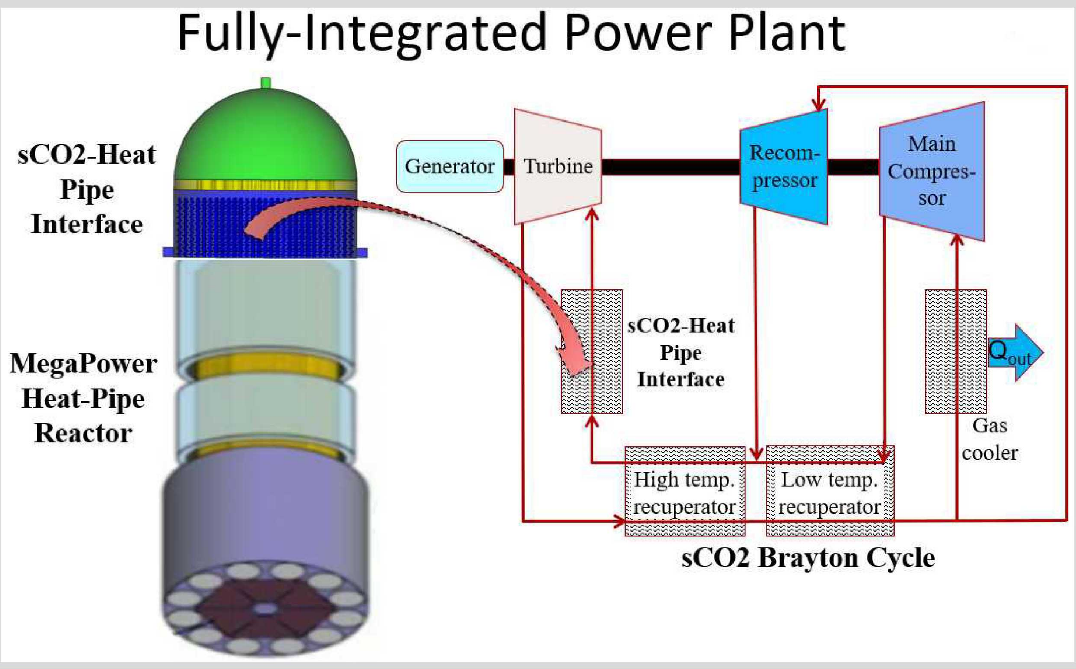
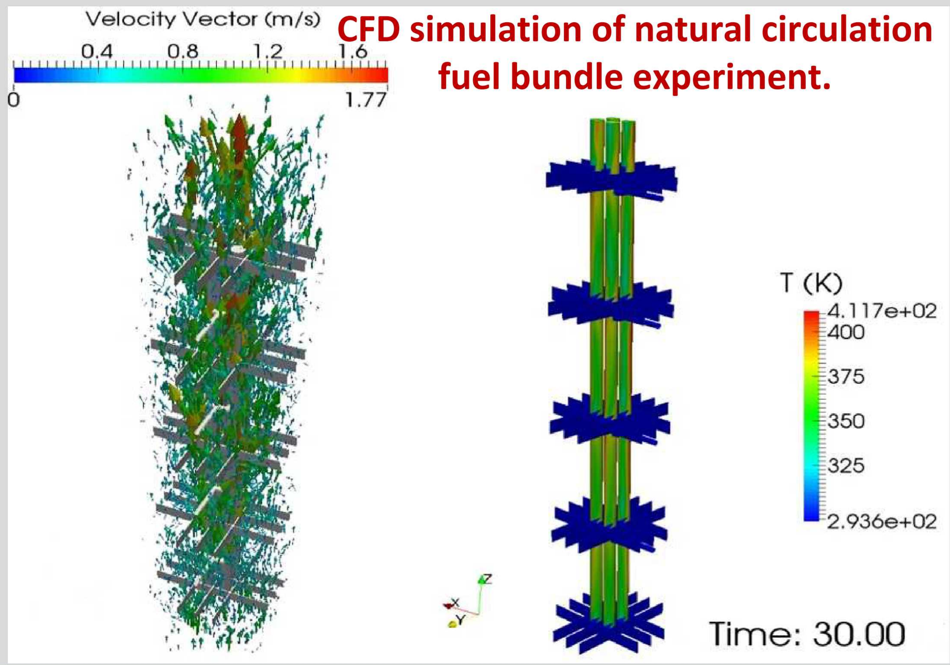
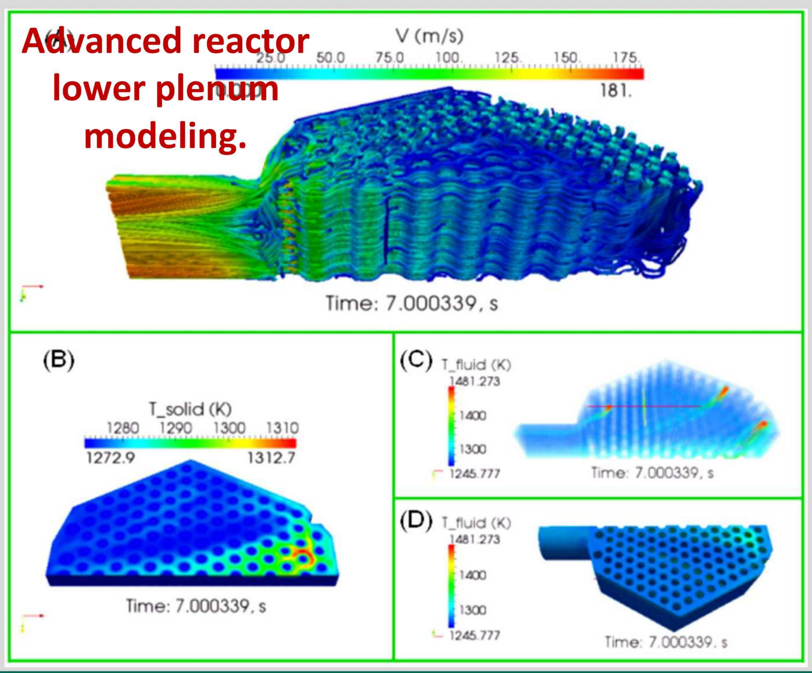
SAND2019-1960D

