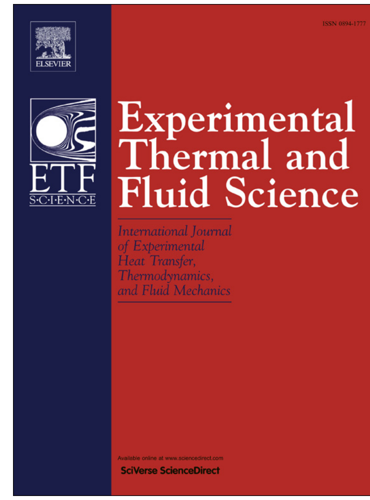
Accepted Manuscript



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

Dong Xu, Laifeng Li, Huiming Liu

PII: S0894-1777(15)00236-8
DOI: http://dx.doi.org/10.1016/j.expthermflusci.2015.08.024
Reference: ETF 8558

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 23 March 2015
Revised Date: 29 July 2015
Accepted Date: 18 August 2015

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

Dong Xu, Laifeng Li*, Huiming Liu

Key Laboratory of Cryogenics, Technical Institute of Physics and Chemistry, Chinese Academy of Sciences

ABSTRCAT

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 +30º 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

σ	surface tension (kg s^{-2})
ρ_l	liquid density (kg m^{-3})
ρ_v	vapor density (kg m^{-3})
g	gravitational acceleration (m s^{-2})
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^3)
T_1	temperature of the buffer tank (K)
V_{PHP}	volume of the PHP (m^3)
R	gas constant
λ	effective thermal conductivity (W m^{-1}·K^{-1})
R_t	thermal resistance
Q	heat load added to evaporator by the heater (W)