National Aeronautics and Space Administration

3D Printed Heat Exchangers with Creative Internal Patterns

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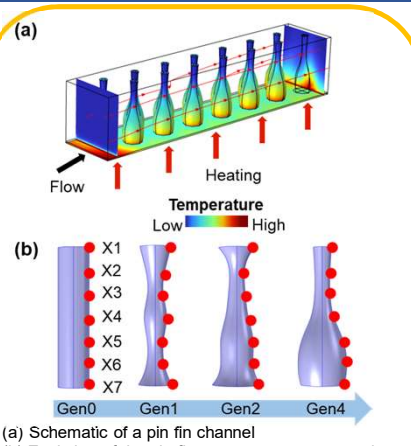
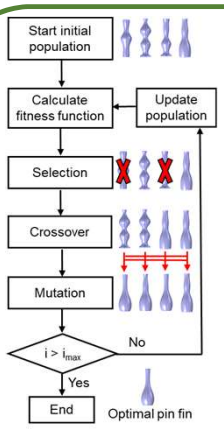
Program: FY22 SURP
Strategic Focus Area: Thermal control systems

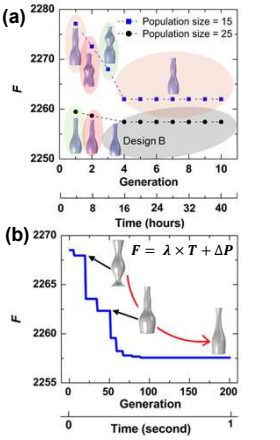
- **Objectives:** Develop 3D printed heat exchangers with creative internal patterns for Mechanically Pumped Fluid Loops (MPFL).
- **Background:** Leveraging 3D printing techniques like ultrasonic additive manufacturing (UAM) for enhancing time efficiency as well as reducing labor cost and complexity in manufacturing.
- **Approach and Results:** Optimization with genetic algorithm (GA) and machine learning (ML). Increase the heat rejection performance to pressure drop by a factor of 3 while reducing the weight greater than 20%. ML reduces optimization time from 40 hours to 1 second.
- **Significance/Benefits to JPL and NASA:** MPFL used on Mars Science Lab (MSL), and M2020 Landers, and upcoming Europa Clipper mission to reject heat during the cruise stage and maintain the electronics temperature within allowable flight temperatures.



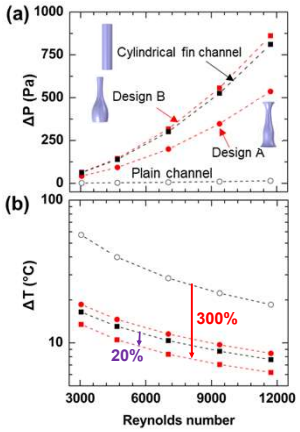
(a) Schematic of a pin fin channel
(b) Evolution of the pin fin geometry over generations



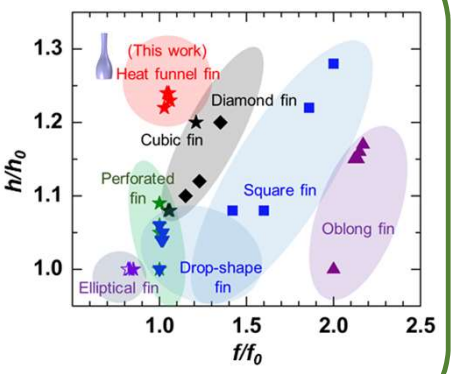
Flowchart of the genetic algorithm optimization



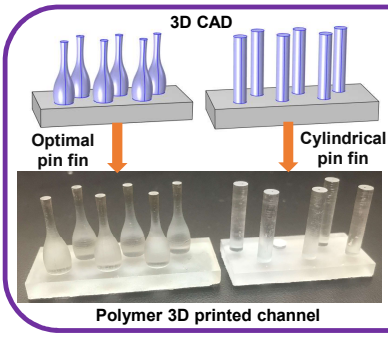
Optimization by (a) numerical simulation and (b) machine learning



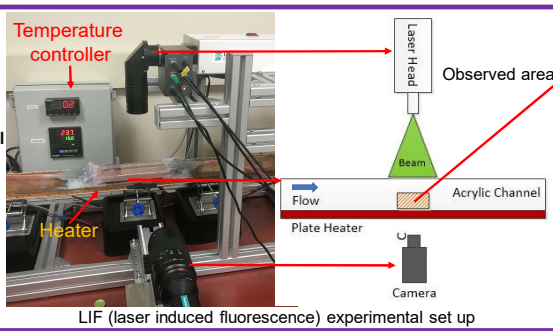
(a) Pressure drop and (b) increase of the heated surface temperature



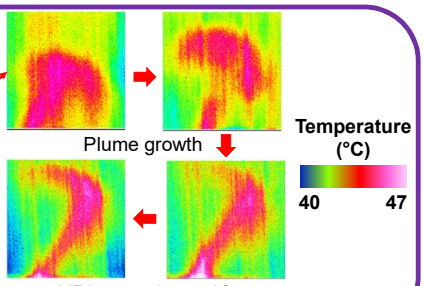
Comparison with previous publications



Polymer 3D printed channel



LIF (laser induced fluorescence) experimental set up



LIF images observed for mix convection heat transfer

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Publications:

Nam Phuong Nguyen, Elham Maghsoudi, Scott N. Roberts, and Beomjin Kwon, "Shape Optimization of Pin Fin Array in a Cooling Channel Using Genetic Algorithm and Machine Learning," under review at *International Journal of Heat and Mass Transfer*.

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