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HPC 4 ENERGY INNOVATION

HPC 4 MATERIALS

HPC 4 MANUFACTURING

HPC 4 MOBILITY

Compact Diffusion Bonded Heat Exchanger Fatigue Life Simulations

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NNSA National Nuclear Security Administration

U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

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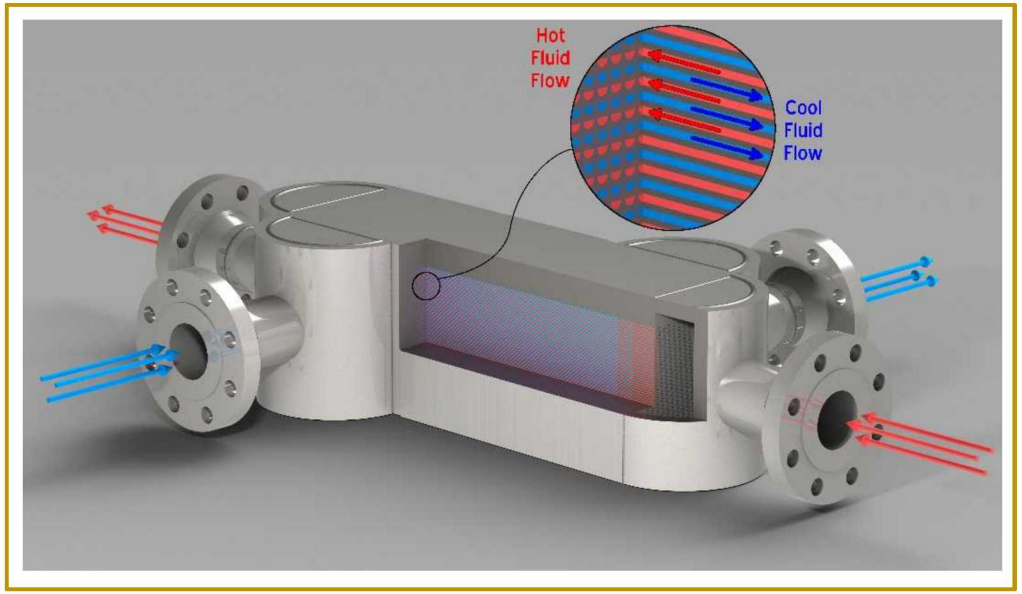
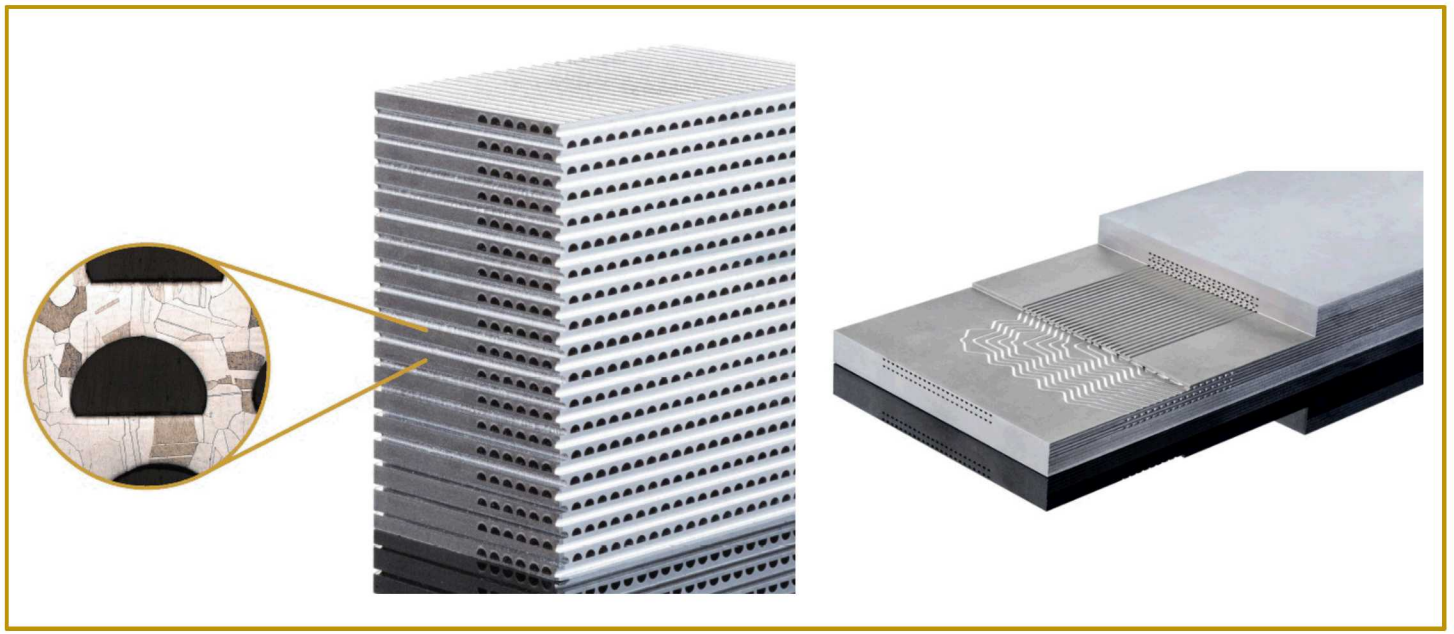
Compact diffusion bonded heat exchangers are critical to high pressure heat exchange



