Fluid Management of Advanced Hot Reservoir Variable Conductance Heat Pipes

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The next generation of Lunar rovers and landers requires variable thermal links to maintain payload temperatures nearly constant over wide sink temperature fluctuations.  It has been demonstrated on earth that a hot reservoir variable conductance heat pipe (VCHP) can provide a much tighter passive thermal control capability compared to a conventional VCHP with cold-biased reservoir. However, previous ISS test results revealed that the fluid management of a hot reservoir VCHP needs to be improved to ensure its long-term reliability. Under an STTR Phase I program, Advanced Cooling Technologies, Inc. in collaboration with Case Western Reserve University performed fundamental research to understand the complex transport phenomena within a hot reservoir VCHP. A novel loop VCHP configuration was developed during the program. This loop design allows a net flow to be induced and circulate along the NCG tubing system, which will continuously remove the excessive working fluid from the reservoir (i.e. purging) in a much faster rate compared to diffusion alone. Two potential mechanisms to induce net transport flow were identified:

1. By momentum transfer from vapor to NCG through shearing in the condenser/front region.
2. By filtering the pulses (via a tesla/check valve) generated in the heat pipe section of VCHP loop.

This paper presents the work performed in Phase I to proof the existence of momentum transfer flow (mechanism #1) and its effectiveness on VCHP purging. The work includes theoretical analysis, numerical modeling, prototype development and experimental demonstration.

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