Computational Multiphysics, Engineered Surfaces, and Next-Generation Advanced Reactor Materials

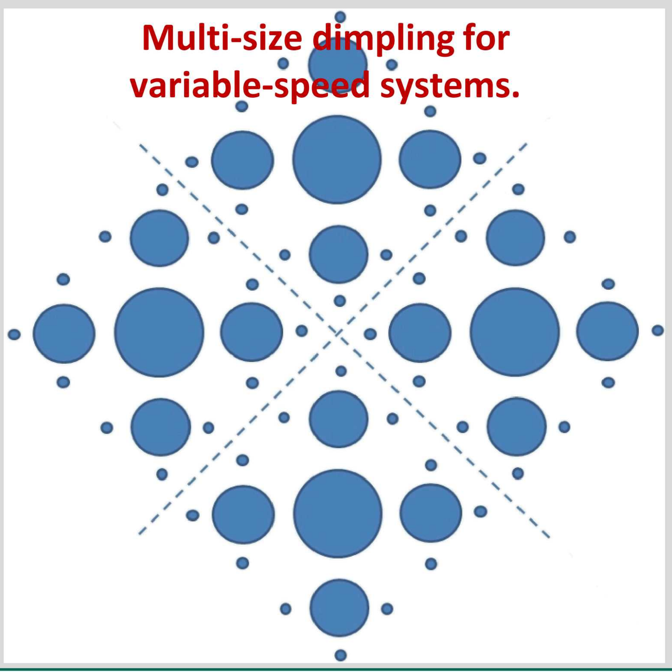




CFD simulation of natural circulation fuel bundle experiment.



