Progress on the Development of 4 K Turbo-Brayton Cryocoolers

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Creare is developing low temperature, turbo-Brayton cryocoolers for space and terrestrial applications. The terrestrial version is being developed for cooling superconducting electronics for digital communications. This cooler provides refrigeration at 4.2 K and rejects heat at 77 K to an upper-stage cryocooler or through boil-off of liquid nitrogen. The space-borne version also provides refrigeration at 4.2 K and rejects heat at nominally 300 K through radiation to space. Cooling loads at 4.2 K are in the range of 100 to 400 mW. The key developments for both cryocoolers are the low-temperature recuperators and the 4 K expansion turbine. The low temperature recuperators are based on Creare's silicon slotted plate recuperator technology with further miniaturization and optimization to address low flow rates while preserving its inherent size, weight and performance benefits. The 4 K turboalternator is based on our isothermal turboalternator with further miniaturization for high efficiency at low flow rates and cooling capacity. An additional challenge for the 4 K turboalternator is the operation of gas bearings at extremely low temperatures and viscosities. This paper reviews the development and testing of these key cryocooler components.