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FINITE ELEMENT ANALYSIS OF A MOVING PACKED-BED PARTICLE-TO-sCO_2 HEAT EXCHANGER TESTING AND PERFOMANCE

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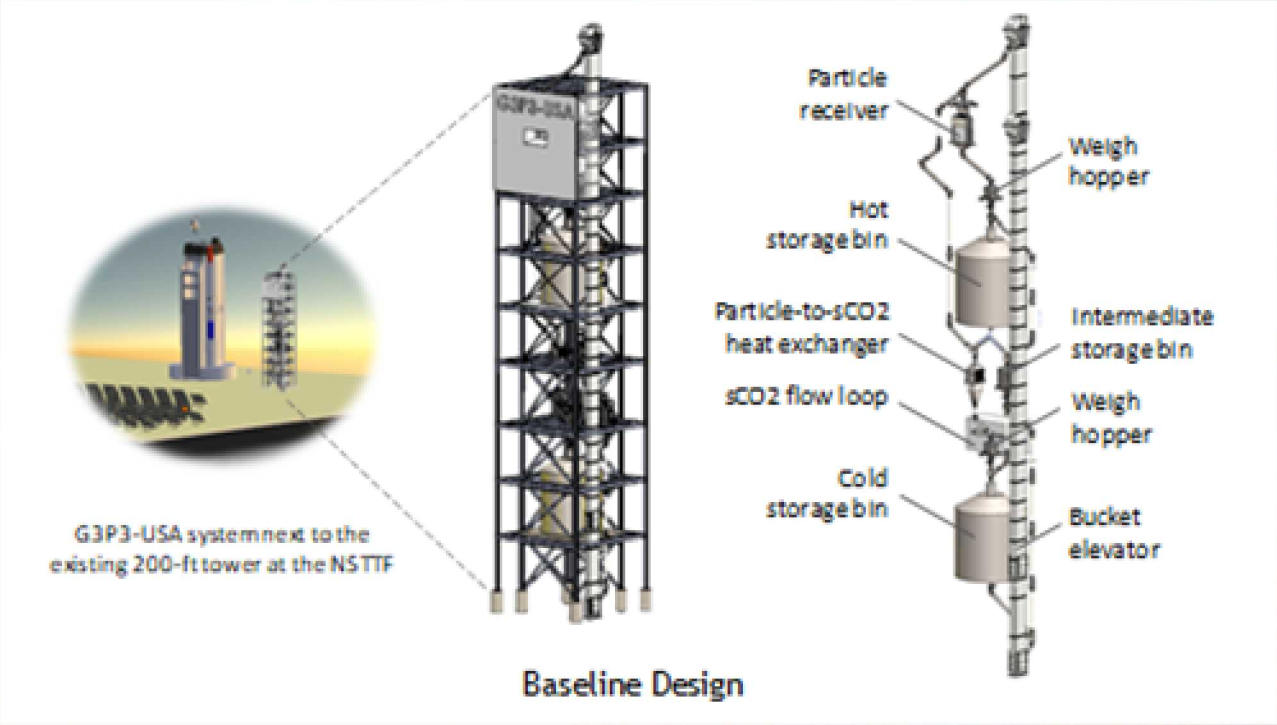
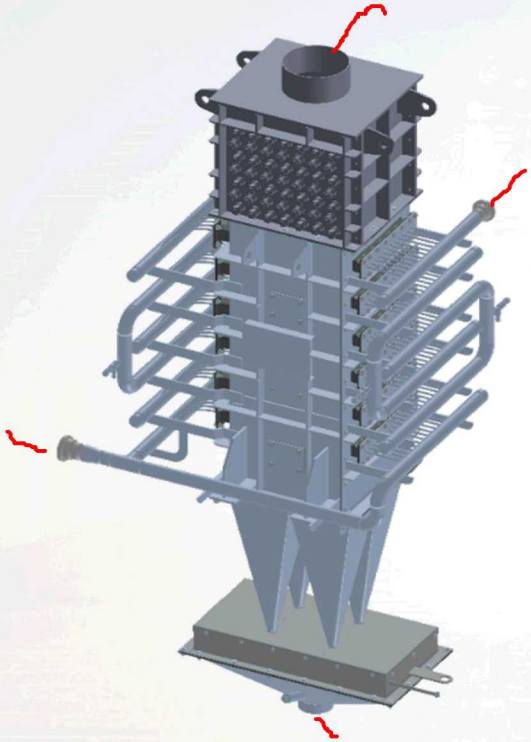
Particle-sCO2 Solar Power Plant



- High temperature particles enable the use of a high efficiency sCO_2 Brayton cycle.
- Particle-sCO_2 heat exchanger performance is critical to the levelized cost of electricity.