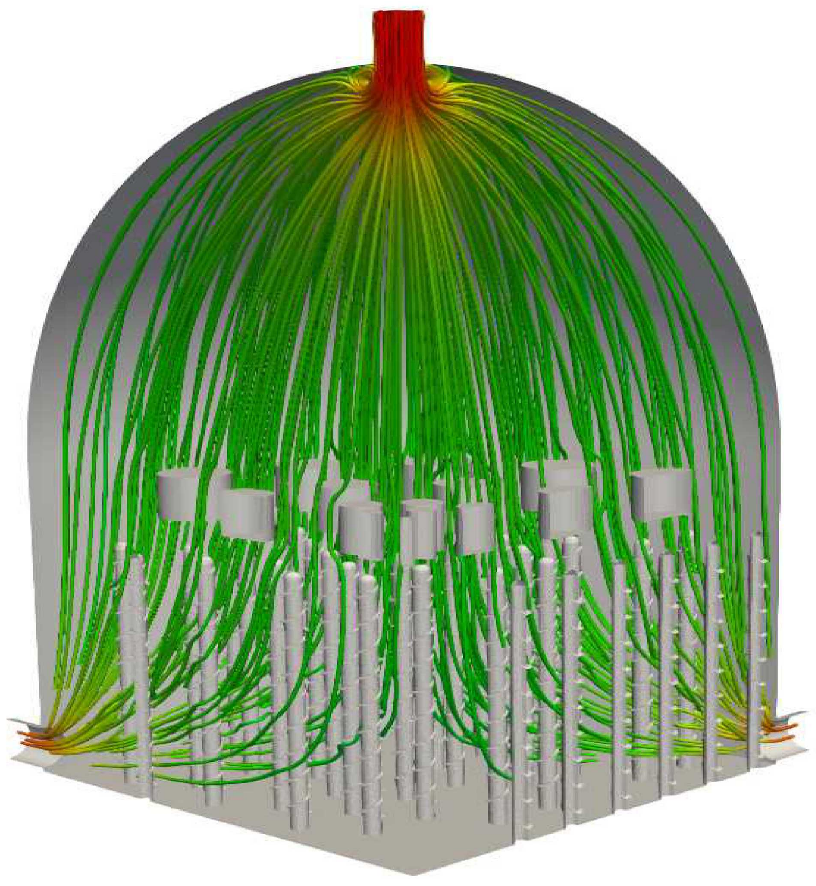
Advanced reactor lower plenum modeling.



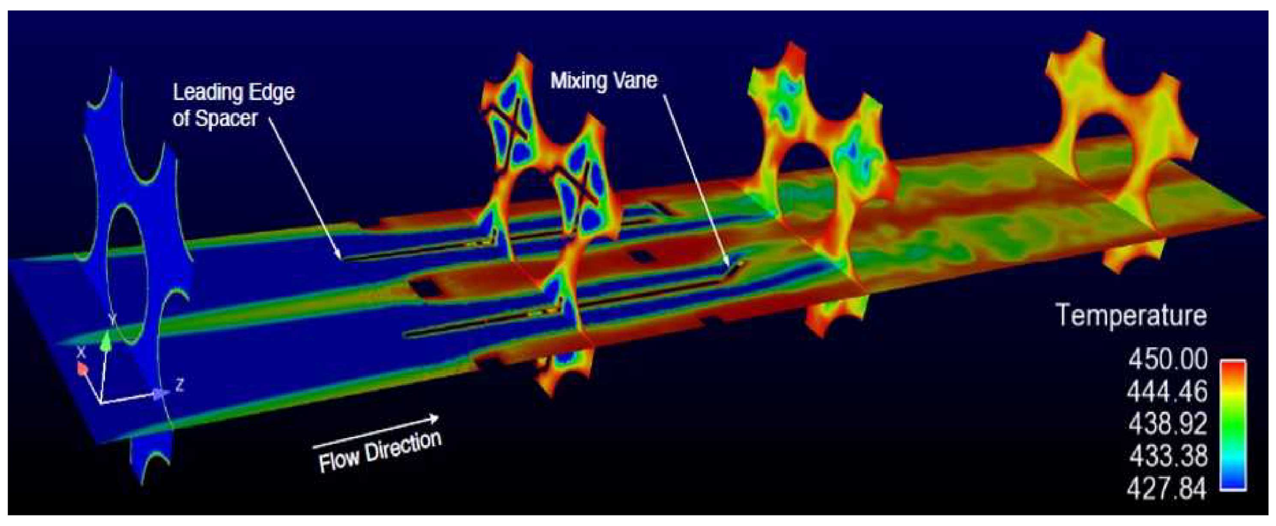
Multi-size dimpling for variable-speed systems.

