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# Experimental investigation on the thermal performance of helium based cryogenic pulsating heat pipe

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## ABSTRACT

An experimental investigation was conducted to study the thermal performance of a cryogenic pulsating heat pipe (PHP) filled with helium in terms of thermal resistance, effective thermal conductivity and the maximum transferred power. The stainless steel helium PHP in this paper with an inner diameter of 0.5 mm was bent to 8 parallel channels, and the lengths of the evaporator, condenser, and adiabatic section were 50mm, 50mm, and 100mm, respectively. A mechanical-thermal switch worked as a novel pre-cooling system for the helium PHP was developed, which was on during the pre-cooling process and off during the test process. Tests were performed with different heat power, tilt angle and liquid filling ratio. For the helium PHP at +30° with a liquid filling ratio of 70.8%, the effective thermal conductivity was 4800-13000 W/m·K, which was higher than that of copper. With the increment of heat power, the thermal resistance decreased at first and then increased, while the effective thermal conductivities were the opposite. The effective thermal conductivity and the maximum transferred power increased with the increment of the tilt angle. In addition, the helium PHP possessed the optimal liquid filling ratio which could make the maximum thermal conducting effectivity, and the optimal liquid filling ratio changed with the heat power. The optimal liquid ratio, by its very nature, meant reasonable proportion of sensible and latent heat.

Keywords:

Helium pulsating heat pipe

Pre-cooling system

Thermal performance

Tilt angle

Liquid filling ratio

## Nomenclature

$\sigma$	surface tension (kg s <sup>-2</sup> )
$\rho_l$	liquid density (kg m <sup>-3</sup> )
$\rho_v$	vapor density (kg m <sup>-3</sup> )
$g$	gravitational acceleration (m s <sup>-2</sup> )
$D_{crit}$	critical diameter of the capillary tube (m)
LFR	liquid filling ratio (%)
$P_{1*}$	pressure of buffer tank after charge helium gas (pa)
$P_1$	pressure of buffer tank before charge helium gas (pa)
$V_1$	volume of the buffer tank (m <sup>3</sup> )
$T_1$	temperature of the buffer tank (K)
$V_{PHP}$	volume of the PHP (m <sup>3</sup> )
$R$	gas constant
$\lambda$	effective thermal conductivity (W m <sup>-1</sup> ·K <sup>-1</sup> )
$R_t$	thermal resistance
$Q$	heat load added to evaporator by the heater (W)

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