National Aeronautics and Space Administration

FY23 Strategic University Research Partnership (SURP)

3D Printed Heat Exchangers with Creative Internal Patterns

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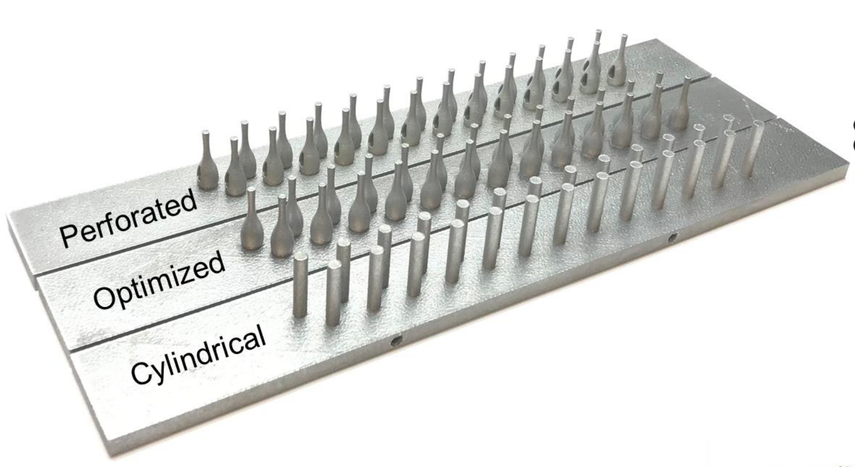
Objectives: Experimentally investigate the flow and temperature fields formed in optimally designed 3D printed heat sinks with creatively designed internal patterns for Mechanically Pumped Fluid Loops (MPFL).

Background: Utilizing the technology of 3D printing, specifically Laser Power Bed Fusion (LPBF), to expand the design freedom of heat sink surface geometry and improve manufacturing lead times while reducing labor costs by streamlining the intricacies inherent in the manufacturing process.

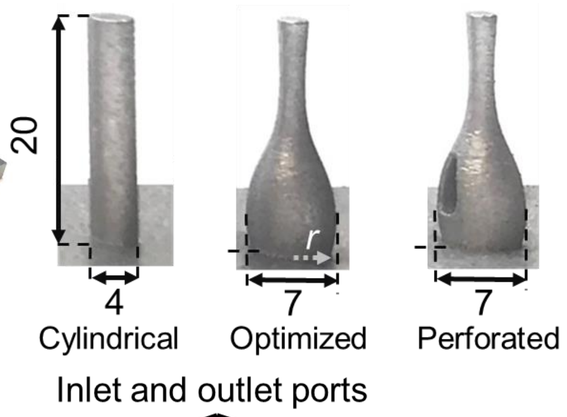
Approach and Results: Laser-induced Fluorescence (LIF) and Particle Image Velocimetry (PIV) visualized the flow and temperature fields in 3D printed finned channels. An intense thermal and flow mixing phenomenon of the working fluid is observed when using perforated and optimized fins.

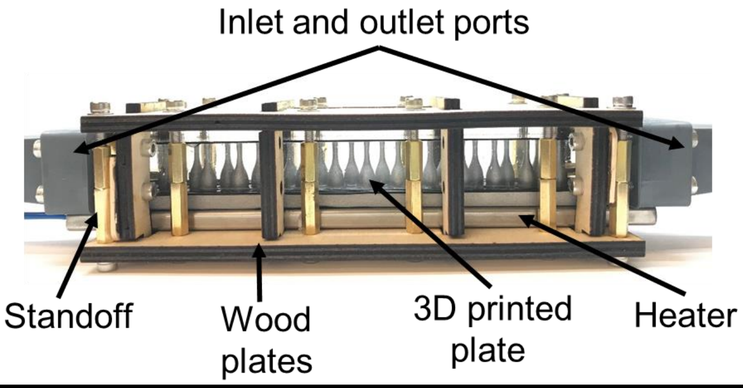
Significance/Benefits to JPL and NASA: MPFL is used on the Mars Science Lab (MSL), M2020 Landers, and the upcoming Europa Clipper mission to reject heat during the cruise stage and maintain the electronics' temperature within allowable flight temperatures.

