

Proposal No. X10.01-8855 - An Advanced Wet Expansion Turbine for Hydrogen Liquefaction

PI: Mark Zagarola

Creare, Hanover, NH

<p><u>Identification and Significance of Innovation</u></p> <p>This project was 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 and facilities will require hydrogen liquefaction systems for spaceport, planetary, and lunar surface operations. A critical part of these systems is the cryogenic turbines, which 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. Our turbines have the innovative feature of recovering the expansion work through use of an alternator (i.e., turboalternator) instead of dissipating work using a brake wheel. This approach greatly simplifies controls, improves reliability, and reduces system mass and input power.</p> <p>TRL achieved at the end of Contract (1-9): 5</p>	
<p><u>Technical Objectives and Work Plan</u></p> <p>On this Phase I/II program, Creare built and tested a cryogenic turbine for use in a hydrogen liquefier. On the Phase I project, we identified and optimized the liquefaction cycle and developed preliminary designs for the product stream expansion turbines. There are a total of five product stream expansion turbines that share a common design except for the flow passages, which are optimized for each expansion stage. On the Phase II project, we built and tested a turboalternator capable of operating in hydrogen liquefiers. Upon fabricating the turbine, we conducted detailed performance testing, demonstrating net efficiencies as high as 80%. Furthermore, using our test data we validated our performance models by accurately predicting performance, even at off-design conditions. Finally, we conducted various cryogenic functionality and bearing stability tests to demonstrate the capability of the turboalternator to operate over a wide temperature range.</p>	<p><u>NASA and Non-NASA Applications</u></p> <p>The result of this project was the demonstration of expansion turbines for small- to medium-scale hydrogen liquefiers operating at temperatures from 80 K to 20 K, and suitable for use in liquefiers for spaceport, planetary, and lunar surface operations.</p> <p>The expansion turbines can also be used to produce refrigeration as part of turbo-Brayton cryocoolers. NASA and other government agencies have initiated a large, long term effort to develop superconducting motors, generators and power transmission lines, as well as shipboard superconducting degaussing systems.</p> <p><u>Firm Contacts</u> Mark V. Zagarola, Creare P.O. Box 71 Hanover, NH 03755 (603-640-2360)</p>