Particle-to-sCO_2 Heat Exchanger Design

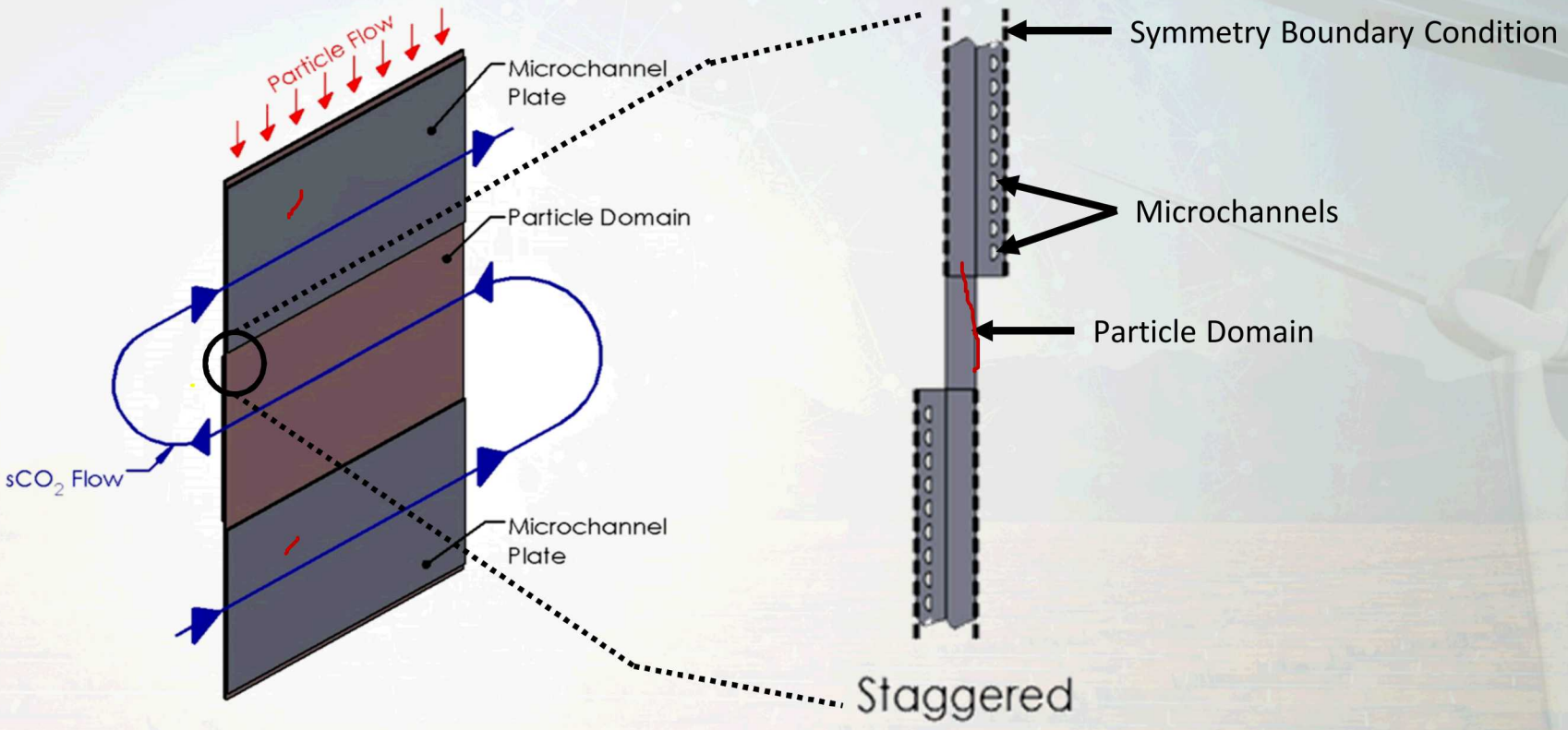


VACUUM PROCESS ENGINEERING

SOLEX THERMAL SCIENCE

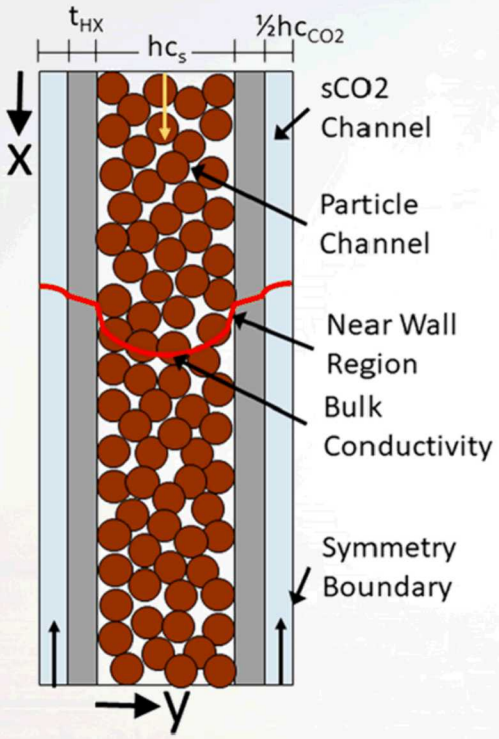
- A 100 kW Particle-to-sCO_2 Heat Exchanger was built and tested.
- The error between simulated & experimental results was reduced & matched at certain conditions.

