A Small-Particle Solar Receiver for High-Temperature Brayton Power Cycles

San Diego State University

Award Number: DE-EE0005800 | March 15, 2013 | Miller

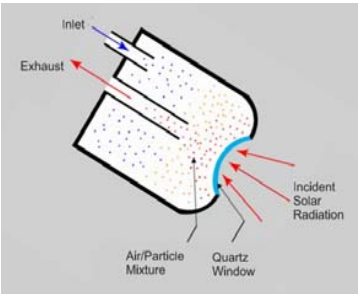
PROJECT OBJECTIVES

Goal: The objective of this project is to design, construct, and test – on sun - a revolutionary high temperature solar receiver in the multi-MW range that can be used to drive a gas turbine to generate low-cost electricity. Secondary objectives include demonstrating for the first time a pressurized solar receiver with a window greater than 1 m in diameter, and developing a robust, 3-D multi-physics model of the receiver[1].

Innovation: Current commercial receivers are all liquid-cooled. Experimental gas-cooled receivers for Brayton cycles have temperature and or flux limitations due to absorber material constraints. This receiver absorbs the radiation in a carbon nano-particle suspension without limitation. The concept of a volumetric, selective, and continually replenishable absorber is unique in the solar field.

[1]Fletcher Miller and Arlon Hunt, "Developing the Small Particle Heat Exchange Receiver for a Prototype Test, ASME 6th International Conference on Energy Sustainability, Paper ES2012-91337, San Diego, 2012

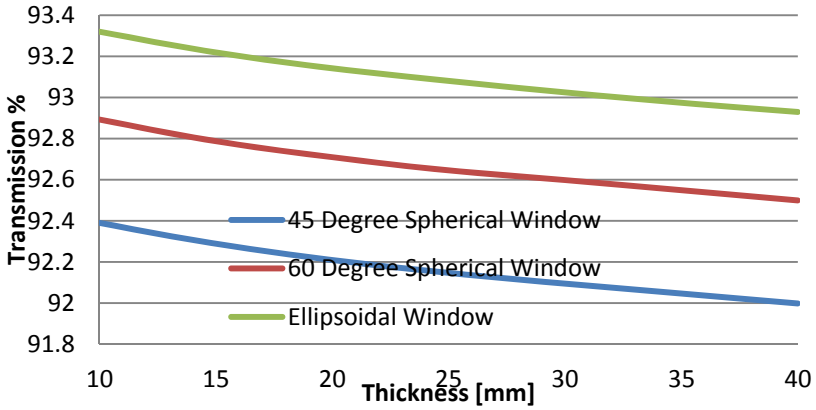
APPROACH



- Lab-scale receiver for testing pressurized window and outlet temperature.
- Lab-scale carbon particle generator and laser diagnostics to create and characterize particle suspension.
- Upgraded version of MIRVAL to predict intensity from heliostat field at NSTTF.
- In-house codes to predict window optics, thermal loading, temperature profiles.
- In-house Monte Carlo code for radiative transfer inside receiver to determine the divergence of the radiative flux.[2]
- FLUENT model for solving the momentum and energy equations.[3]
- ANSYS Mechanical for window stress analysis

[2]Steve Ruther, Master's Thesis, SDSU, 2010 (2-D version)
[3]Adam Crocker and Fletcher Miller, ASME 6th ES Conf. ES2012-91235, 2012

KEY RESULTS AND OUTCOMES



Monte Carlo code completed that calculates optical properties and thermal loading of window for different geometries, materials, and times.

** Four papers submitted to SunShot Symposium at ASME ES Conf. **

NEXT MILESTONES

- Finish design of new lab-scale particle generator (end of May.)
- Determine thermal loading on window using new program and actual quartz optical constants (end of April. Risk: have not been able to get enough optical constants from vendor and may need to measure or approximate them)
- Use 2-D code to calculate window internal temperature profile (end of May).
- Benchmark 3-D Monte Carlo code for receiver (end of May)
- Couple 2-D MC code to particle oxidation model (end of May. Risk: student has graduated and my leave. Training new student)
- Calculate stresses in window for different boundary conditions (end of April)
- Receiver design meeting with Rocketdyne (mid April)
- Create numerical model of lab-scale receiver (end of May)