Introduction to Oscillating Heat Pipes’

Construction, Operation and Applications

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# Abstract

Oscillating Heat Pipes (OHPs) or Pulsating Heat Pipes (PHPs) have unique attributes when compared to other wick-based or gravity-driven two-phase heat transfer technologies. Accordingly, OHPs have unique operating capabilities as well as distinct limits of operation. Significant advancements in OHPs’ methods of construction, predictive modeling, and on-ground as well as on-orbit testing have helped transition this technology into aerospace, defense and commercial thermal management applications. Ongoing research and product development is underway to increase OHPs’ utility in a wide range of thermal-mechanical end uses from microelectronics to cryogenics to nuclear reactors.

This presentation will first introduce OHPs’ methods of construction and mechanical features. An overview of the process includes: forming microchannels into a characteristic meandering pattern within a channel body material; hermetically bonding such channel body to lid or lids; then rendering the bonded assembly into a final form factor; next is the cleaning, evacuating and partially filling/sealing of the microchannel volume with working fluid; and, finally, inspection and acceptance testing. A short discussion of proven OHP material-fluid pairs and available OHP shapes and sizes will conclude this section.

Second, a brief discussion with visual aids will be provided to describe the heat transfer mechanisms and operating conditions that cause OHPs’ (i) start-up of the working fluid’s two-phase flow within the microchannel pattern; (ii) sustain the fluid’s two-phase flow and heat transfer; and (iii) partial or complete shut-down of such two-phase flow. Quick review of the Drolen, Smoot2 limits of operation model will be provided as well as a discussion of OHPs unique capabilities with respect to: (i) operation in adverse gravitational orientations; (ii) sustaining flow under extreme input heat fluxes; and (iii) heat transfer through thin, 3D pathways.

Finally, a cursory review of OHP hardware demonstrated for aerospace, defense and commercial applications will complete the presentation. End uses for OHPs to be discussed include: (i) conduction cooling of circuit card assemblies and their temperature-sensitive electronic devices; (ii) heat spreaders for transforming relatively high input heat fluxes into lower heat fluxes at rejection sites – and doing so with minimal thickness or temperature rise; and (iii) meter-scale heat transporters or radiators for platform-level thermal control.