Particle-to-sCO_2 Heat Exchanger Model

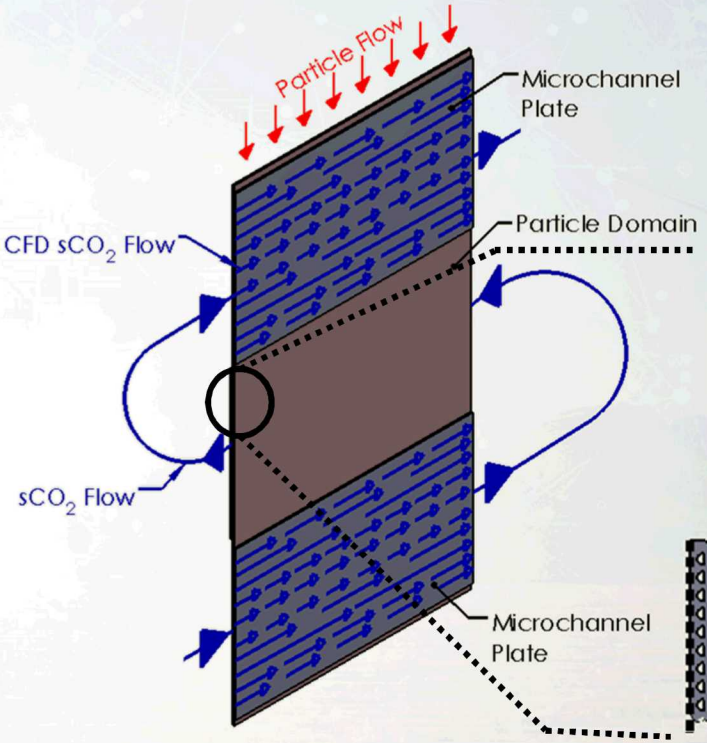


- Goal: predict thermal performance via the overall heat transfer coefficient (U).

