

ANNUAL SUMMARY REPORT: YEAR 3

2012 NASA Early Stage Innovations (ESI2) – Grant NNX13AC82G

TITLE	Design and Development of a Next Generation High Capacity, 20K Pulse Tube Cryocooler for Active Thermal Control on Future Space Exploration Missions		
PI	Professor S. Mostafa Ghiaasiaan	UNIVERSITY	Georgia Institute of Technology, University of Wisconsin - Madison

RESEARCH OBJECTIVES AND RELEVANCE TO NASA

- The main objective is to design and develop a state-of-the-art two-stage pulse tube cryocooler with a 5W or larger cooling capacity at 20K.
- Other objectives include:
 - » In-depth investigation of $Er_{50}Pr_{50}$ lower stage regenerator.
 - » Theoretical design of a 20W at 20K two-stage pulse tube cryocooler.
- This technology will lead to accomplishing near-zero boil-off rates which address NASA's Technology Area 14 (TA14) – Thermal Management Systems and in turn, NASA's Grand Challenges needs.



Fully assembled
two-stage cold head

TECHNICAL APPROACH

- Simulation and experiments were carried out concurrently.
- Component and system-level design and optimization simulations were performed for the development of two-stage cryocoolers with targeted performance metrics, and simulations were performed in support of experiments.
- The experiments included a prototype two-stage 3W at 20K cryocooler; and a separate-effects test facility for the experimental characterization of key components at prototypical cryogenic flow and temperature conditions.

TEAM MEMBERS AND AFFILIATIONS

- Professor S. Mostafa Ghiaasiaan – PI - Georgia Institute of Technology
- Professor Franklin Miller – Co-investigator - University of Wisconsin – Madison
- Dr. James Maddocks – Co-investigator - Madison CryoGroup
- Dr. Jose Rodriguez – Advisory Role - NASA Jet Propulsion Lab (JPL)
- Dr. Jeff Feller – Advisory Role - NASA Ames
- Matthew Perrella – Graduate Student – Georgia Institute of Technology
- Avi Friedman – Graduate Student – University of Wisconsin, Madison

SIGNIFICANT ACCOMPLISHMENTS

- Fabrication and assembly of the two-stage prototypical cryocooler has been completed. Diagnostic and shake-down tests were performed. Design and fabrication method modifications were implemented to remedy some persistent and unexpected technical problems.
- Simulation and optimization have been carried out in conjunction with experiments.
- A test apparatus for measurement of regenerator characteristics at prototypical flow and temperature conditions has been completed; shake-down tests, diagnostics and desing modifications were conducted. Experiments with a stand-alone $Er_{50}Pr_{50}$ regenerator, as well as some other regenerator fillers are in progress.



Separate-effects
test rig at
Georgia Tech
Cryo Lab

PLANNED ACTIVITIES

- Complete system-level experiments, including tests with second stage cryocooler as well as the entire-two-stage cooler, and validate theoretical models and simulations.
- Complete separate-effects experiments and utilize the results for refinement of component and system-level models.
- Refine the design of optimized 5 W 20K two-stage cryocooler(s)
- Complete a full theoretical design for a 20W at 20K two-stage pulse tube cryocooler.