SAND2019-11328C

Particle Lift Design for a Third Generation Falling Particle Receiver

Joshua Christian, Clifford Ho, Sheldon Jeter[2]

[1]Concentrating Solar Technologies Department

Sandia National Laboratories, P.O. Box, 5800, Albuquerque, NM 87185-1127

E-mail: jmchris@sandia.gov Web: www.sandia.gov/csp

[2]Georgia Institute of Technology, Atlanta, GA, USA

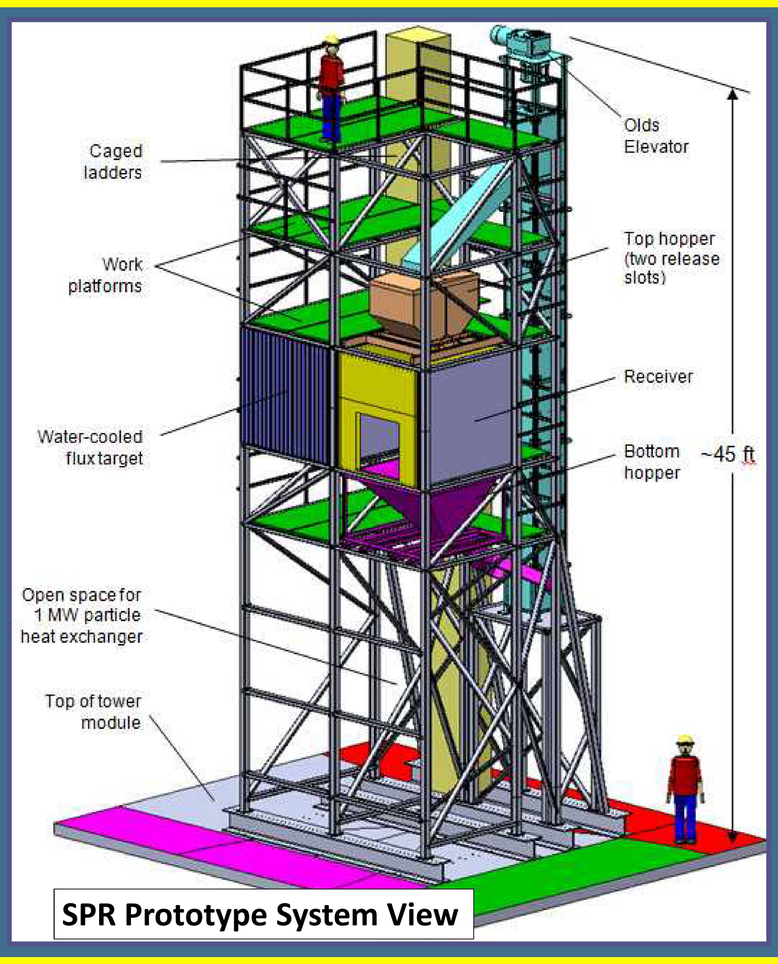
Introduction and Approach

Background

- Falling solid particle receivers (SPR) can enable increased working-fluid temperatures for central receiver power plants and reduced thermal storage costs
- Transport of the particles in the system is a critical operation that needs to account for large infrastructure and associated heat loss

Lift Features

- Heat loss <5% (as low as possible)
- Mass Flow rate 5-10 kg/s
- 600 °C operation
- Minimal particle attrition
- Cost less than $300/kW$_{th}$