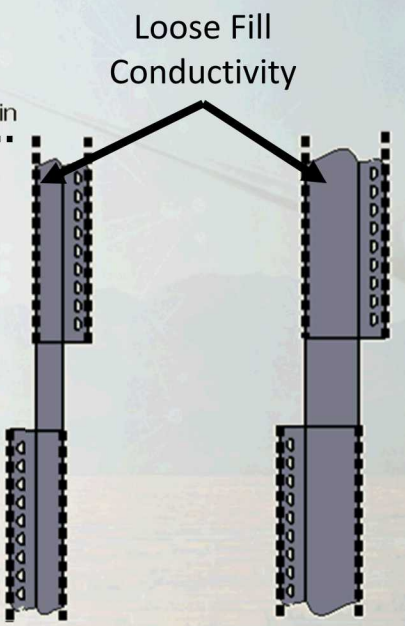
Overview of Additions to Model



Initial Model



Two Simulations



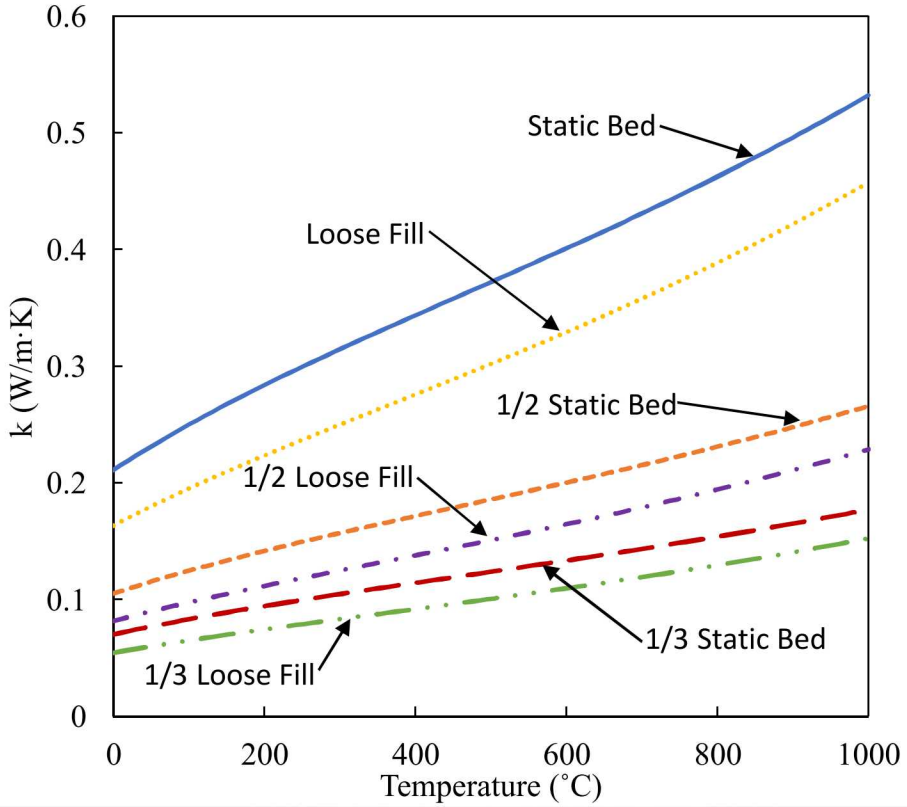
7 mm Particle Width

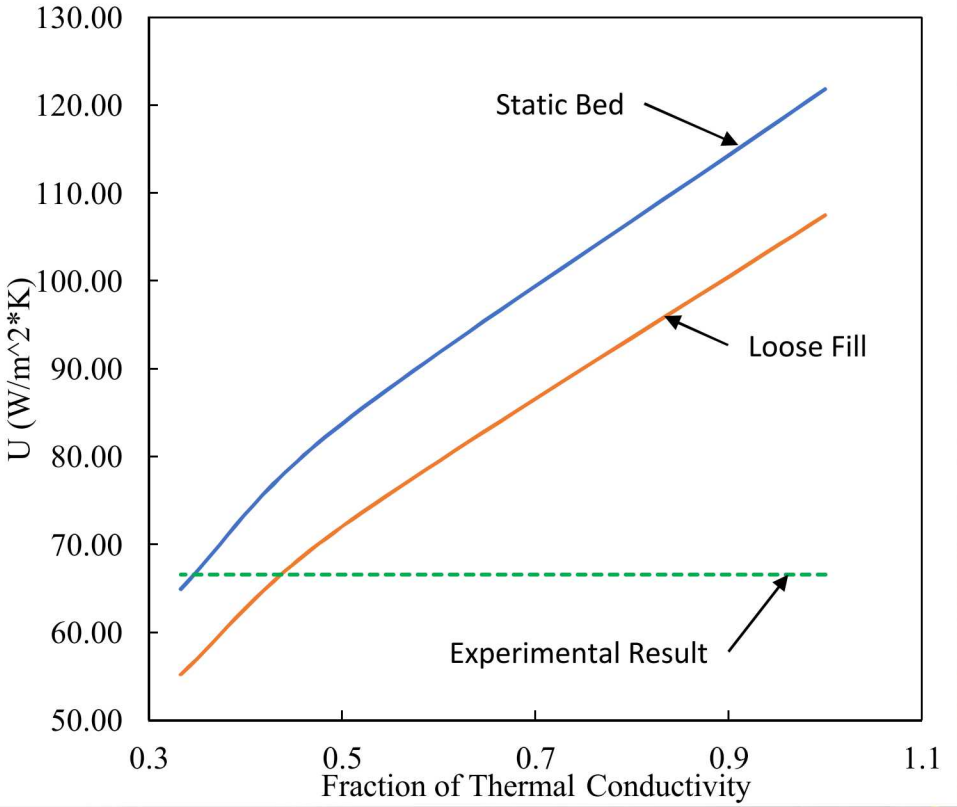
15 mm Particle Width

Final Model

Albrecht, Kevin J. and Ho, Clifford K. "Heat Transfer Models of Moving Packed-Bed Particle-to-SCO2 Heat Exchangers," Journal of Solar Energy Engineering Vol. 141 (2019).

