High Temperature Falling Particle Receiver

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PROJECT OBJECTIVES

Goal:

- *Enable higher temperatures and greater efficiencies of concentrating solar power by developing an advanced falling particle receiver. Particles will be heated to >650°C by direct heating from concentrated sunlight and will provide cheap, efficient energy storage.*

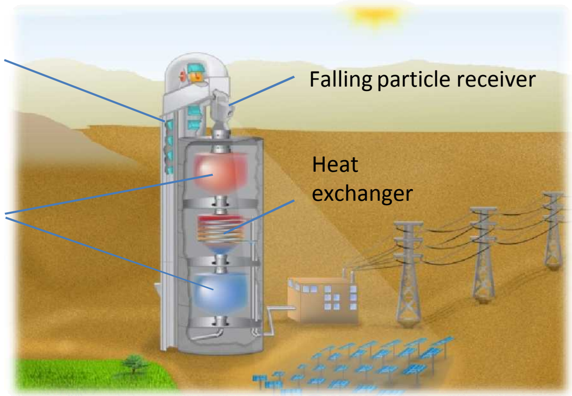
Innovations:

- *Develop particle recirculation, air recirculation, and interconnected porous structures, which have not been tested before[1]*
- *Advance particle materials to increase the solar absorptivity and durability[2]*
- *Design and improve particle thermal storage, heat exchange, and particle conveyance[3]*

[1]Tan and Chen, 2010, Review of study on solid particle solar receivers, Renewable & Sustainable Energy Reviews, 14(1), p. 265-276.
2Hellmann et al., 1987, Evaluation of Spherical Ceramic Particles for Solar Thermal Transfer Media, Sandia National Laboratories, SAND86-0981, Albuquerque, NM.
[3]Spelt et al., 1982, Heat-Transfer to Flowing Granular Material, International Journal of Heat and Mass Transfer, 25(6), p. 791-796.

APPROACH

- This project employs modeling, design, testing, and optimization to further develop and improve key areas of falling particle receiver technology (see "Innovations") to achieve SunShot technical targets



KEY RESULTS AND OUTCOMES

- CFD simulations of air and particle recirculation were initiated to investigate means for higher temperature and efficiency
- High temperature lift elevators were reviewed for particle lift and recirculation
- Tests were conducted of particle flow through porous materials to confirm that clogging could be averted
- Optical properties of particles were measured under ambient and heated conditions to determine solar absorptance and thermal emittance
- Particle durability tests were initiated to investigate attrition
- Thermal properties of materials for thermal storage bins were measured, and designs were developed for particle storage
- Small-scale particle heat exchangers were designed
- Submitted abstracts for two conference papers[1,2]

[1]Ho and Christian, 2013, "Modeling Air Recirculation for High-Temperature Falling Particle Receivers," ASME Energy Sustainability Conference.
[2]Siegel et al., 2013, "Physical Properties of Solid Particle Thermal Energy Storage Media for Concentrating Solar Power Applications", ASME Energy Sustainability Conference.

PHASE 1 MILESTONES

- MILESTONE 1.1.1 – Complete the conceptual design of a lab-scale lift and recirculation system that will allow particles to be heated above 700 C
- MILESTONE 1.2.1 – Develop CFD model capable of simulating air recirculation, particle movement, and wind effects to minimize particle loss and heat loss
- MILESTONE 1.3.1 – Complete systematic study using mass measurements after successive particle passes through the porous structures
- MILESTONE 2.1.1 – Experimentally identify five or more candidate particle materials having steady-state solar weighted absorptivity in excess of 85%
- MILESTONE 2.2.1– Identify particle parameters (e.g., size, density, material) that yield particle attrition that is less than 0.01% of the mass flow rate
- MILESTONE 3.1.1 – Deliver a ranked list of concept designs for Sandia on-sun storage testing
- MILESTONE 3.2.1 – Validation of the heat transfer model predictions with experimentally determined data
- MILESTONE 3.3.1 – Develop at least two viable designs for particle lift

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