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C2Or4C-07: Gas bearing turbo compressor and expander technology for cryogenic applications

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Cryogenic applications require high complexity air and gas handling. Hydrogen is liquefied for ease of storage and transportation. Once liquefied, boil-off is avoided by cooling the hydrogen (zero-boil off). For both liquification and zero-boil off the reverse Brayton cycle is the most efficient and therefore preferred technology. Driven by a turbo compressor and a turbo expander, it is referred to as a reverse turbo-Brayton cycle cryocooler. Such cryocoolers have a low specific power (lower than 100 W/W possible at 20 K cooling temperature) and therefore are more efficient and can achieve higher cooling power per cryocooler weight and size than Gifford-McMahon or Stirling type cryocoolers. Finally, for recirculation and transport of cryogenic gases, cryo fans are employed. For all these applications, a compressor, a fan and/or an expander are key components.

Gas bearing turbo compressor, fan and expander technology has significant advantages to other technology: small size and weight due to high-speed operation, maintenance free due to an oilfree bearing and no rotating sealings, high efficiency, low amount of wetted materials and therefore no outgassing or compatibility issues, and low microvibration emission due to the continuous flow operation. The gas bearing technology, which does not require sensors, allows to fully immerse the fan and expander into the cryogenic temperatures in a cold box down to 20 K and below. However, running gas bearing turbo compressors and expanders at cryogenic temperatures is a challenge.

This presentation introduces gas bearing turbo compressor, fan and expander technology feasible for cryogenic temperatures, its advantages, limitations and key characteristics. The applicability of the gas bearing turbo compressor technology to cryogenics is demonstrated with design calculations for gas bearing stability, mechanical stability and motor/generator performance. Furthermore, an experimental proof-of-concept of a gas bearing turbo machine is presented with a cryogenic cold test.

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