NBB Enclosed Particle Receiver

National Renewable Energy Laboratory

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PROJECT OBJECTIVES

Goal: This project will develop a near-blackbody particle receiver and an integrated fluidized-bed heat exchanger to achieve >20% cost reduction and overcome solar energy conversion performance and cost barriers.

Innovation:

- Gas/solid two-phase flow as heat transfer fluid, and separated solid particles as storage media for low-cost, high-performance CSP w/TES.
- Near-blackbody absorber design to augment receiver efficiency.
- Innovative receiver absorber design and prototype fabrication.
- Fluidized-bed heat exchanger to support high-efficiency power cycles.

Milestones: this milestones will be due on March 31, 2013.

- Preliminary design of receiver and critical components to generate 6-sigma design matrix QFD Table.

APPROACH

Needs	Approaches	Remarks
Reduce convection losses	• Convection loss appears small • Tilted absorber tube arrangement • Wind effects may be insignificant	Discussed minimization of convective losses with subject matter experts.
Minimize reflection	• Prefer specular reflection • Tapered tube to avoid flare entrance	SolTrace simulation underway. Testing in BP2.
Minimize infrared re-radiation loss.	• Lower absorber temperature • Reduce re-radiation area • Low entrance section emissivity	2nd year's focus, consistent with minimizing reflection.
Enhance absorber tube heat transfer	• High thermal conductivity • Ribs or thicker tubes • Embed high conductivity additives	Spreading flux deep into the tube may be more significant than heat conduction.
Select Fluidization	• Particle granular flow (moving bed) •Particles fluidized by gas (fluid bed)	High particle/absorber heat transfer coefficient.
Enhance particle/tube heat transfer	• Mixing and particle impingent • Extended heat transfer surface • Particle-absorber radiation transfer	Design focus of OSU work. Radiative transport to be investigated by CU in BP2.

KEY RESULTS AND OUTCOMES

- Receiver design QFD develops two best design on each category.
- Developed SolTrace model capable of simulating the receiver absorber wall flux distribution.
- Studied critical thermal/optical properties for material selection

Categories	Proposed	Alternative	Comment
Particle flow and heat transfer	Granular flow (moving bed)	Gas fluidization (fluidized bed)	Gas fluidization provides better particle mixing for uniform temperature, but consumes energy and needs hermetic seal.
Absorber optical characters	High diffuse absorptivity	High specular reflectivity	Proposed high absorptivity material. Flux analysis indicates that specular reflection provides better flux penetration.
Absorber material options	Ceramic absorber	Metallic absorber	If metallic absorber be considered, it would expand the SOPO scope, but could be closer to commercialization and cost target.

- Three U.S. provisional patents filed[1].

[1]Please refer the publication attachment for the provisional patent list.

NEXT MILESTONES

- The milestones and anticipated dates:
  - M(ST-1.1.1) Preliminary design of receiver and critical components to generate 6-sigma design matrix QFD Table (3/31).
  - M(T-1.1) Preliminary receiver design and performance prediction (9/30).
  - M(T-1.2) Identify testing data on heat-transfer rate with wide operating conditions that can be used for heat-transfer analyses (9/30).
  - M(T-1.3) Select and characterize materials including particles and ceramics. Use the properties for modeling and design (9/30).
  - M(T-1.4) Generate PFD, heat/mass balance, preliminarily down-select and size equipment (9/30).
- PI is actively involved in coordinating contracting requirements. However, risk of delay in partner's efforts due to lengthy and rigorous NREL and recipient subcontracting processes.