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

San Diego State University

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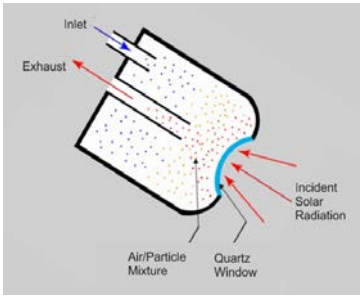
PROJECT OBJECTIVES

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

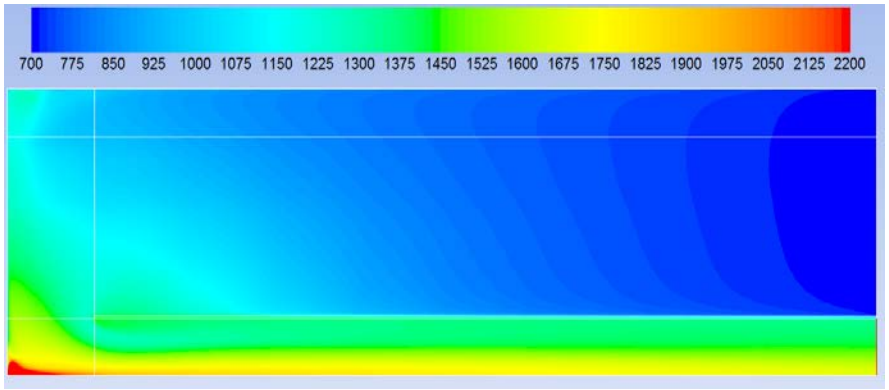
APPROACH



- 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



Two-dimensional radiation and fluid dynamic code completed that calculates temperature and flow fields inside the receiver. Receiver efficiency of 89% with a 1400K average outlet temperature for collimated input.

NEXT MILESTONES

- Complete three-dimensional receiver model (March).
- Determine flux on aperture plane using MIRVAL (Feb.)
- Create preliminary soot oxidation model in FLUENT with UDF (March)
- Test particle generator with propane (Feb.)
- Design and build new extinction tubes (March)
- Train students on electron microscope (March)
- Calculate window temperature profile using 1-D model (Feb.)
- Calculate window stress for different foot designs (Feb.)
- Submit papers to ASME conference (Feb.)