Dish Stirling High Performance Thermal Storage

Sandia National Laboratories
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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.

Q3 KEY RESULTS AND OUTCOMES

- Two metallic PCM's fabricated and characterized. Leading candidate must be re-fabricated and tested in inert atmosphere in Q3
- Identified thermodynamic possibility of compatibility issues with PCM and containment. Developed 100-hour test to evaluate acute attack
- Heat pipe wick samples fabricated, awaiting characterization
- Manuscript "Numerical Simulation of Heat Pipe-Assisted Latent Heat Thermal Energy Storage Unit for Dish-Stirling Systems" to ASME 2013 International Mechanical Engineering Congress & Exposition.
- Preliminary studies on HP-assisted LHTES with a metallic PCM and performance compared with LHTES systems utilizing a salt PCM.
- Further enhanced 2-D PCM/Heat pipe system model, including diode effects, initial natural convection, and alternative 2-D approach
- Manuscript "Dish Stirling Advanced Latent Storage Feasibility" for SolarPACES 2013 conference

NEXT QUARTER

PCM candidate evaluation

- Complete 100-hour acute compatibility test and sample evaluation
- Begin design of long-term compatibility test
- Design and implement test for liquid metal embrittlement

2-D PCM model development

- Parametric studies and optimization of PCM/HP system
- Develop design guidelines for LHTES/HP system
- Prepare manuscript on 2-D model

Heat pipe advanced wick development

- Complete characterization and modeling of wicks and downselect

Systems analysis

- Complete extend model based on findings of 2-D PCM model
- Complete probabilistic cost studies

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