U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

SETO CSP Program Summit 2019

Particle Heat Transfer Mechanisms

Sandia National Laboratories

Award: Gen3 - 34152

Kevin Albrecht, Senior Member of Technical Staff

energy.gov/solar-office

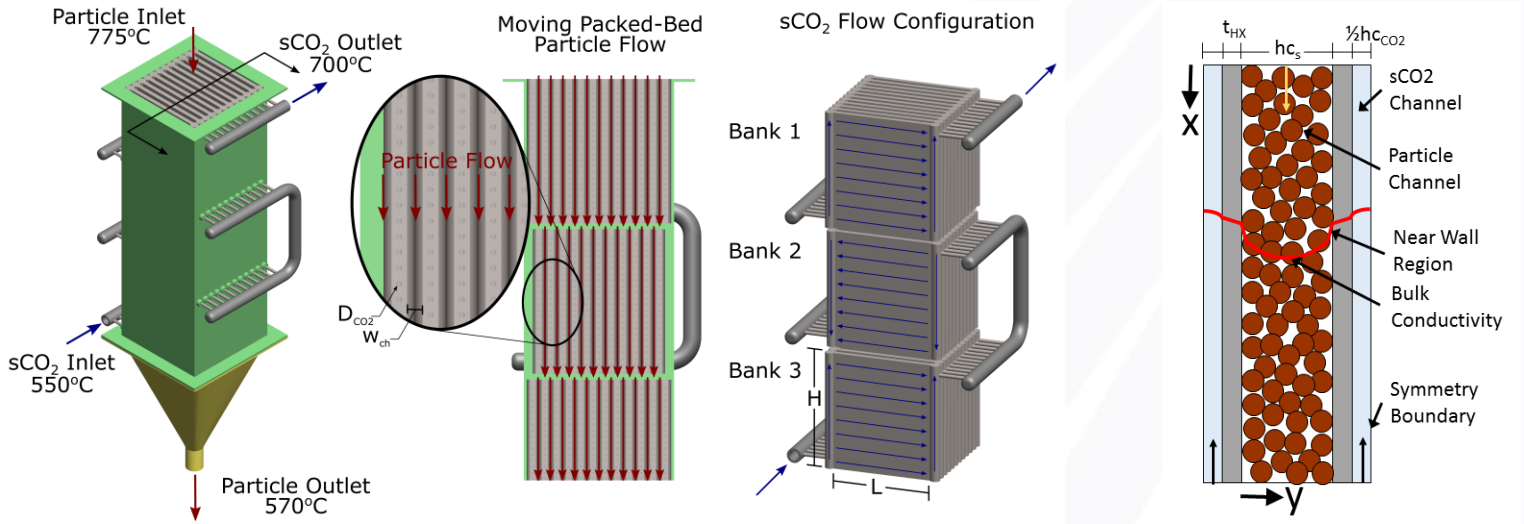
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories

Project Overview

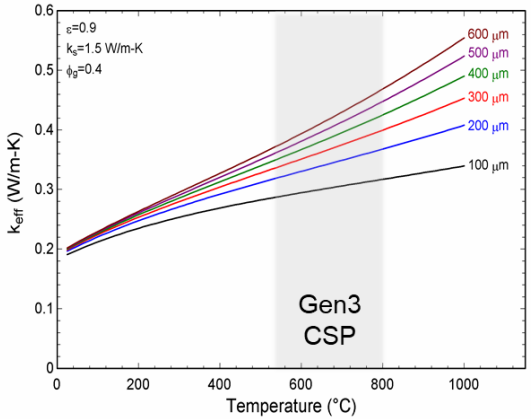
- Objective
  - This project will characterize the heat transfer mechanisms for packed beds of particles at CSP relevant operating temperature (500-800 °C). The data gathered in the experimental campaign will directly influence the design of moving packed-bed heat exchangers, which have been identified as the leading particle-to-fluid heat transfer technology in the Gen3 CSP program.
- Innovative Features
  - Separation of bulk thermal conductivity from near-wall conductance
  - Measurement of sintered bauxite particles in temperature range and geometry of interest
  - Provide key inputs and reduce uncertainty in particle heat exchanger models

