Microchannel Thermal Management Analysis and Simulation Tool for Integration into Electronic Component Design

by

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ABSTRACT

This study focuses on the use of microchannel cold plates as a thermal management solution. The goal of the study was to build the Microchannel Simulation Library Tool (MSLT), which allows cold plate designers to analyze possible solutions to electronic component cooling. The MSLT relies on a library of geometries built in the Star-CCM+ software suite, but pulls the user interaction level to a Matlab interface for ease of access to said library and implementation by designers.

Four basic geometries are included that have been shown to provide cooling enhancement to cold plates: straight microchannels, zig-zagged microchannels, straight microchannels with cavities, and oblique pin fins. Geometric parameters including channel width, length and depth as well as cold plate and working fluid material properties are variable from the Matlab user interface level. Pre-processing to ensure viable geometries and the generation of a Java script to dictate run parameters of the simulation sweeps are completed within Matlab prior to Star-CCM+ running simulations through its Design Manager tool. The data is then retrieved and post-processed from Matlab to generate performance metrics for use.

The straight microchannel simulation set-up was validated against published experimental data with temperature trends and pressure drop analyzed.

Trend analysis was conducted for the geometric features showing the relationship between performance in terms of maximum cold plate temperature and channel width, as well as the impact that it has on pressure drop across the cold plate. Generally, results show that smaller channels provide better performance in the form of lower maximum cold plate temperatures but at the cost of a higher pressure drop. Additionally, features that enhance flow redirection and mixing also cause lower maximum cold plate temperatures at the cost of higher pressure drops.

The MSLT can be used by cold plate designers to simply and cheaply generate modeling of a wide range of microchannel cold plate solutions. This ease of solution analysis allows for integration of thermal management into component design rather than a problem to be solved later. This is especially useful in the case of heat generating components in the developmental stages of the design process with potentially changing conditions.

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