U.S. Department of Energy
Energy Efficiency and Renewable Energy
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DOE Solar Energy Technologies Program Peer Review

Technical Track: CSP

Project Name: Advanced HTF/Thermal Storage

Principal Investigator: Greg Glatzmaier

Denver, Colorado

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This presentation does not contain any proprietary or confidential information.

Project Goal

Project goal: improve the performance and cost of heat transfer fluids, thermal storage components and storage systems for CSP plants to help meet near and long-term CSP cost targets

Project Activities

- Golden Field Office FOA support
- Materials characterization
- Nanofluids research
- Storage systems performance modeling
- Storage systems cost analysis

Team Members

- Greg Glatzmaier, Ph.D. Chemical Engineering
- Craig Turchi, Ph.D. Chemical Engineering
- Desikan Bharathan, Ph.D. Mechanical Engineering
- Joongoo Kang, Ph.D. Physics (post doc)
- Yong-Hyun Kim, Ph.D. Physics
- Hongjun Xiang, Ph.D. Chemical Physics (post doc)
- Calvin Curtis, Ph.D. Synthetic Chemistry
- Su-huai Wei, Ph.D. Physics
- Dan Blake, Ph.D. Chemistry (NREL Emeritus)

Special Capabilities

- new materials laboratory for fluid and PCM characterization
- molecular dynamics modeling for nanofluids research
- computational fluid dynamics & heat transfer modeling (FLUENT) for storage systems performance analysis

Major Accomplishments

Accomplishments – FY2008

- prepared and review advanced HTF-TES solicitation for the DOE Golden Field Office FOA
- initiated long-term R&D work for the development of advanced heat transfer & storage fluids using nanomaterials
- initiated CFD modeling of two-tank and thermocline storage systems

Major Accomplishments

Accomplishments – FY2009

- established new materials laboratory for characterizing advanced fluids and phase-change materials
- placed new subcontract with Worley-Parsons for updating storage systems capital costs

Budgets & Milestone Status

Agreement	FY2008	FY2009
GFO FOA Support	200K	130K
Advanced Fluids	169K*	345K*
Storage Systems Modeling	319K	556K
Totals	**688K**	**1,031K**

*nanofluids research supported with internal NREL funding

milestone status: no delayed milestones in FY2009

Scientific/Technical Approach

Golden Field Office FOA Support

- preparation and review of Advanced HTF-TES Solicitation supported DOE's need to expand research, development and demonstration of advanced heat transfer fluids and storage systems
- NREL and SNL staff performed application reviews and participated in GFO's review panels

Golden Field Office FOA Support

- NREL & SNL currently updating cost and performance criteria to evaluate FOA projects Phase 1 progress in FY2009
- criteria to be used in the FOA down-select process at the end of FY2009

Scientific/Technical Approach

Materials Characterization Laboratory

- NREL established a thermal storage materials characterization laboratory
- purpose is to measure the thermophysical properties of heat transfer & storage fluids and phase-change materials
- properties include thermal conductivity, heat capacity, density, viscosity, melting point, etc.

Materials Characterization Laboratory

New laboratory will support the nanofluids research work at NREL, low-freezing molten salt work at SNL and several of the FOA projects