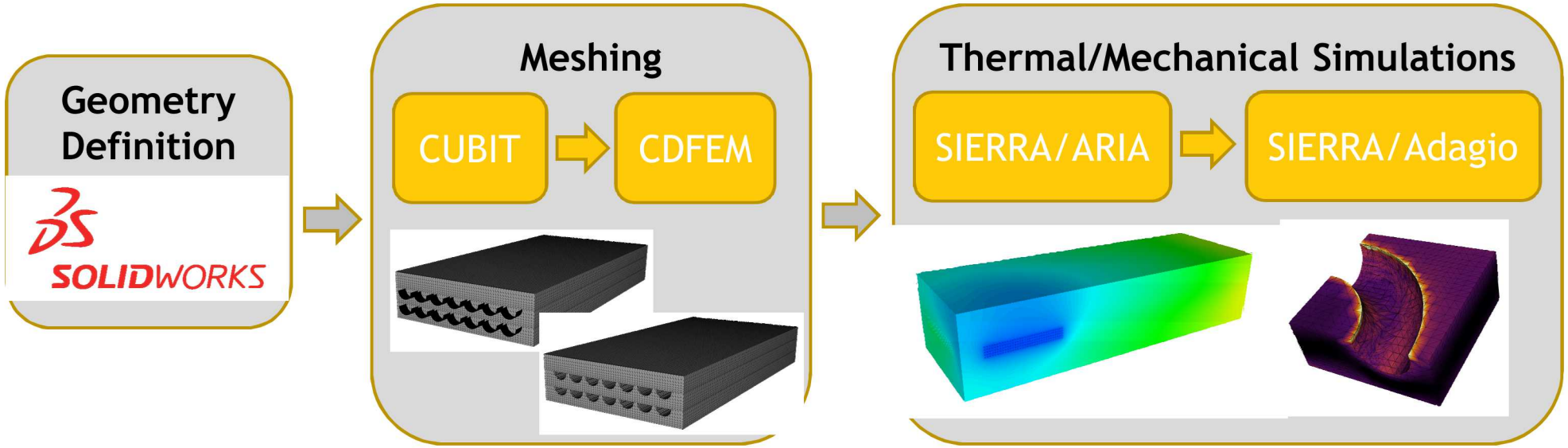
- Referred to as Microchannel Heat Exchangers (MCHEs)
- Pressures easily up to 14,500 psi (100 MPa)
- MCHEs are ~10x smaller and ~4x lower cost when compared to shell and tube heat exchangers at high pressure



Applications:

- Supercritical CO2 power cycles
- Hydrogen vehicle filling stations
- Liquefied natural gas processing
- Gas turbine fuel pre-heating