Computational Multiphysics

- Computational fluid dynamics (CFD), heat transfer, and structural analysis for the design and modeling of advanced nuclear reactors, including small modular reactors (SMRs), micro-reactors, and very high temperature reactors.
  - Increased thermal efficiency,
  - Enhanced reactor safety,
  - Increased nuclear-energy cost-competitiveness.
- sCO2 power conversion unit design, modeling, and integration.
  - Micro-reactors, SMRs, and non-nuclear energy sources.
  - High-efficiency, waterless power production.
  - Mobile, deployable, energy-source agnostic.
- Sandia has 251,000 massively-parallel processor cores for a total computational power of 7.1 peta FLOPS.



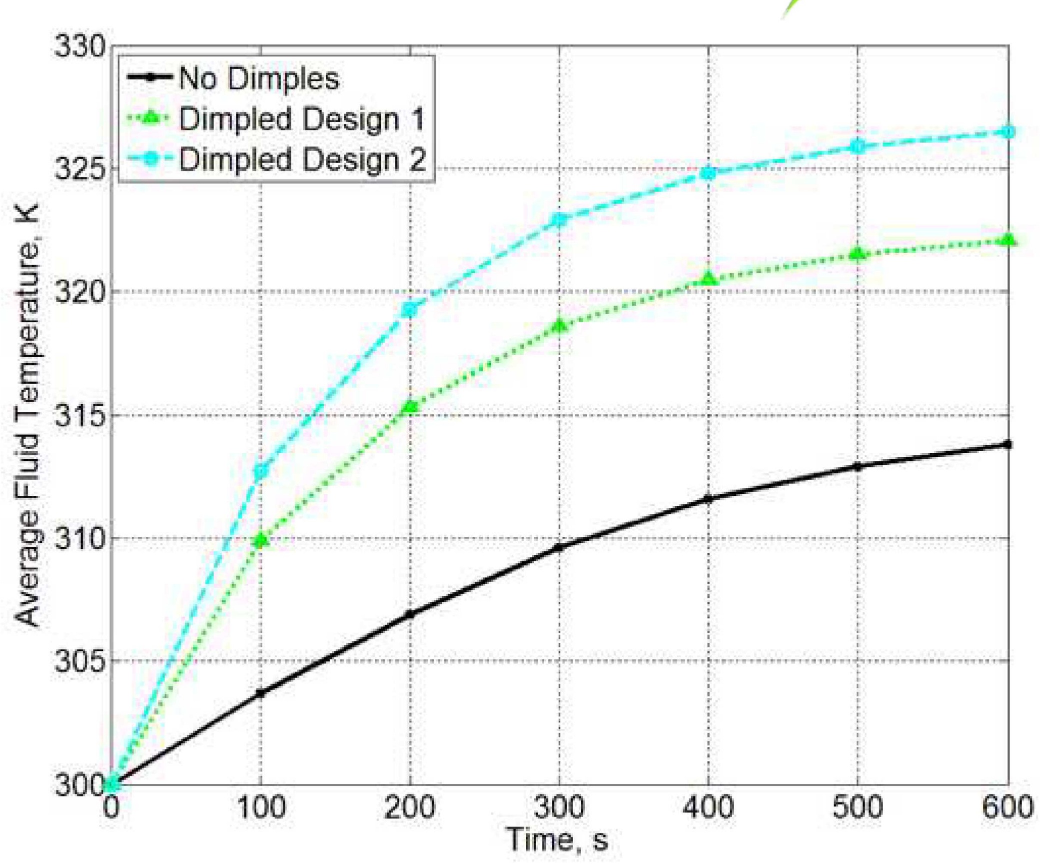
CFD simulation of the sCO2-Heat Pipe Interface: velocity streamlines.