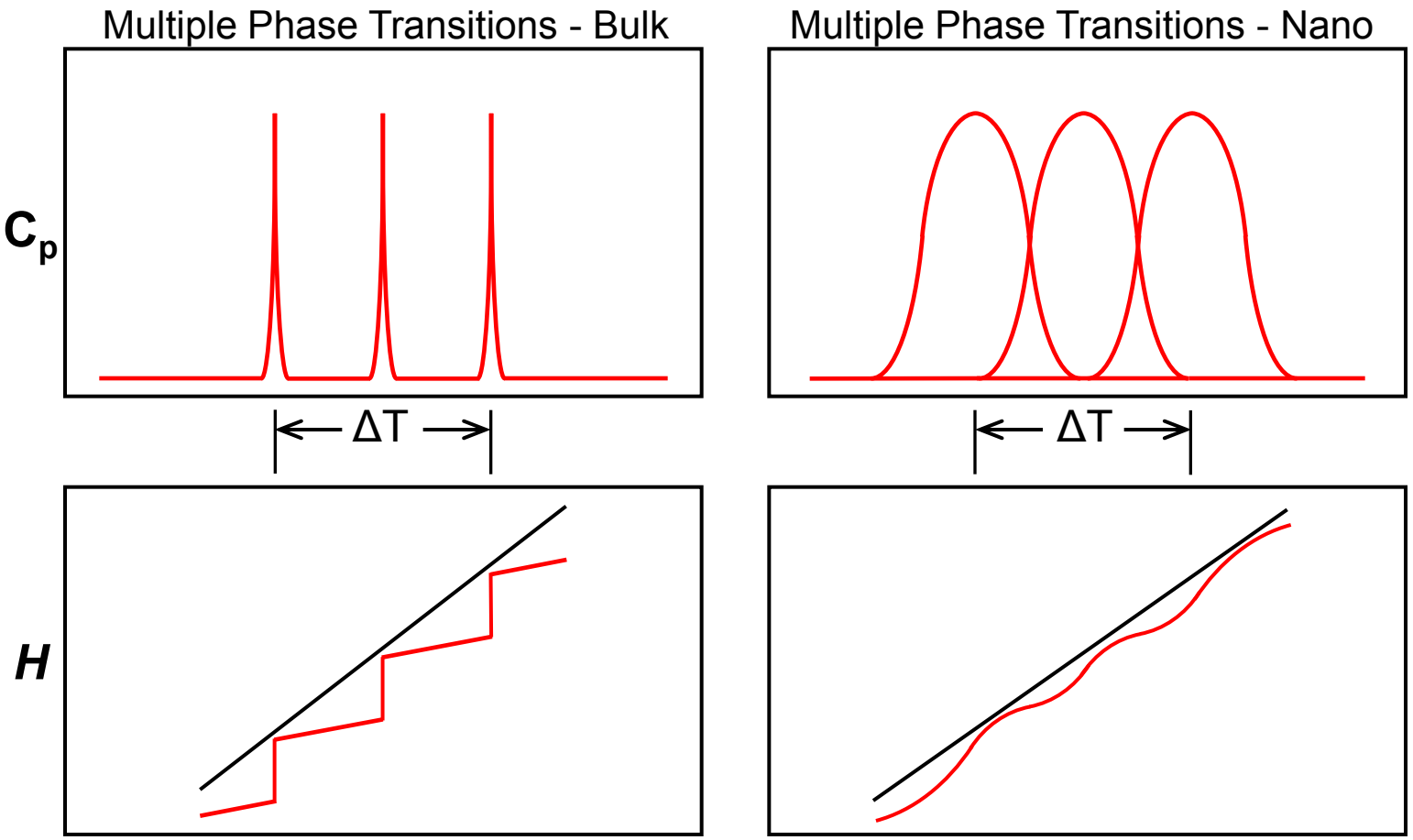
Scientific/Technical Approach

Nanofluids Research

- nanoclusters (50-500 atoms) possess thermophysical properties vastly different from bulk material properties
- addition of nanoclusters to a traditional fluid may greatly improves its heat capacity, melting point, conductivity
- developing molecular dynamics modeling methods to predict the properties of bare nanoclusters and nanoclusters surrounded by fluid molecules