Simulations utilize conformal meshing and one-way coupled multiphysics capabilities



- Goal: Predict mechanical stress response to transient operating conditions including temperature, pressure, and flow
- Conformal Decomposition FEM (CDFEM) decomposes a non-conforming background mesh into sub-elements that conform to interfaces defined by a level set method
- SIERRA/Aria is a finite element method (FEM) for solving systems of partial differential equations (PDEs) used here to solve the thermal advection-diffusion equation
- SIERRA/Adagio is a three-dimensional, implicit solid mechanics code used to solve for quasi-static, nonlinear deformation of solids.

Simulations used to determine transient thermal/mechanical response

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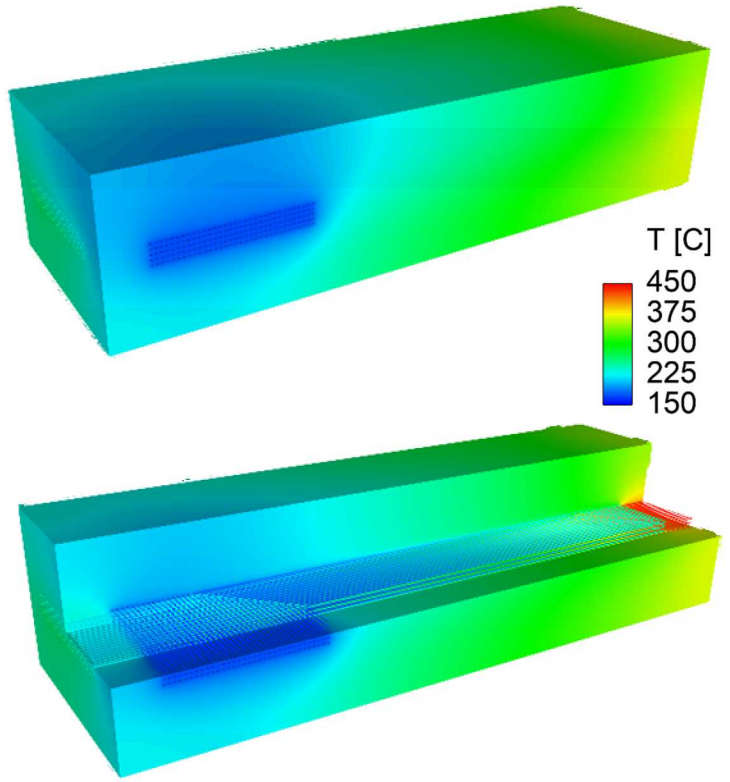
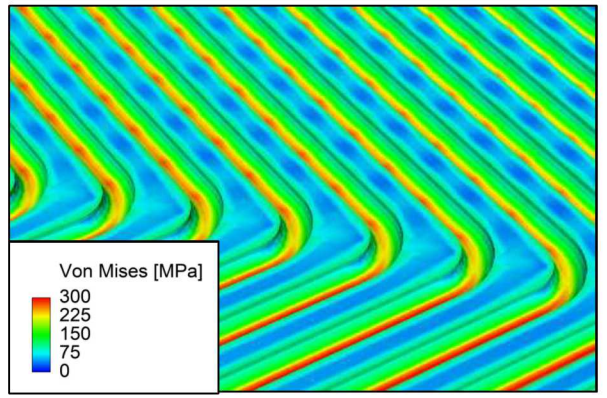
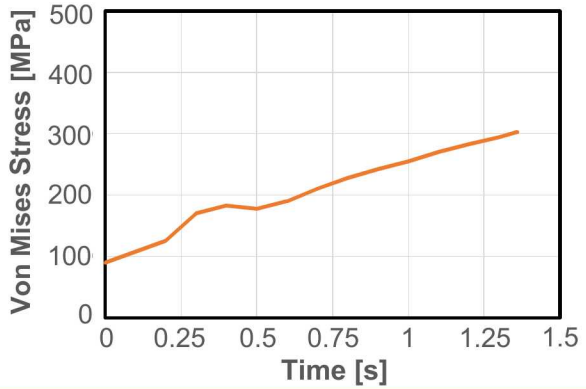
Thermal Results



