PROJECT SUMMARY

Purpose of the Research

Our work is responsive to NASA SBIR Topic X10.01, specifically, the need for efficient small- to medium-scale hydrogen liquefaction technologies including domestically produced wet cryogenic turboexpanders. Future NASA missions will require hydrogen liquefaction systems for spaceport, planetary, and lunar surface operations. By replacing the Joule-Thomson throttles in conventional liquefaction systems with expansion turbines, the liquefier input power can be significantly reduced. The expansion turbines must be designed for high-speed operation and long life, and must be robust against the pressure and momentum excursions and the surface tension effects associated with two-phase flow.

Brief Description of the Research Carried Out

On the Phase I project, we identified and optimized a liquefaction system for spaceport operations. We demonstrated by analysis the benefits of using expansion turbines instead of the customary Joule-Thomson throttle. We designed a set of high-performance turbines for use in these systems. The expansion turbines have the innovative feature of recovering the expansion work through use of an alternator instead of dissipating work through a brake wheel. This approach greatly simplifies controls, improves reliability, and reduces system mass and input power.

Research Findings or Results

We have shown that liquefier input power can be reduced by 17 to 18% by the use of expansion turbines. In addition, we have shown that multiple turbine expansion stages will be desired for a typical spaceport system. We developed a turbine design that can be used for all expansion stages from 80 K to 20 K by replacing a small subset of the parts. This modular approach has development and production cost benefits.

Results Justify Phase II Continuation

The result of this Phase II project will be the demonstration of expansion turbines for small- to medium-scale hydrogen liquefiers. These expansion turbines provide between 1.4 kW of refrigeration at nominally 80 K to 0.5 kW of refrigeration at 20 K. The turbines will be suitable for liquefiers for spaceport, planetary, and lunar surface operations. The turbines may also be used in high-capacity cryocoolers for cooling high temperature superconducting motors, generators, and transmission lines. These cryocoolers are needed for advanced superconducting electric aircraft being developed by NASA.