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Design and Operation of a Cryogenic Nitrogen Pulsating Heat Pipe

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We report test results using an innovative passive cooling system called a "Pulsating Heat Pipe" (PHP) operating at temperatures ranging from 77 K to 80 K and using nitrogen as the working fluid. PHPs, which transfer heat by two phase flow mechanisms through a closed loop tubing have the main advantage that no electrical pumps are needed to drive the fluid flow. In addition, PHPs have an advantage over copper straps and thermal conductors since they are lighter in weight, exhibit lower temperature gradients and have higher heat transfer rates. PHPs consist of an evaporator section, thermally anchored to a solid, where heat is received at the saturation temperature where the liquid portion of the two-phase flow evaporates, and a condenser where heat is rejected at the saturation temperature where the vapor is condensed. The condenser section has been thermally interfaced to a CT cryocooler from SunPower, with a cooling capacity of 10 W at 77 K. Alternating regions of liquid slugs and small vapor plugs fill the capillary tubing, with the vapor regions contracting in the condenser section and expanding in the evaporator section due to an electric heater that will generate heat loads up to 10 W. This volumetric expansion and contraction provides the oscillatory flow of the fluid throughout the capillary tubing thereby transferring heat from one end to the other. The thermal performance and temperature characteristics of the PHP will be correlated as a function of average condenser temperature, PHP fill liquid ratio, and evaporator heat load. The experiment is also operated at different inclination angles in order to investigate whether Earth's gravitational force has a significant effect on its efficiency.

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