- Three-dimensional thermal effects are apparent and design dependent
- Core stresses are maximal on channel walls
- Transient responses can be used to estimate MCHE fatigue life and establish best practices for transient operations

Mechanical Results





Thermal/mechanical simulations improve MCHE reliability

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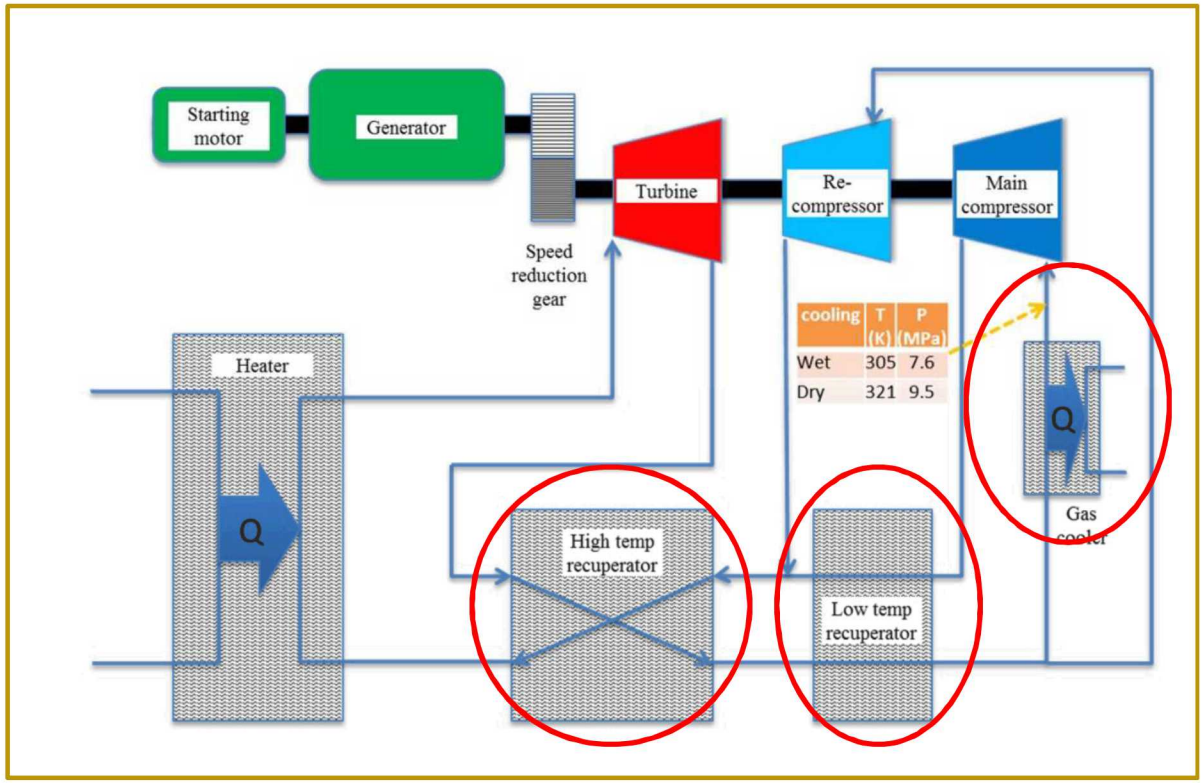
Payoff to MCHE development/applications:

- Influence industry guidance on thermal ramp rate limitations for MCHEs in sCO_2 power cycles
- Increase credibility of MCHEs in cyclic operations
- Improve designs to reduce stress concentrations
- Reduce material cost

Modeling impacts:

- Better understand thermal distributions in MCHE
- Insight into localized mechanical stresses
- Assess mechanical fatigue life and ramp rate limits



Simplified flow diagram of sCO_2 Recompression Closed Brayton Cycle showing three MCHEs **circled**