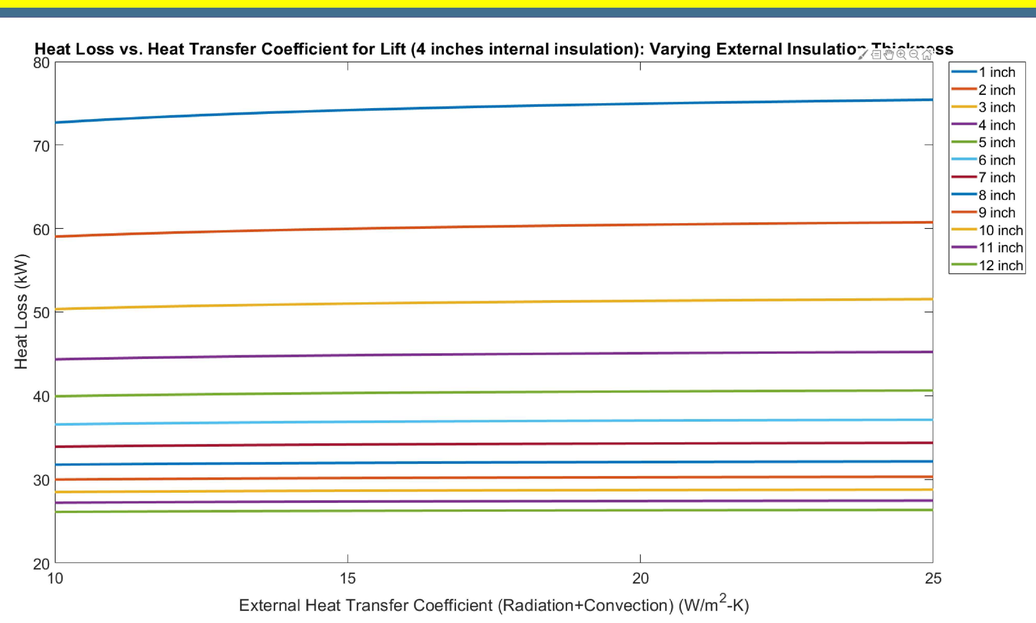


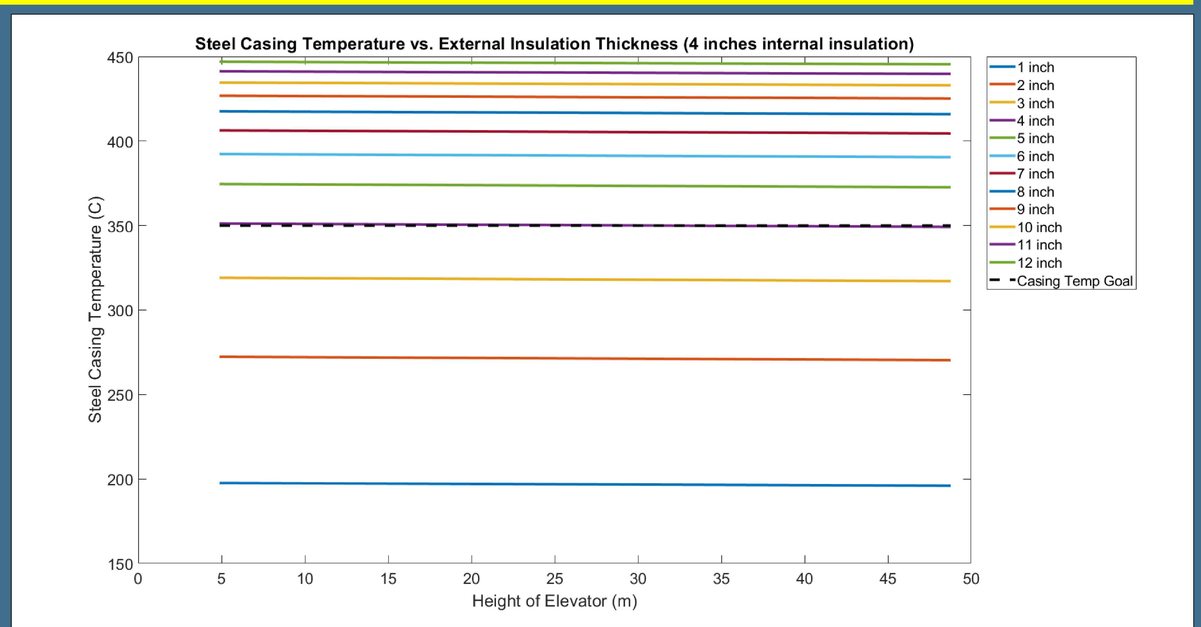
SPR Prototype System View

Approach

- Heat loss calculations performed with steady state analysis
  - Elevator width = 1.26 m
  - Elevator depth = 0.51 m
  - Elevator height = 48.8 m
  - Discretized elevator into 10 steps
  - Particle Inlet temperature of 580 °C
  - Ambient temperature 40°C
  - Outer surface emissivity = 0.9
  - Temperature dependent thermal conductivity for insulation (SuperWool Insulation)

Results – Heat Loss Analysis





- Two potential lift insulation configurations:
  - Scenario 1: External Insulation Only meaning all internal components are exposed to high temperatures. Resulted in a steel casing temperature of over 500°C for all external insulation thickness values.
  - Scenario 2 (plots shown above): Combination of Internal and External Insulation resulted in an acceptable steel casing using 10.2 cm (4 in) internal insulation
    - A 45 kW heat loss at steady state conditions with 20 W/m^2-K heat transfer coefficient on the outer surface; Particle temperatures leaving the elevator were approximately 573 °C
    - A structural steel wall temperature of 350 °C along the height of the lift; Near constant temperature along height due to particles being lifted at a speed with little temperature drop

Conclusions

- Particle lifts have a large surface area that leads to a significant source of heat loss if insulation is not properly designed
- A bucket elevator can meet the needs of particle receiver systems, but are not the only choice

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.