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Investigation of Energy Conversion Processes in High Length-to-Diameter Ratio Coiled Resonant Tubes Driven by Periodic Mass Injection Conditions in Thermo-acoustic Expansion Device

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Themoacoustic Expansion Devices (TAEDs) produce cooling power through a steady pressure drop in DC flowing conditions. The TAED cooling performance imperatively relies on its energy conversion component, a bundle of resonant tubes in which pressure energy released from the constant pressure drop is converted to heat by pressure wave systems, and rejected to high temperature reservoir by resonant-tube surface. This paper reports the experimental and numerical investigations on a high length-to-diameter ratio coiled resonant tube used in TAED under periodic mass injection conditions. The results of experiments and numerical simulations demonstrate the cooling mechanism under high modes of gaseous oscillation, and provide the guidance to design and miniaturize TAED run under cryogenic conditions, especially in the cases of variable temperature and density of supply stream encountered in the recuperative cooling of a TAE cryocooler system, where TAED's inlet temperature is continuously depressed before expansions. The influences of variable boundary conditions that drive high length-to-diameter ratio resonant tubes to carry out energy conversion and transportations are discussed in comparison to the configuration of conventional pulse tube that is operated under the dynamic moving boundary condition (moving piston or temperature gradient).