

High Effectiveness Micro-Tube Recuperators for Low-Capacity Turbo-Brayton Cryocoolers for Space

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In 2014, Creare with our partners at Edare and Mezzo Technologies started to develop a micro-shell-in-tube recuperator for high-capacity turbo-Brayton cryocoolers. This technology was initially pursued for a 20 W at 20 K cryocooler because the cost, size and mass of existing recuperator technologies did not scale well to high mass flow rates. The microtube technology has inherently high heat transfer rates per unit volume, which is ideal for high capacity cryocoolers because several kilowatts of heat must be transferred in a turbo-Brayton recuperator. The challenges of using this technology for high-performance cryogenic recuperators are minimization of two critical performance penalties - axial conduction within the core structure and flow mal-distribution. Axial conduction is typically a non-factor for high-capacity cryocoolers. Flow distribution was addressed in the case of the 20 W at 20 K cryocooler by a combination of design features of the headers and core and using 5 modules in series to allow mixing. We recently applied the microtube technology to a low capacity cryocooler producing less than 500 mW at 10 K. Here mass flow rates are an order of magnitude less than at high capacities and thermal effectiveness requirements are commensurate (0.99 per module). This paper reviews the design features, analyses and thermal performance test results of a low-capacity microtube recuperator, and compares the technology to prior space-proven technology.