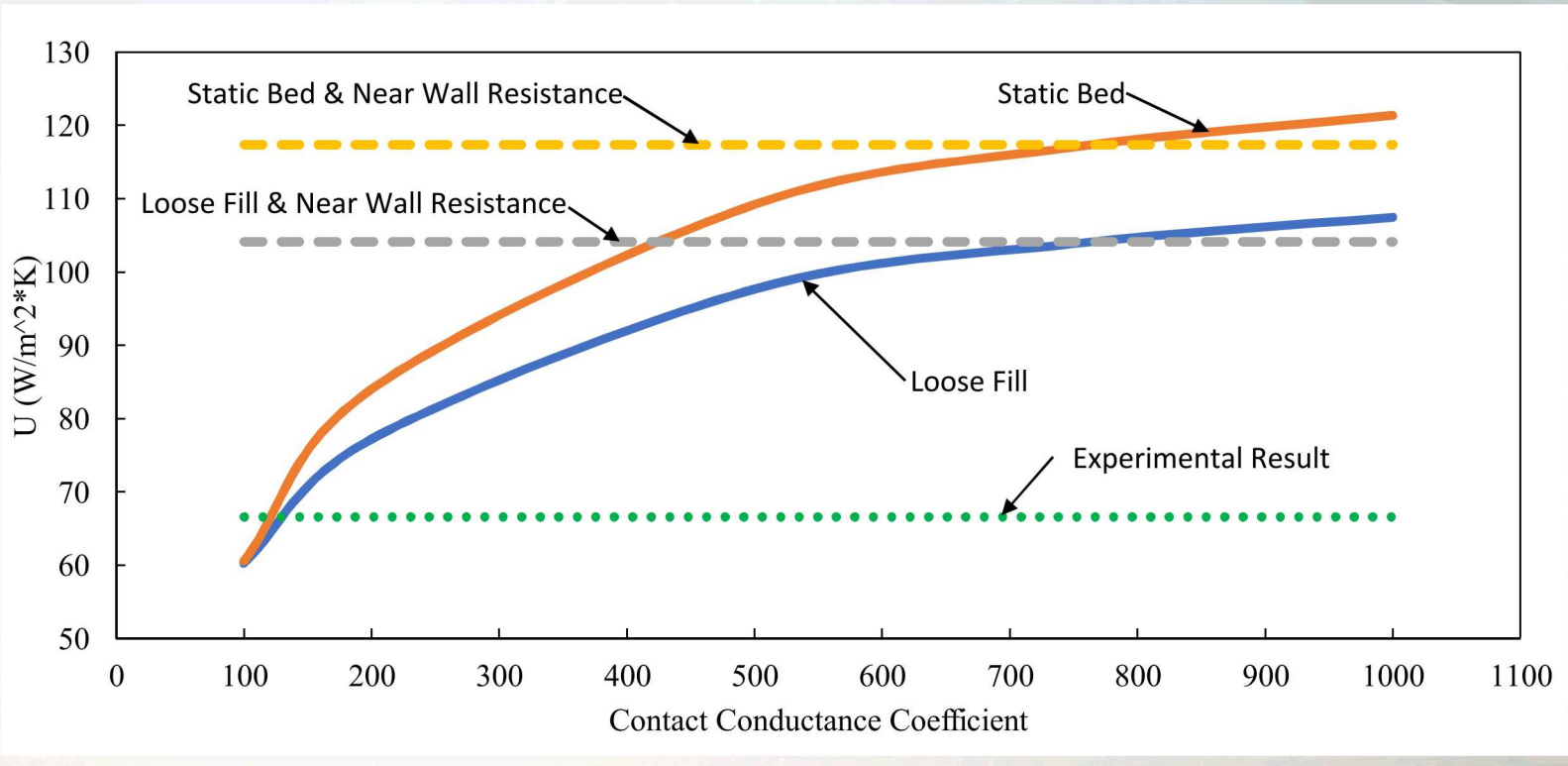
Particle Conductivity Test





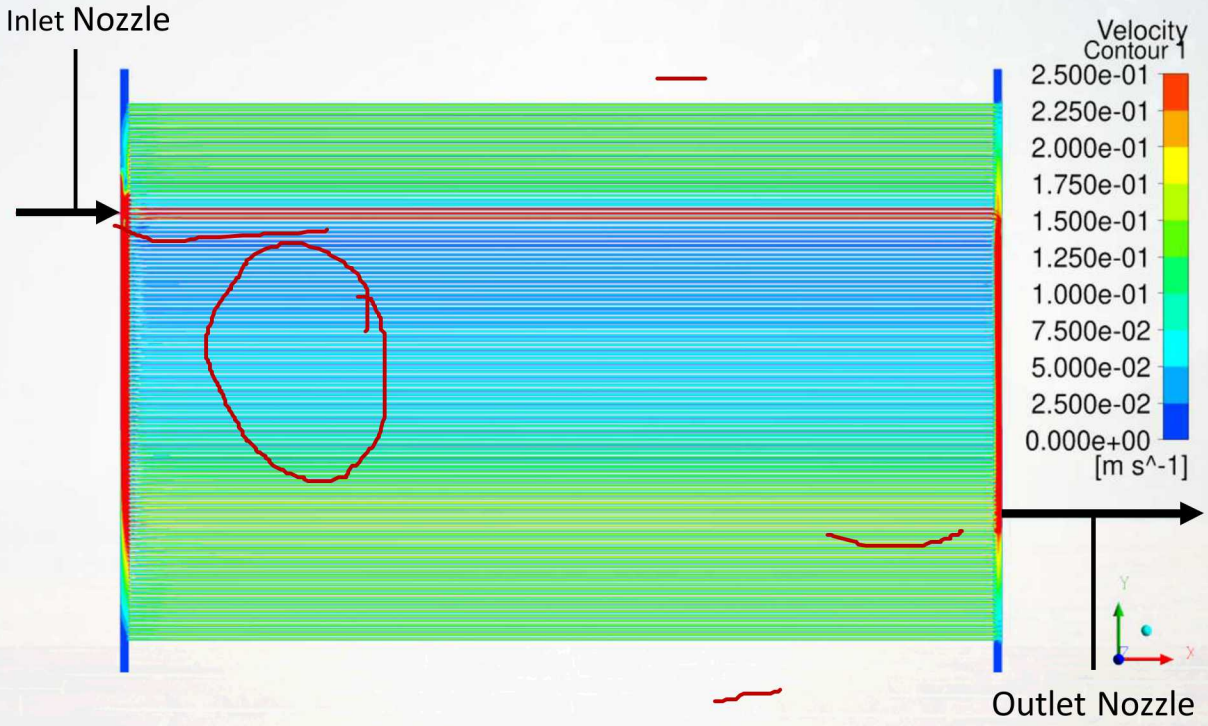
- A 66% reduction of the particle thermal conductivity was needed to match experimental results.