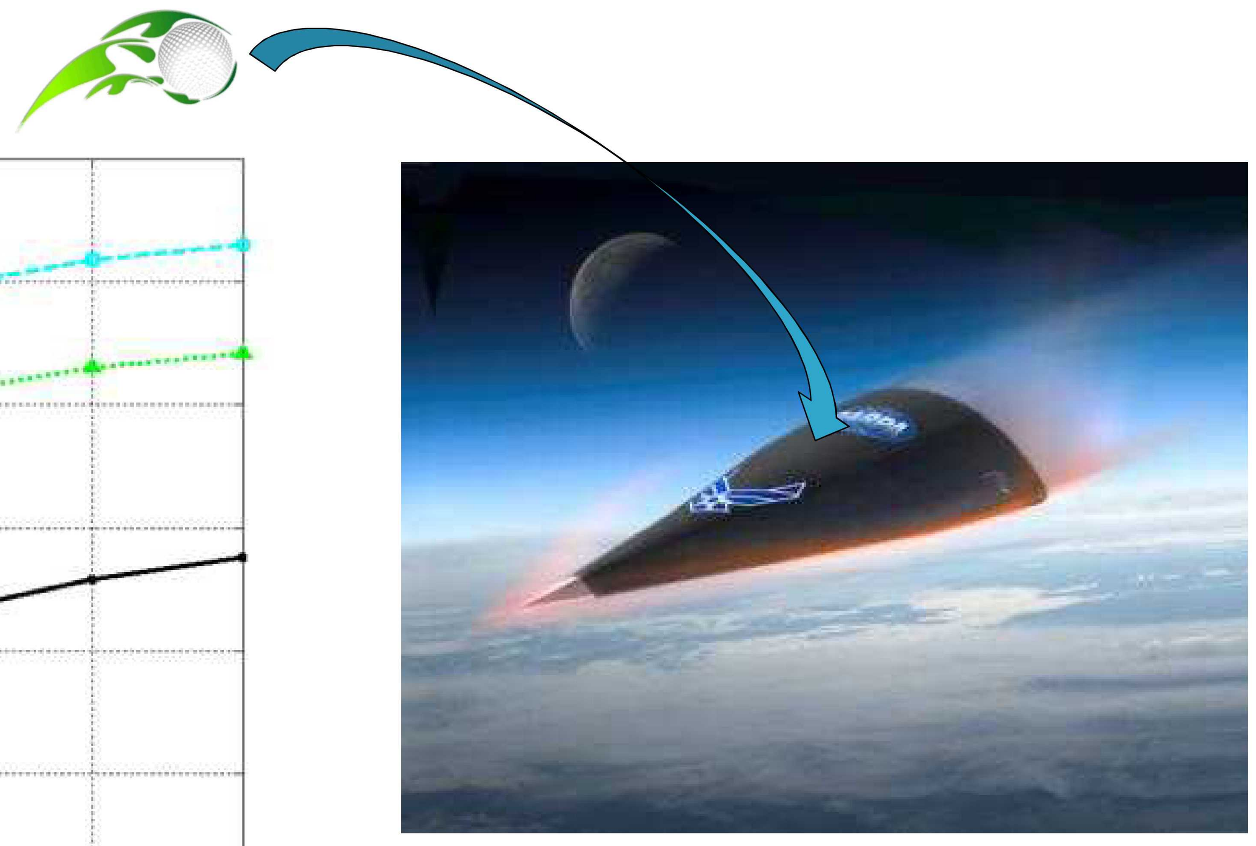
Momentum, energy, and structural Multiphysics analysis of a nuclear fuel bundle.

Engineered Surfaces

- A dimpled golf ball can travel twice as far than a smooth ball when hit with the same force.
- Dimple modifications improve system performance in aerospace, reentry vehicles, transportation vehicles, microfluidics, energy (solar, wind, and nuclear), waterless power production, turbines, heat exchangers, ships; Any system with turbulent flow.
- Sandia Labs has developed a software that predicts optimal dimpling for any turbulent system for reduced flow drag.
- A side benefit is that the dimpling brings the boundary layer closer to surface, thereby increasing heat transfer.
- Sandia's Right-Size Dimple Evaluator uses a unique set of independent turbulence equations, with input based on the system's specific characteristics.
- The software uses the input to calculate an optimal dimpled pattern for the intended application—thereby eliminating guesswork or design by trial and error.
- Other engineered surfaces include swirled surfaces for enhanced heat transfer, augmented condensation.



