

Loop Heat Pipe With Thermal Control Valve as a Variable Thermal Link

New arrangement reduces energy demands while maintaining circuits and batteries within optimal temperature range.

Marshall Space Flight Center, Alabama

Future lunar landers and rovers will require variable thermal links that allow for heat rejection during the lunar daytime and passively prevent heat rejection during the lunar night. During the lunar day, the thermal management system must reject the waste heat from the electronics and batteries to maintain them below the maximum acceptable temperature. During the lunar night, the heat rejection system must either be shut down or significant amounts of guard heat must be added to keep the electronics and batteries above the minimum acceptable temperature. Since guard heater power is unfavorable because it adds to system size and complexity, a variable thermal link is preferred to limit heat removal from the electronics and batteries during the long lunar night. Conventional loop heat pipes (LHPs) can provide the required variable thermal conductance, but they still consume electrical power to shut down the heat transfer. This innovation adds a thermal control valve (TCV) and a bypass line to a conventional LHP that proportionally allows vapor to flow back into the compensation chamber of the LHP. The addition of this valve can achieve completely passive thermal control of the LHP, eliminating the need for guard heaters and complex controls.

A schematic of the system is shown in Figures 1 and 2 for operation during the Lunar day and night, respectively. During the Lunar day, maximum vapor flow to the radiator is desired for efficient operation. In the example shown, 95% of the vapor flows through the radiator and 5% flows through the bypass line. In contrast to the Lunar day, the thermal link must be as ineffective as possible during the Lunar night (see Figure 2). As the temperature of the TCV drops, more and more of the vapor is directed directly back into the compensation chamber, gradually shutting down the LHP.

Previous LHPs with a TCV have the bypass vapor flow directly mix with the liquid return line. In this arrangement, the vapor and liquid flows will interact with each other, possibly causing flow instabilities as the two streams come to the thermodynamic equilibrium. A LHP incorporating a passive TCV and bypass line proportionally allows vapor to flow back into the compensation chamber, minimizing flow instabilities experienced in previous LHPs with TCVs by allowing mixing of the vapor and liquid in the relatively large volume of the compensation chamber.

This work was done by John Hartenstine, William G. Anderson, Kara Walker, and Pete Dussinger of Advanced Cooling Technologies, Inc. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32915-1.

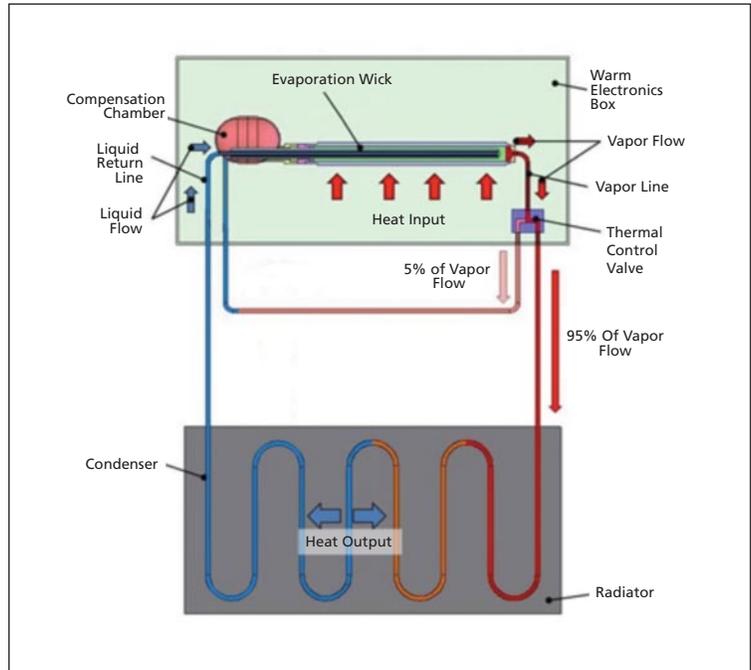


Figure 2. Variable Conductance Loop Heat Pipe schematic during the Lunar night. Most of the vapor flows directly back into the compensation chamber, shutting down the LHP. The 95% and 5% flow rates are representative.

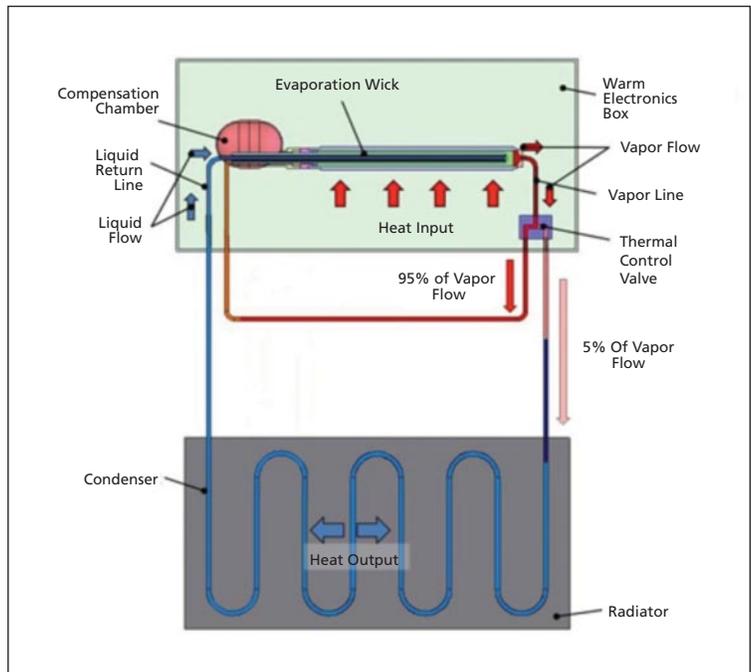


Figure 1. Variable Conductance Loop Heat Pipe schematic during the Lunar day. Most of the vapor flows through the radiator. The 5% and 95% flow rates are representative.