Heat transfer in moving packed-bed heat exchangers

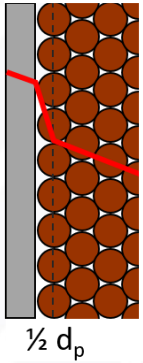


- Heat transfer in moving packed-bed heat exchangers is governed by bulk effective thermal conductivity and near-wall conductance
- Uncertainty in moving packed-bed heat exchanger models is due to unknown thermal transport properties at CSP relevant temperatures

Packed-bed and near-wall thermal transport



ZBS correlation prediction of bulk effective thermal conductivity for sintered bauxite particles



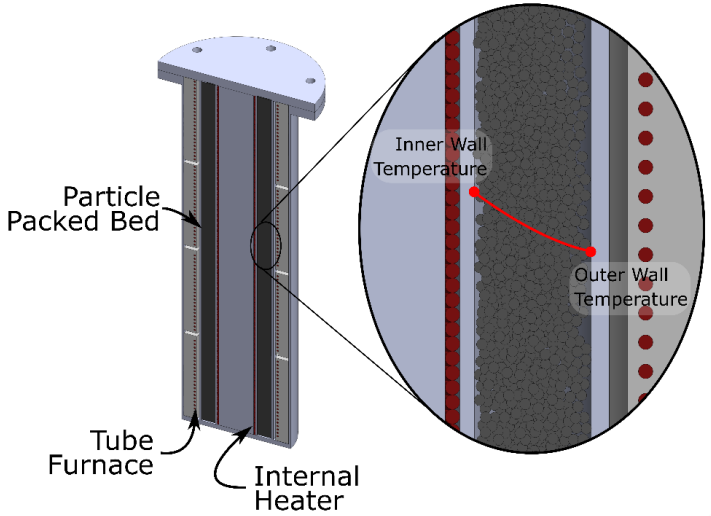
Increased voidage in the near-wall region can lower thermal conductivity

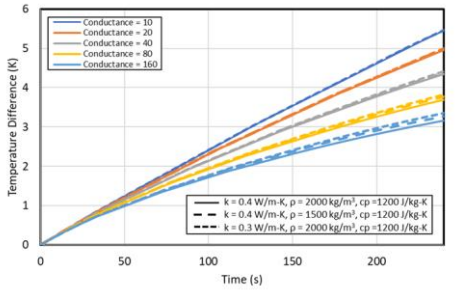
- Optimal plate spacing and particle size depends on the relative values of thermal conductivity and near-wall conductance

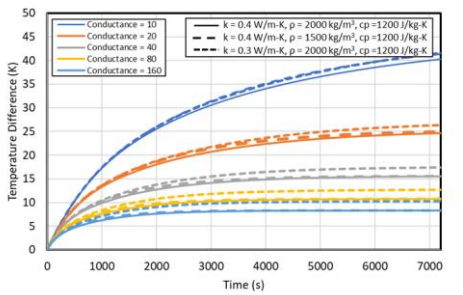
Task Summary – Phase 1

- Task 1.1: Design of particle packed bed heat transfer experiment
  - Subtask 1.1.1: CFD/FEA simulations of experimental geometry to confirm measurement technique
  - Subtask 1.1.2 Specify equipment to confirm operation at up to 800 °C
- Task 1.2: Construction and uncertainty characterization of experimental measurement
- Task 1.3: Propagate experimental error to overall heat transfer coefficient uncertainty
- Task 1.4: Characterization of particles and dissemination of results in as-received form

Approach to particle thermal characterization







- Transient measurements in an annular packed bed to separate bulk properties from near-wall conductance

Task Summary – Phase 2

- Task 2.1: Characterize the dependence of the packed bed thermal transport on the physical properties of the particles (size, size distribution, surface roughness, sphericity)
- Task 2.2: Characterize the packed bed heat transfer performance for the most likely candidate particles in a degraded form

Questions?

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.