

Non-Integrated Hot-Reservoir Variable Conductance Heat Pipes for Lunar Surface Applications C. Tarau¹, J. Diebold¹, J. Smay¹, T. Hahn¹ and R. Spangler¹, ¹Advanced Cooling Technologies, Inc., Lancaster, PA

Introduction: As NASA prepares to further expand human and robotic presence in space, it is well known that spacecraft architectures will be impacted by unprecedented power requirements and extreme thermal environments. Thermal management systems need to reject large heat loads into hot environments and have high heat rejection turn-down ratios in order to minimize vehicle power needs during periods of darkness, such as the 14-day lunar night. Variable conductance heat pipes (VCHP) are capable of passively transporting large quantities of heat and provide high thermal turn-down ratios ideal for surviving extreme cold environments. In this work, Advanced Cooling Technologies, Inc. (ACT) will discuss the design and performance of two unique non-integrated warm reservoir VCHPs designed for application on the lunar surface.

Non-Integrated Hot-Reservoir VCHPs: The first VCHP is flight hardware designed to fly onboard Astrobotic Technology's lunar lander Peregrine. The Astrobotic VCHP is designed to operate during transit and on the lunar surface and utilizes a hybrid wick design. The evaporator wick was 3D printed while the adiabatic and condenser sections utilized grooved wicks with high permeability optimum for operation in a microgravity environment.

The second VCHP was designed for NASA's lunar rover VIPER. A unique feature of the VIPER VCHP was the flexible adiabatic section. In order to accommodate relative motion between the heat spreader panel and the radiator panel, due to launch induced vibrations, nested flexible lines for the VCHP envelope and internal non-condensable gas (NCG) tube were used in the adiabatic section.

Both VCHPs utilized a non-integrated warm reservoir of non-condensable gas. The non-integrated reservoirs provided high thermal turn-down ratios and the ability to independently heat the reservoir in order to purge working fluid increasing the reliability of the device. While hot-reservoir VCHPs offer superior passive thermal control compared to cold-reservoir VCHPs, over time their performance can be degraded due to the migration of working fluid into the reservoir. The partial pressure of superheated vapor in the hot reservoir displaces NCG from the reservoir resulting in a higher nominal operating temperature for the heat pipe. If the reservoir is not integrated with the evaporator (separated from the evaporator), then during periods of non-operation an independent heater can be applied to the reservoir in order to purge the working

fluid from the reservoir and restore normal operation. This is critical to ensure long-term reliability of the hot-reservoir VCHP.

Description of Work to Be Presented: This work will begin with a detailed description of the design and manufacturing of the two non-integrated hot-reservoir VCHPs. This will be followed by a discussion of the performance of both devices. Experiments were conducted to demonstrate the startup process and the temperature control capability of each VCHP. Results from thermal control experiments were used to calculate the conductance and thermal turndown ratio of both devices. Finally, experiments were conducted to demonstrate the ability to purge working fluid from the non-integrated reservoir.

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