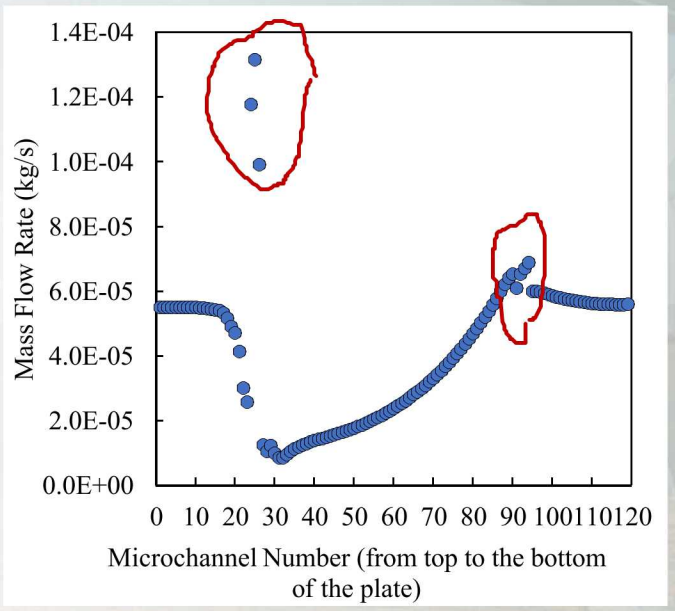
Increased Near Wall Resistance



- A reduction of the contact conductance coefficient from 1000 to 100 W/m^2·K was needed to match experimental results.