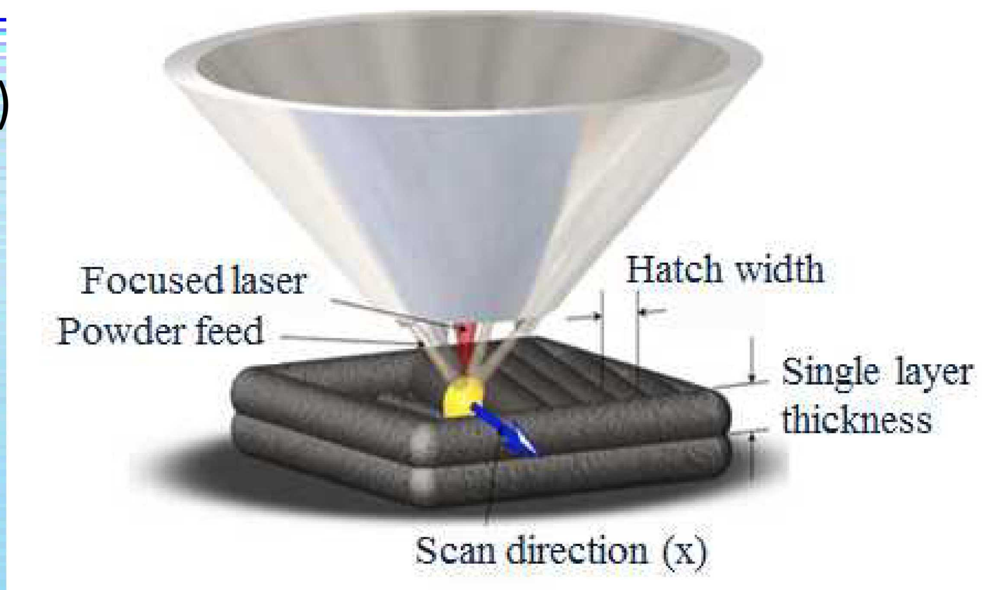
Significant heat transfer increase as a result of right-sized surface dimpling.

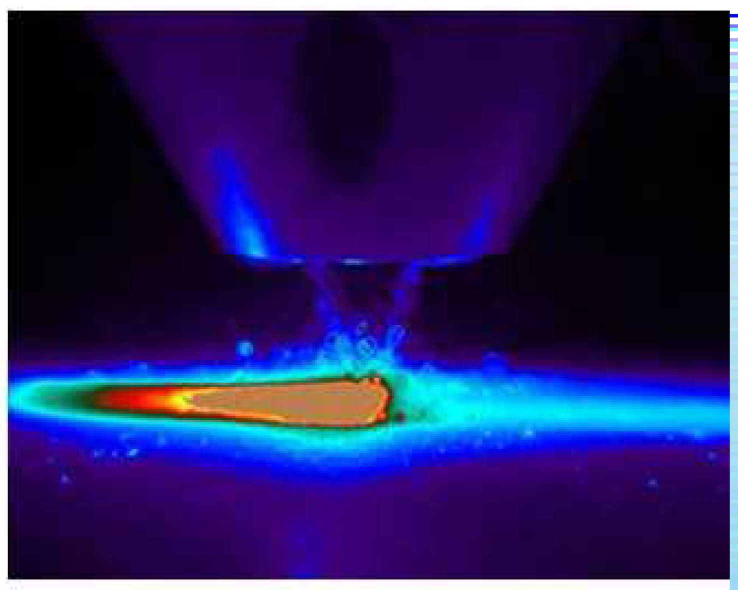


Application of surface dimpling for drag reduction and enhanced heat transfer.

Advanced Reactor Materials

- Refractory high entropy alloys (RHEAs) have superior mechanical properties compared to Inconel 718, Hastelloy, and Ni-Fe alloys. (σ_Y> 7,350 bars at 1,200 °C.)
- RHEAs are ideal for high-temperature, high-pressure, high-radiation, and highly-corrosive environments, as well as weight constraints.
- SNL has extended RHEA thermal and structural properties through rapid cooling rates, thus controlling properties more effectively than conventional metallurgy.
- Provisional Patent Application, 62/747,818, "Soft Ferromagnetic Alloys and Uses Thereof", A. Kustas, Sandia National Labs, S149009/SD14553.0, 2018.
- "Refractory High Entropy Alloy Compact Heat Exchangers", SD# 14916, Sandia National Labs, 2018. A provisional patent is in process. [Kustas, A., S. Rodriguez, et al., 2018].





Advanced Manufacturing: SNL hybrid laser engineered net shaping (LENS) system.

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