High-Temperature Falling-Particle Receiver

SNL, Georgia Tech, Bucknell, KSU, DLR

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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.*

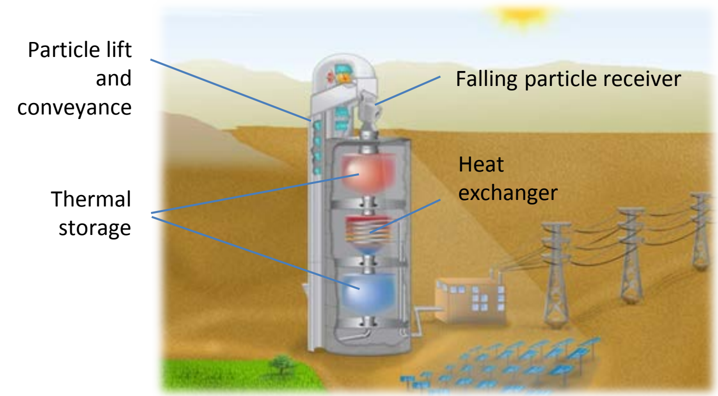
Innovations:

- *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 analyses of free-falling and discrete-element designs were performed
- Parametric analyses of particle flow in the prototype receiver were performed
- Attrition tests at temperatures up to 1000 C were performed with nearly 6000 cycles
- Changes in particle properties were characterized after heating and modifications to the particle chemistry were investigated
- Tests were performed on small-scale and large-scale particle heat exchangers to obtain heat transfer coefficients
- Receiver lift designs were evaluated and identified
- Over 10 conference papers (ASME and SolarPACES) on this work have been submitted

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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