Additively Manufactured Finned Heat Sink



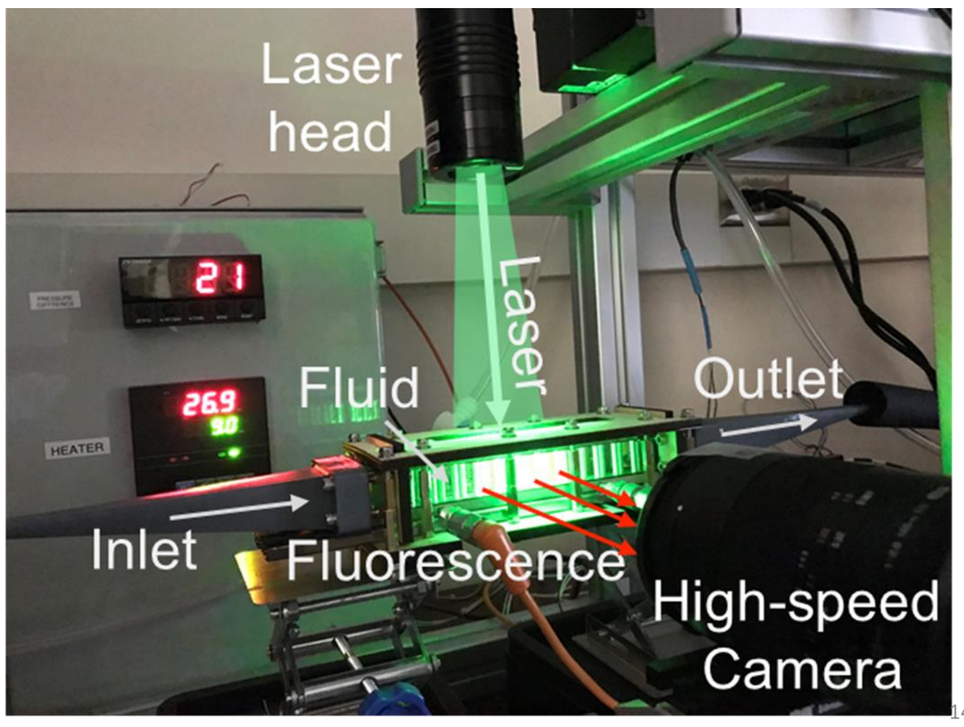
Unit: mm



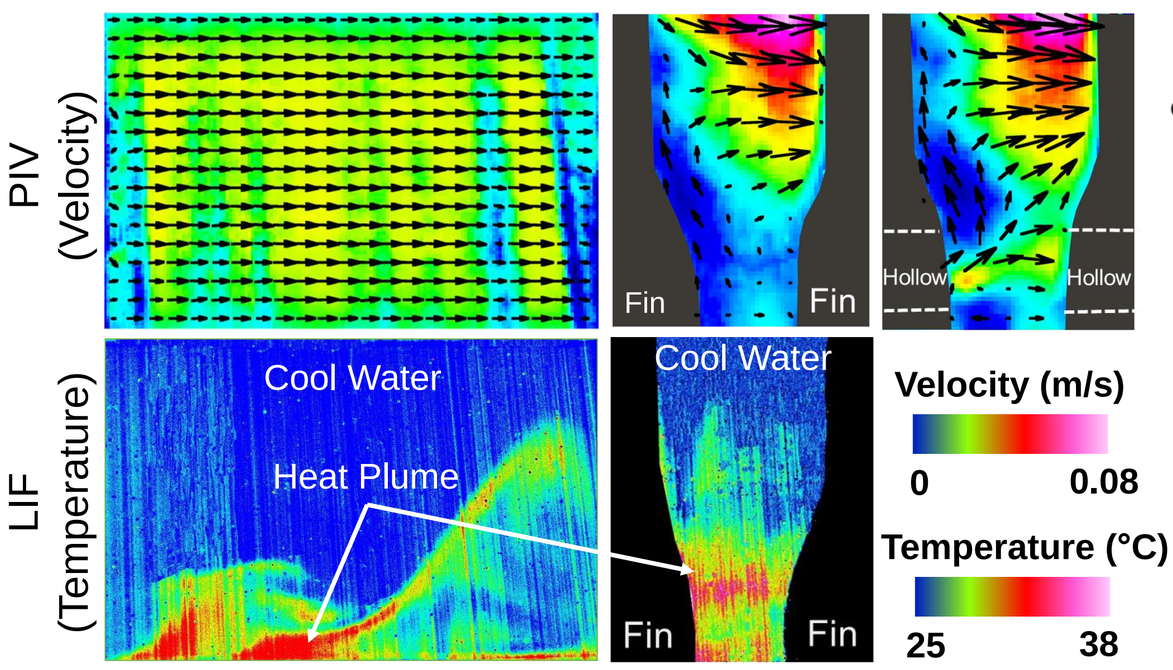


- Powder bed fusion of Al6061-RAM2
- Thermal conductivity: 162 W/m·K
- Young's modulus: 76 GPa
- Tensile strength: 331 MPa

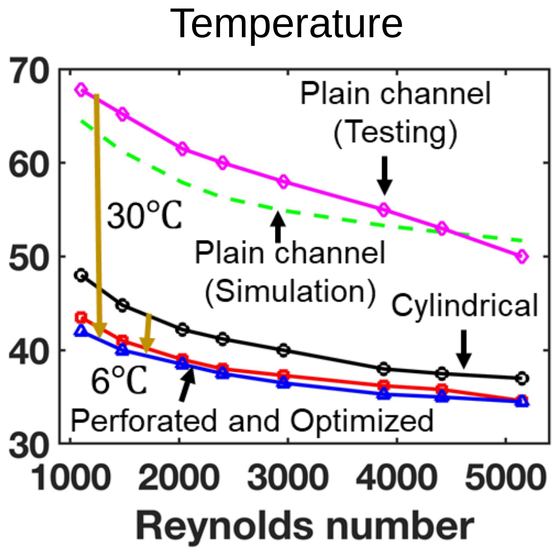
PIV and LIF Facility

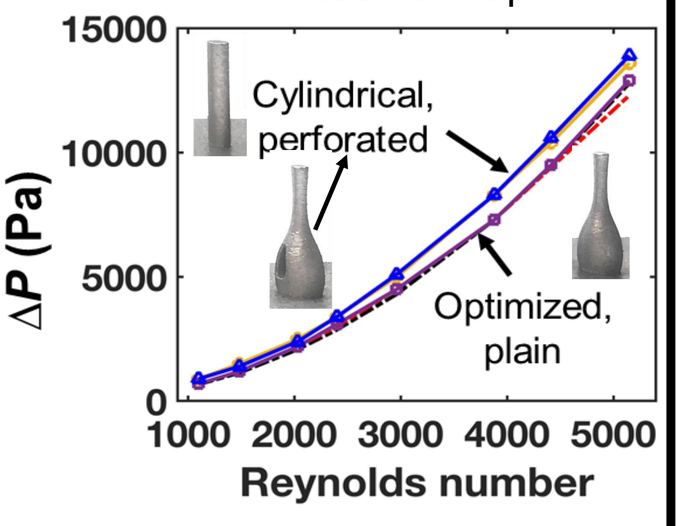


PIV and LIF Images within Channels at Re = 1100



Testing Thermal and Hydraulic Performance Results





- Perforated and optimized fins reduce T_{base} by up to 6°C compared to cylindrical fins, thanks to the effectively extended heat transfer area and more intense flow mixing.
- Perforated, optimized, and cylindrical fins exhibit similar ΔP.

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Publications:
Nam Phuong Nguyen, Elham Maghsoudi, Scott N. Roberts, and Beomjin Kwon, "Understanding Heat Transfer and Flow Characteristics of Additively Manufactured Pin Fin Arrays through Laser-Induced Fluorescence and Particle Image Velocimetry" *in preparation*

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