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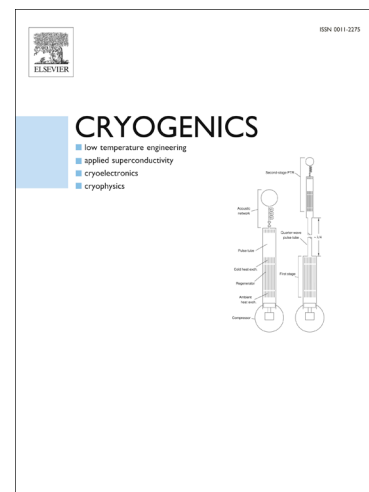
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CFD modeling and experimental verification of oscillating flow and heat transfer processes in the micro coaxial Stirling-type pulse tube cryocooler operating at 90–170 Hz

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Abstract

This paper presents the CFD modeling and experimental verifications of oscillating flow and heat transfer processes in the micro coaxial Stirling-type pulse tube cryocooler (MCSPTC) operating at 90–170 Hz. It uses neither double-inlet nor multi-bypass while the inertance tube with a gas reservoir becomes the only phase-shifter. The effects of the frequency on flow and heat transfer processes in the pulse tube are investigated, which indicates that a low enough frequency would lead to a strong mixing between warm and cold fluids, thereby significantly deteriorating the cooling performance, whereas a high enough frequency would produce the downward sloping streams flowing from the warm end to the axis and almost puncturing the gas displacer from the warm end, thereby creating larger temperature gradients in radial directions and thus undermining the cooling performance. The influence of the pulse tube length on the temperature and velocity when the frequencies are much higher than the optimal one are also discussed. A MCSPTC with an overall mass of 1.1 kg is worked out and tested. With an input electric power of 59 W and operating at 144 Hz, it achieves a no-load temperature of 61.4 K and a cooling capacity of 1.0 W at 77 K. The changing tendencies of tested results are in good agreement with the simulations. The above studies will help to thoroughly understand the underlying mechanism of the inertance MCSPTC operating at very high frequencies.

Keywords: CFD modeling; Oscillating flow and heat transfer; 90–170 Hz; Micro coaxial Stirling-type pulse tube cryocooler; Experimental verification

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