High Temperature Additively Manufactured Monolithic Heat Pipe Radiators

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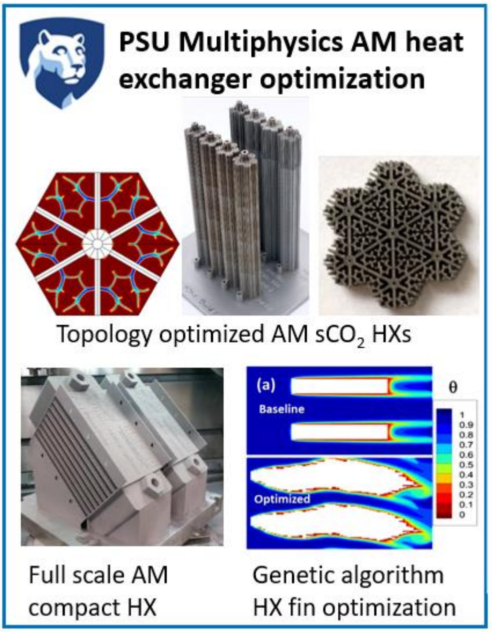
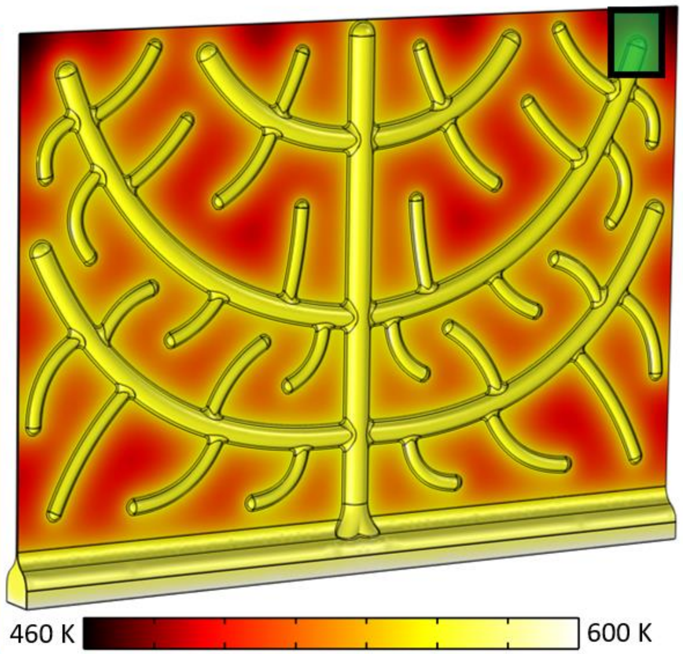
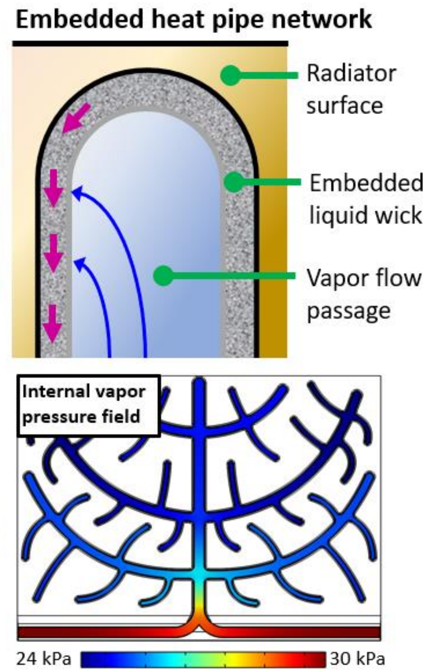
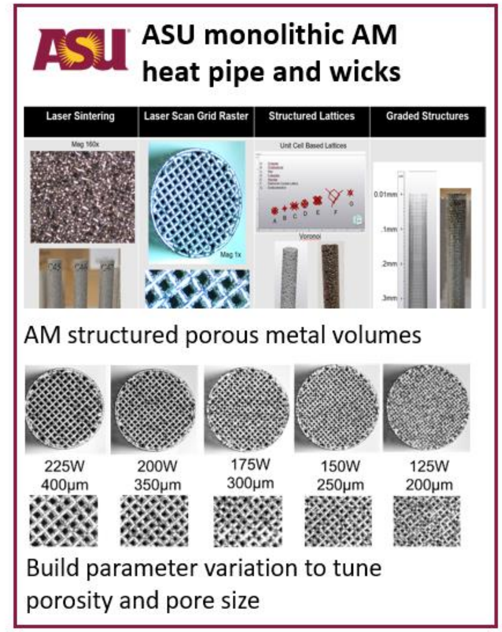
Research Objectives

Goals: Experimentally demonstrate additively manufactured (AM) monolithic heat pipe radiators (HPRs) at laboratory-scale ($\boldsymbol{Q}$ = 100 W) with: T_{in} = 600 K, $\boldsymbol{\rho}$ = 2–3 kg m^{-2}, $\boldsymbol{\eta_f}$ > 70%.
Innovations: Efficient fully integrated heat-pipe radiators • Translation of AM heat pipe processes to high temperature fluids • Multiphysics radiative–thermal–fluid–structural HPR design tools.
Advancement to SOTA: Leverage advances in AM, high temperature heat pipes, and heat exchanger topology optimization to achieve novel robust radiators that enable spacecraft nuclear power. Multiphysics design tools will enable radiator optimization for diverse space missions.
Starting TRL 1: AM heat pipes not yet achieved for high temperature fluids, AM monolithic HPR concept feasibility based on original simulations
Ending TRL 3: $\boldsymbol{\rho}$ = 2–3 kg m^{-2} AM HPR demonstration in relevant thermal vacuum environment









Leveraging PSU heat exchanger optimization and ASU AM wicking structure expertise in radiator development to enable nuclear power and propulsion

Approach

1. Identification of HPR technical requirements
2. Adaptation of AM heat pipe technology to high temperature working fluids. Baseline HPR specimen fabrication.
3. Development of open-source multiphysics design and optimization tools for high temperature HPRs.
4. Construct high temperature radiator test stand for thermal vacuum testing. Characterize baseline HPR specimen.
5. Collaboratively refine HPR design through two design–analysis cycles (DACs) to meet technical performance targets.
6. Disseminate research findings and techniques. Form partnerships for next-step technology development.

Impact

- Demonstration of high performance radiator technology that can enable emerging spacecraft nuclear power and propulsion technologies
- Advancement of additive manufacturing knowledge for spacecraft thermal management
- Development and public release of open-source multiphysics radiator design and optimization tools for diverse aerospace applications