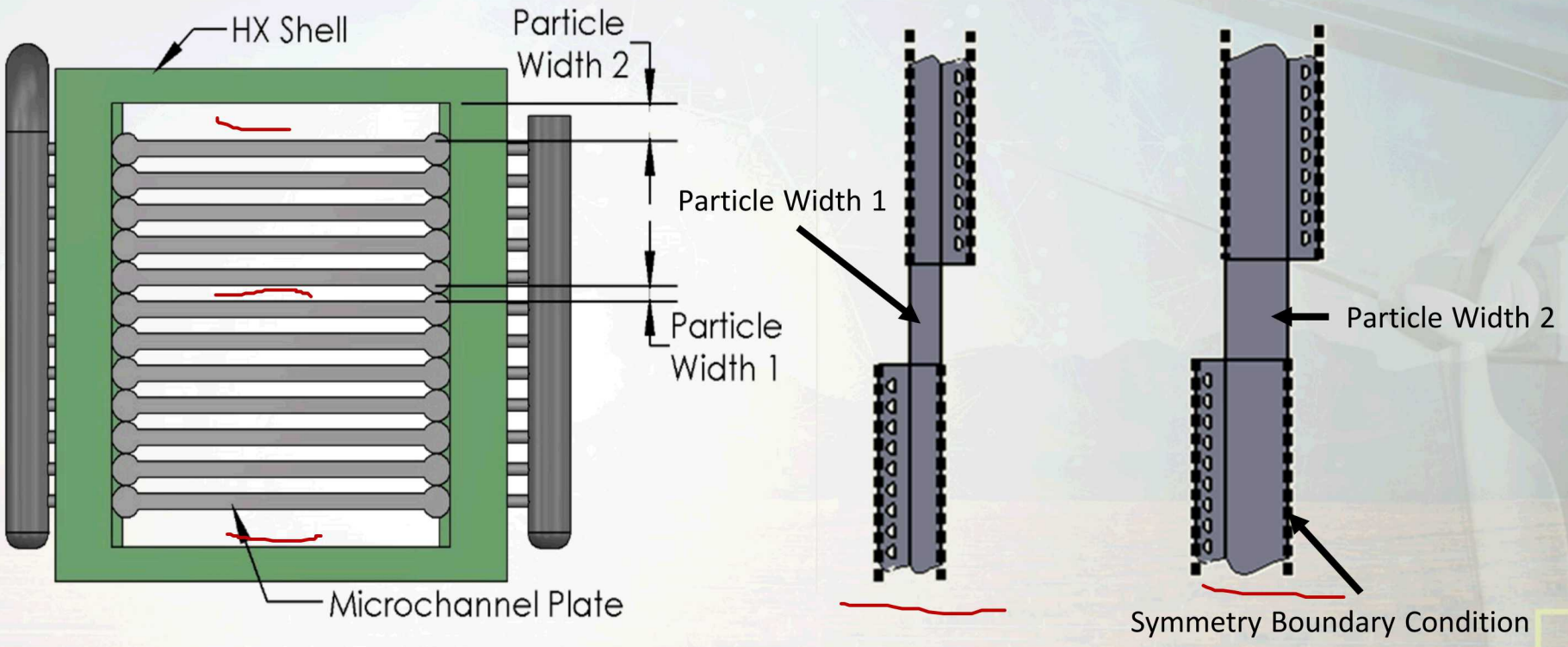
CFD Analysis of sCO_2 Flow





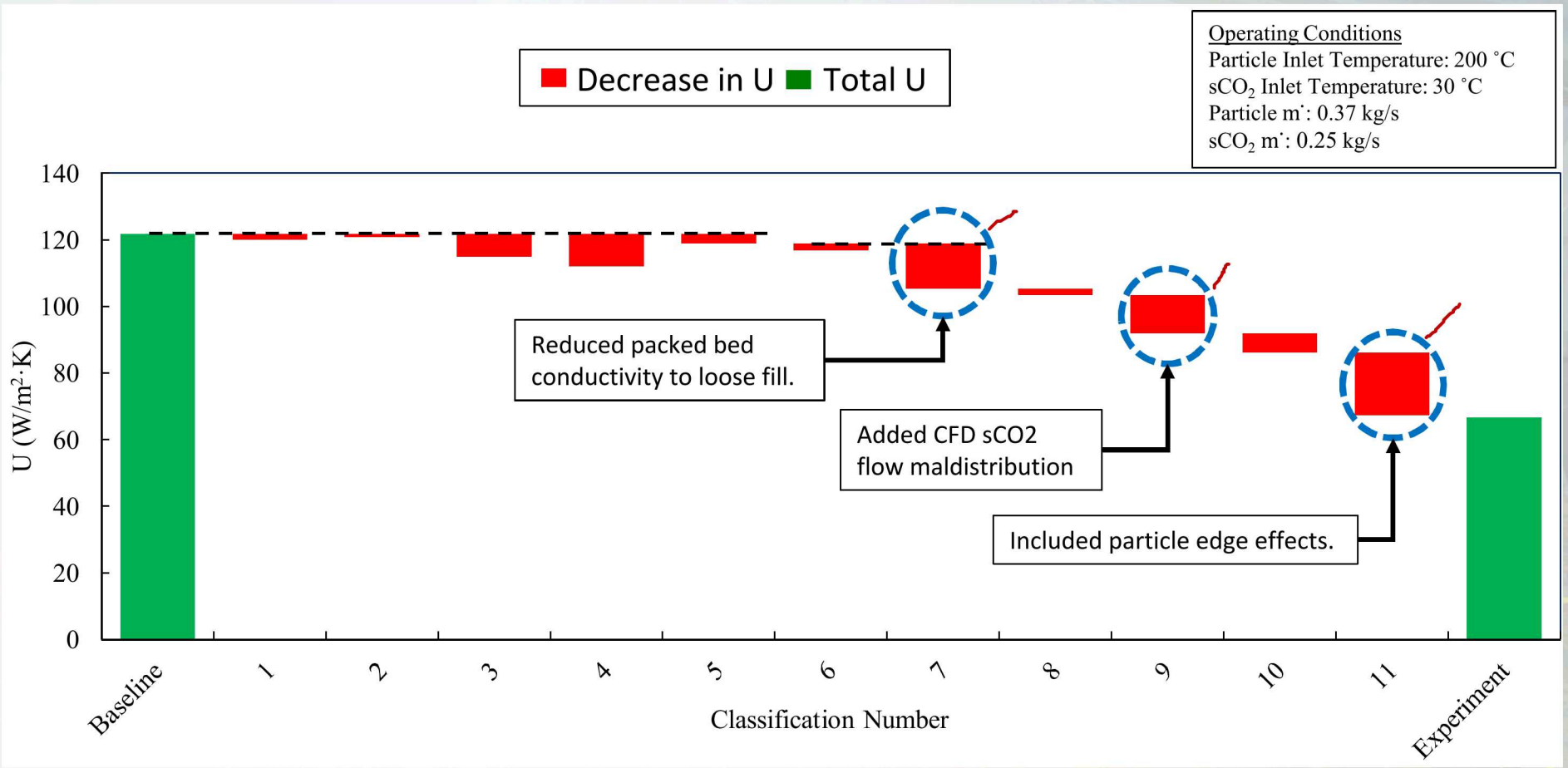
- Area in center of plate with low sCO2 flow resulting in less effective heat transfer area.

