Dish Stirling High Performance Thermal Storage

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PROJECT OBJECTIVES

Goal:

- Demonstrate the feasibility of significant thermal storage for dish Stirling systems to leverage their existing high performance to greater capacity
- Demonstrate key components of a latent storage and transport system enabling on-dish storage with low exergy losses
- Provide a technology path to a 25kW$_e$ system with 6 hours of storage

Innovation:

- Leverage high performance heat pipes to support feasible system layout
- Develop and test high temperature, high performance PCM storage
- Optimize storage configuration for cost and exergy performance
- Latent storage *and* transport matches Stirling cycle isothermal input[1]

[1]Andraka, C.E., Rawlinson, K.S., Siegel, N.P., "Technical Feasibility of Storage on Large Dish Stirling Systems," Sandia report SAND2012-8352 (2012).

APPROACH

- PCM development and selection
  - Literature searches and modeling to develop candidate eutectics
  - Sample fabrication and characterization to develop properties
  - Modeling of compatibility with potential containment
  - Long-term testing of compatibility
- Storage optimization
  - Advanced modeling of PCM/heat pipe interfaces including free convection in combined solid/liquid states
  - Exergy and cost optimization
  - 2-D and 3-D models
- Heat Pipe
  - Felt wick enhancements for robust high performance
- Proof-of-concept hardware subscale demonstration

[3] Shabgard, H., Faghri, A., Numerical Simulation of Latent Heat Thermal Energy Storage (LHTES) Systems for Solar Steam Generation Applications, to be submitted to peer-reviewed journal (2013).
[4] Shabgard, H., Robak, C.W., Bergman, T.L., Faghri, A., "Heat transfer and exergy analysis of cascaded latent heat storage with gravity-assisted heat pipes for concentrating solar power applications," Solar Energy 86 (3) (2012) 816–830.

Q4 KEY RESULTS AND OUTCOMES

- PCM Candidate Evaluation
  - Acute attack of proposed containment experimentally verified, with 30% wall thickness affected in 150 hours
  - Containment coating development approach proposed
  - Coating chemistry evaluation underway, potential coating candidates identified through thermodynamic modeling
  - Additional PCM candidates re-evaluated, backup metallic selected
- Heat pipe advanced wick development
  - Porosimetry, strength measurements completed on 6 candidates
  - Best feasible wick solution selected for heat pipe testing
- Modeling
  - Parametric studies of PCM configurations with realistic boundary conditions completed, showing 95% exergetic efficiency for metallic PCM in all proposed configurations
  - Two papers accepted for publication

Shabgard, H., Faghri, A, Bergman, T.l., Andraka, C.E., "Numerical Simulation of Heat Pipe-Assisted Latent Heat Thermal Energy Storage Unit for Dish-Stirling Systems", IMECE2013-65487, in Proceedings of the ASME 2013 International Mechanical Engineering Congress & Exposition, San Diego, CA, November 13-21 2013.

NEXT QUARTER

PCM candidate evaluation

- Continue thermodynamic and equilibrium evaluation of potential coatings, consider substrate and PCM
- Design and implement screening test for coating chemistry compatibility
- Perform coating chemistry screening tests for down-selection
- Optimize coating processes for chemistries, substrate, and shape
- Develop 150 hour applied coating compatibility test, fabricate hardware

2-D PCM model development

- Complete final revisions on 2-D papers for publication
- Revise parametric study to incorporate solar multiple

Heat pipe advanced wick development

- Complete fabrication of advanced wick(s) on test device substrate, deliver to Sandia for assembly into test device

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