PROJECT NAME: High-Temperature Particle Heat Exchanger for sCO2 Power Cycles

Last 5 digits of project number: 30342
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BACKGROUND / INDUSTRY IMPACT

- Particle-to-sCO$_2$ heat exchangers did not exist
- Particle-based systems can enable higher temperatures and more efficient processes for CSP, thermochemistry, and solar fuels

PROJECT OVERVIEW / OBJECTIVES

- Design, develop, and test a particle/sCO$_2$ heat exchanger operating at sCO$_2$ temperatures of ≥700 °C and pressures ≥20 MPa that will enable high-efficiency sCO$_2$ power cycles

METHODS

- Team with industry to design heat exchangers
- Evaluate fluidized and moving packed-bed particle designs using analytic hierarchy process
- Construct 100 kW$_t$ shell-and-plate prototype and perform tests to evaluate performance

KEY OUTCOMES / MILESTONES

- Performed lab-scale heat-transfer and particle-flowability tests to demonstrate feasibility
- Constructed 100 kW$_t$ prototype and achieved milestones: overall heat transfer coefficient >50 W/m^2-K and >50 kW$_t$ duty (off-design)
- Developed CFD simulations and identified design features to improve performance

CONCLUSION / REMAINING RISK

- Constructed world's first particle-to-sCO2 heat exchanger and performed tests to evaluate thermal duty and overall heat-transfer coefficient
- Need to perform on-sun tests and implement designs to improve particle-side heat transfer coefficient and reduce pressure drop

SAND2020-2886D

CONCENTRATING SOLAR-THERMAL POWER TRACK (SuNLaMP)

Designed and tested **world's first particle-to-supercritical-CO$_2$** heat exchanger in a falling particle receiver system

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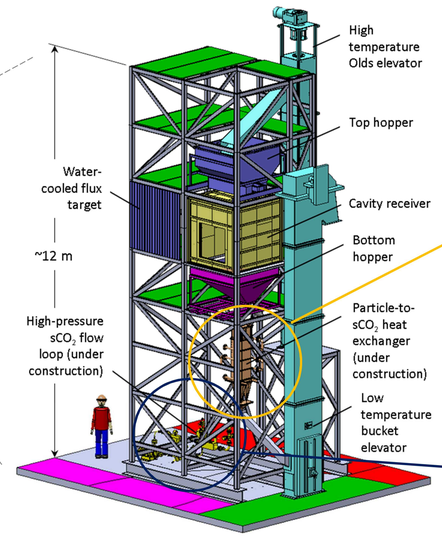
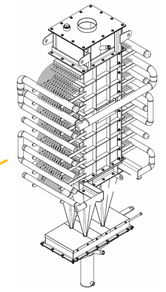
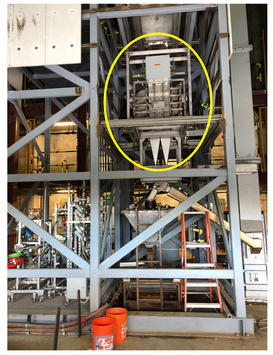
Integrated Falling Particle Receiver / Heat Exchanger / sCO$_2$ loop

Particle receiver testing at the National Solar Thermal Test Facility at Sandia National Laboratories, Albuquerque, NM



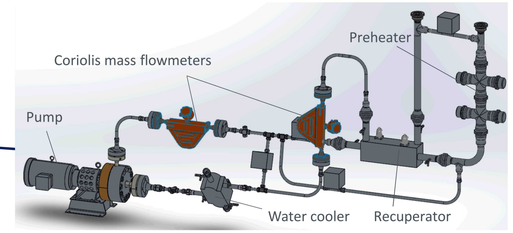
High-Temperature Particle Receiver Assembly





Particle-to-sCO2 shell-and-plate heat exchanger

- Heat duty = 100 kW
- $T_{particle,in}$ = 775 °C
- $T_{particle,out}$ = 570 °C
- $T_{sCO2,in}$ = 550 °C
- $T_{sCO2,out}$ = 700 °C
- $\dot{m}$ = 0.5 kg/s



sCO$_2$ flow system provides pressurized sCO$_2$ at 550 °C to heat exchanger for test and evaluation

Project contributors: Sandia National Laboratories (K. Albrecht, M. Carlson, H. Laubscher), Solex Thermal Science, Vacuum Process Engineering, Babcock & Wilcox, Georgia Institute of Technology, National Renewable Energy Laboratory