Bulk Particle Velocity

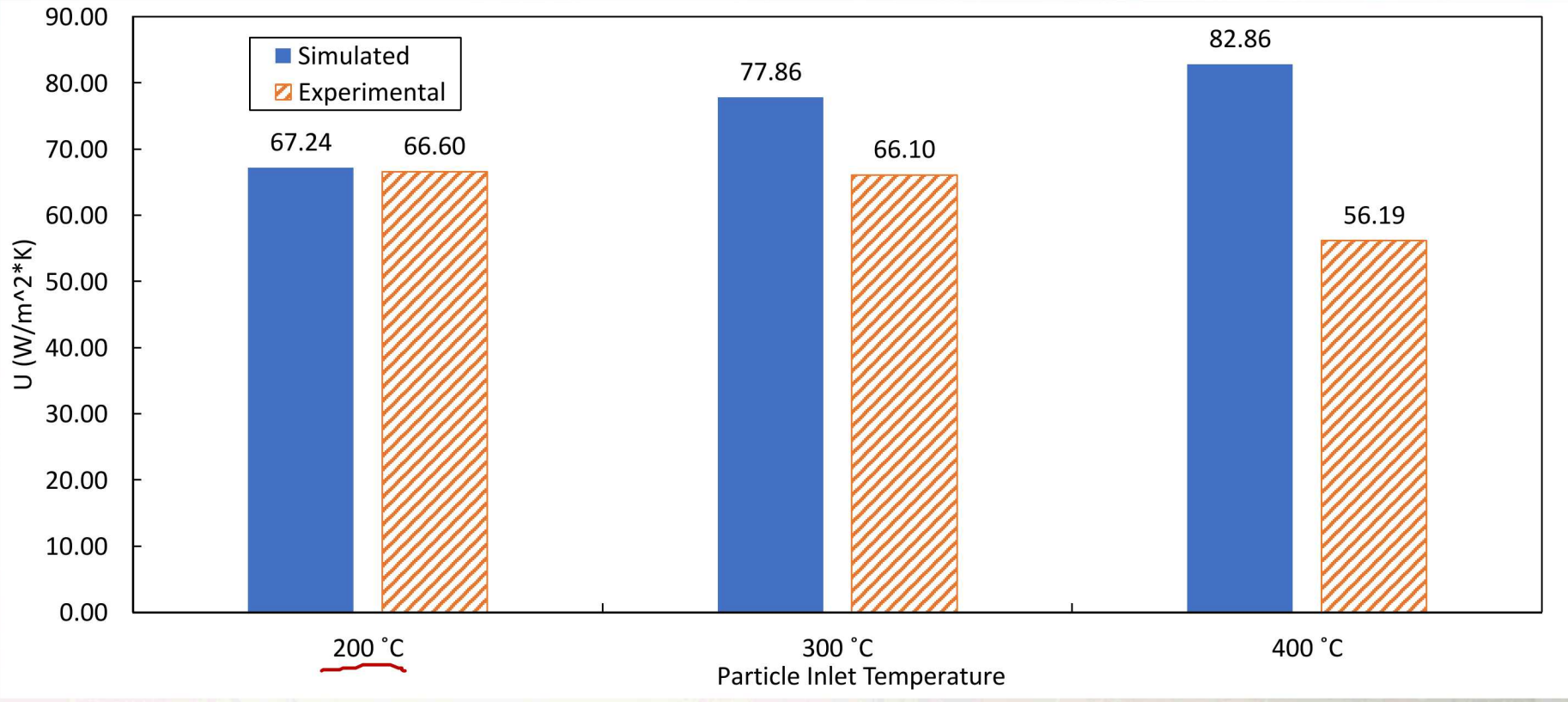


- Used two simulations for each particle width.
- Both simulations set to a common bulk particle velocity.

Results of Sensitivity Analysis



Agreement of Model with Experimental Results



- Model not able to account for decrease in U with increasing temperatures in the experimental tests.

Conclusions

- Key factors found in the modeling of the HX:
  - Particle bed thermal conductivity (14% reduction)
  - sCO_2 flow distribution (13% reduction)
  - Size of the particle domain (27% reduction)

- Further model development:
  - Add sCO2 mixing between banks
  - Create coupled CFD and thermal analysis

ACKNOWLEDGEMENTS

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