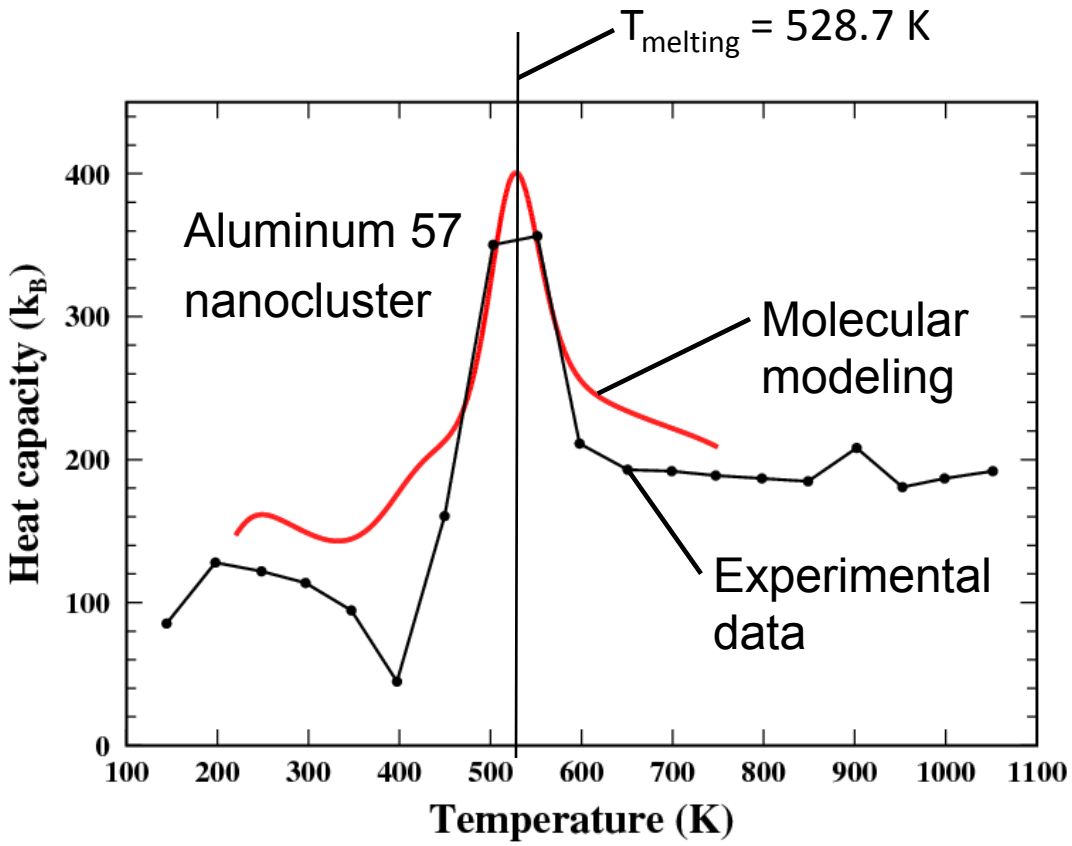
Scientific/Technical Approach

Nanofluids Research



Scientific/Technical Approach

Nanofluids Research

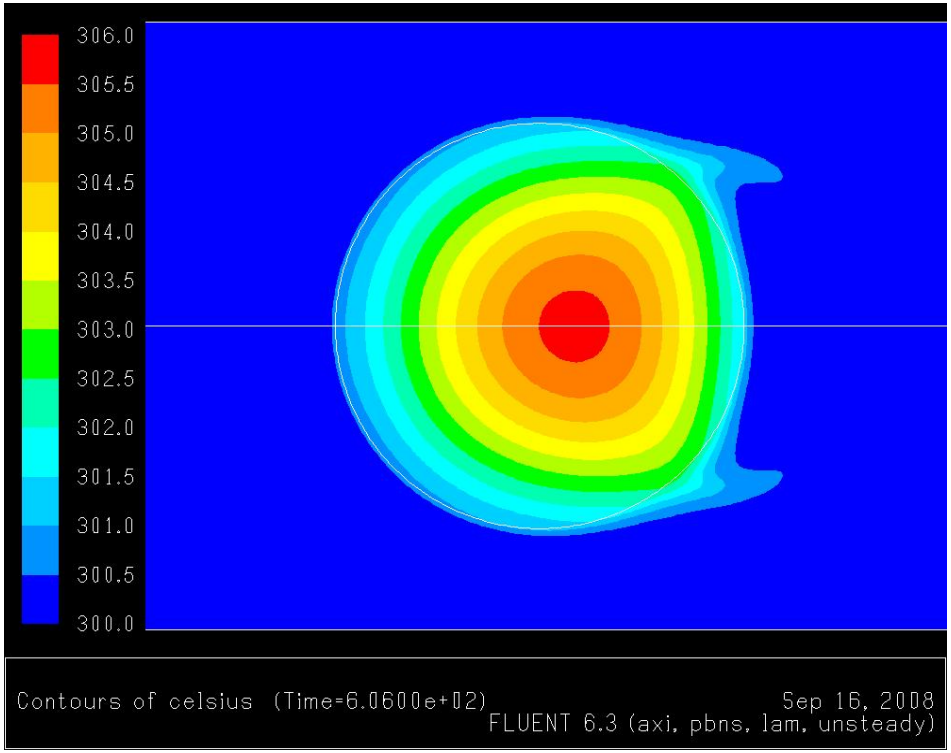


Scientific/Technical Approach

Storage Systems Performance Modeling

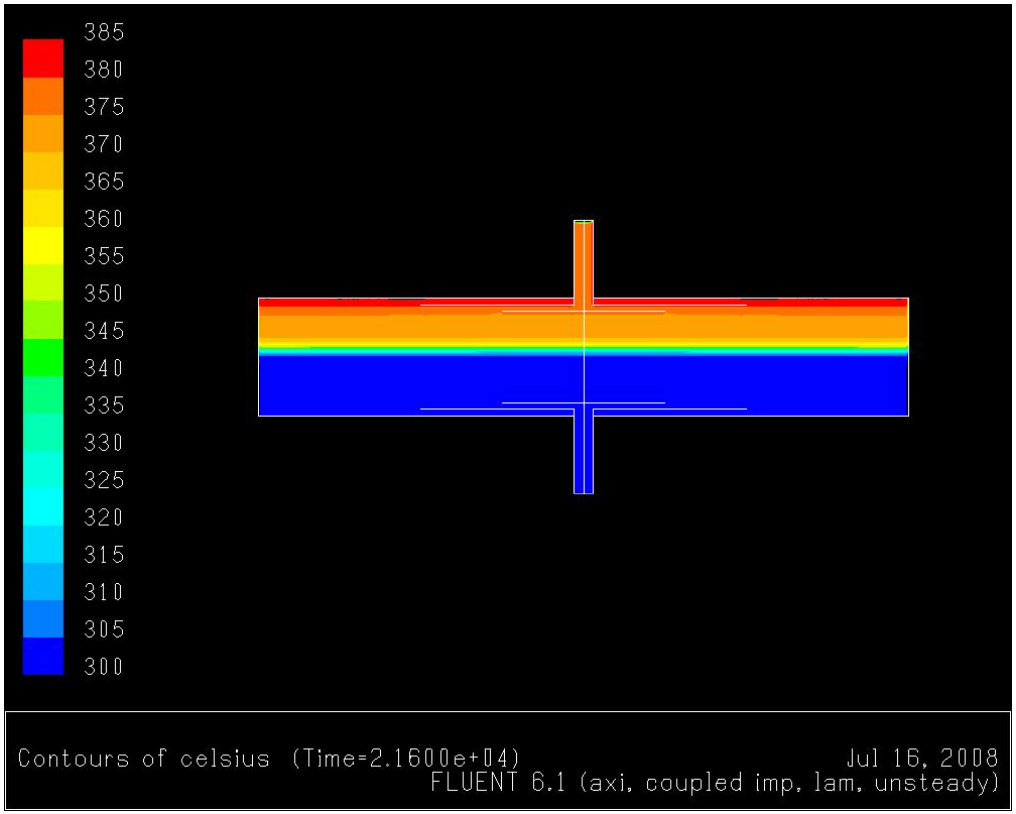
- provides a comparison of the operation and efficiency of the two-tank and thermocline storage systems

- includes modeling of fluid-particle fluid dynamics & heat transfer for thermoclines



Storage Systems Performance Modeling

- bulk flow and heat transfer analysis for two-tank and thermocline analysis
- performance modeling supports the storage system cost analysis work & the FOA evaluation process



Storage Systems Cost Analysis

- purpose is to update the cost model for the two-tank and thermocline storage systems
- model will have reference costs and escalation factors for standard equipment including pumps, piping & valves, instrumentation, etc.
- model structured such that costs of structural & storage materials can be easily updated each year
- model output will serve as an input to the Solar Advisor Model (SAM)
- cost analysis model will be expanded to support the evaluation of the FOA projects

Relevance & Impact

Meeting market needs

- thermal storage allows CSP to generate reliable, dispatchable electricity to the grid
- It also allows CSP electricity generation to match the intermediate load profile

Reducing costs

- improved HTFs result in higher operating temperatures, greater thermodynamic efficiency and low LCOE
- improved storage materials result in lower storage inventory and lower capital costs
- performance & cost analysis optimizes storage systems design and operation, resulting in lower LCOE

Future Directions

GFO FOA support

- continue technical advising to GFO for the 15 FOA awards
- technical advising for the down-select process in September 2009

Materials characterization

- complete utility upgrades to laboratory and start measurements

Nanofluids research

- expand MD modeling to include nanocluster-fluid interactions
- initiate synthesis work to complement MD modeling

Future Directions

Storage system performance modeling

- analyze operational strategies for two-tank and thermocline systems
- analyze performance for both systems as a function of the number of storage vessels
- analyze operational strategies during non-ideal operation

Storage system cost analysis

- complete cost updating for storage systems for the parabolic trough power plant