at the room-temperature side. However, in the two-stage Stirling cooler with a stepped displacer, an additional clearance seal is required at the cryogenic part to prevent leakage between the first and the second stage expansion spaces, making it impossible to structurally avoid friction at the cryogenic part. To address this problem, we introduced a bellows sealing method to the stepped displacer configuration. The clearance seal is installed at the ambient part of the displacer and the appendix gaps are installed at the first and the second stage cold ends of the displacer so that it can avoid the friction at the cryogenic part. In addition, the bellows sealing whose one end is stationary and the other end is oscillating together with the displacer is installed at the first stage expansion space. This sealing prevents the leakage between the first and the second stage expansion spaces. The present study experimentally verifies the performance of the displacer with the bellows sealing, suggesting its potential for practical application. Specifically, we discuss the design and fabrication methods of the two-stage Stirling cooler as well as its cooling performance.

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Session Classification: C1Po1C - Non-Aerospace Cryocoolers I