Narrow-Channel Fluidized Beds for Thermal Energy Transport & Storage **Award# DE-EE0008538**

Narrow-channel fluidized beds enhance particle-wall heat transfer to reduce size and cost of primary heat exchanger for sCO_2 power cycles.

1. Impact

Narrow-channel, counterflow fluidized beds can greatly enhance heat-transfer per unit area of the flux-limiting particle-wall heat transfer. Very small counterflow air flow rates (~ 1% gas mass flow to particle mass) achieve significant particle-wall heat transfer enhancements that reduce heat exchanger (HX) size and provide a potential pathway to HX designs with costs < $150/kW$_{th}$.

2. Project Goal

Overall project goals are listed here:

- scalable fluidized bed particle-sCO_2 HX design with particle-wall heat transfer coefficients $h_{T,w}$ ≥ 1000 W m^{-2} K^{-1} and effectiveness, ε_{hx} > 80%;
- testing a 40 kW$_{th}$ stainless-steel particle-sCO_2 HX at inlet $T \geq 600$°C, particle $\Delta T \geq 150$°C, and mean $h_{T,w} \geq 1000$ W m^{-2} K^{-1};
- technoeconomic analysis of TES subsystem that meets DOE cost targets < $15/kWh$_{th}$.

3. Method(s)

Our team has tested fluidized bed heat transfer in single-channel counterflow arrangements with various CARBO Ceramic oxide particles with diameters d_p < 350 μm to identify trends of particle-wall heat transfer vs. T, d_p, flow rates, and geometry. These test rigs are also used to study particle abrasion and wall wear and to validate 1-D fluidized bed channel models. The models have been used to design a multi-channel 40-kW$_{th}$ stainless-steel particle-sCO_2 heat exchanger to be demonstrated this fall with Sandia at the NSTTF.

4. Outcome(s)

Tests to over 500°C have demonstrated $h_{T,w} \geq$ 800 W m^{-2} K^{-1} and validated correlations show a path to $h_{T,w} \geq$ 1000 W m^{-2} K^{-1} with d_p < 250 μm. Our team has designed and had assembled (VPE) a 12-bed particle HX with integral counterflow sCO_2 microchannel plates to achieve > 40 kW$_{th}$ in a stainless-steel core < 20 liters.

5. Conclusion/Risks

Many challenges have been resolved associated with fluidizing particles and gas flows, but further testing and demonstration needs to assess long-term operation with preferred particles with minimal wall oxide scaling and particle abrasion

6. Team

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Sandia National Labs: Kevin Albrecht, Chris Bowen, and Andrea Ambrosini

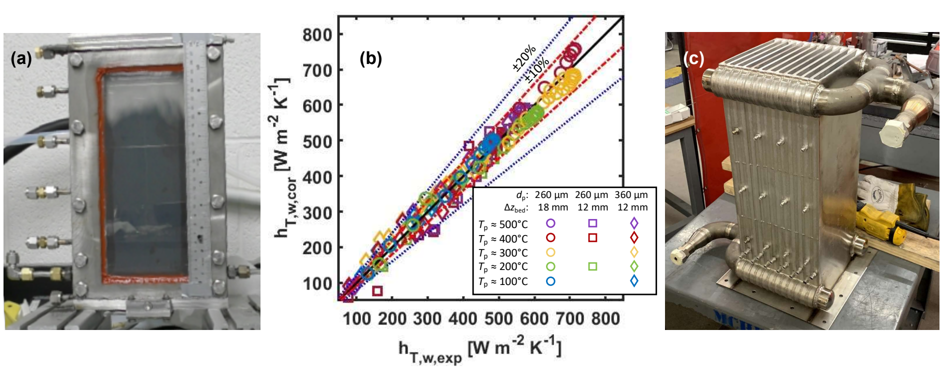

Figure 1. a) Single-channel test rig operating for fluidized bed visualization mode, b) Range of particle-wall $h_{T,w}$ measurements fitted to correlations within ±10% for tests up to 500°C, and c) core of 40-kW$_{th}$ particle-sCO_2 HX for demonstration testing