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Literature Review on Close Loop Pulsating Heat Pipe at Different Filling Ratio

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ABSTRACT

Pulsating Heat Pipes (PHPs) have high heat spreading performance and square measure capable of removing higher heat fluxes. A closed loop pulsating heat pipe is a self-excited driven two phase passive heat transfer device, which transfer heat from one location to another location with a negligible temperature drop. Its operation depends on the phase change of a working fluid within the loop. This research investigates the effect of concentrate on of water based zinc oxide nanofluid (i.e. ZnO/water) on thermal resistance of closed loop pulsating heat pipe. CLPHP is created of copper tubing with internal diameter of 3mm and outer diameter of 4mm. The tube had 2 meandering turns. The length of evaporator and condenser section is 360mm. The experiment is conducted on vertical orientations for different heat loads varying from 10 W to 100 W. The concentration of ZnO/water nanofluid is 0.25%, 0.5%, 0.75% and 1%. The various temperatures were recorded on the outer wall of evaporator and condenser section and inlet & outlet of cooling water. It is found that thermal resistance of CLPHP using ZnO/water nanofluid as working fluid is better than thermal resistance when pure water is used.

Keywords: Pulsating Heat Pipe, Closed Loop, oscillation, filling ratio

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I. INTRODUCTION

Oscillating, loop type or pulsating heat pipes (PHPs) are a comparatively new form of heat transfer devices, which can be classified in a special category of heat pipe. They have been introduced in the mid-1990s. The basic structure of a typical pulsating heat pipe consists of meandering capillary tubes having no internal wick structure. It can be designed in at least three ways: (i) open loop system (ii) closed loop system (iii) closed loop pulsating heat pipe (CLPHP).

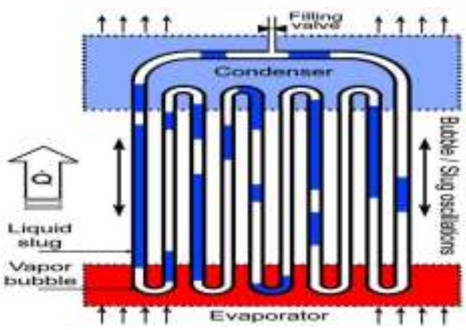

Fig. 1 Pulsating Heat pipe

Initially, the PHP is evacuated and then partially filled with the operating fluid. Effects from physical phenomenon cause the formation of liquid slugs interspersed with vapour bubbles. As heat is applied to the evaporate section, the operating fluid begins to evaporate. These leads to a rise pressure within the tube that causes the bubbles within the evaporator zone to grow and pushes the liquid towards the condenser. As the condenser cools, the vapour pressure reduces and condensation of bubbles happens. This method between the evaporator and condenser section is continuous and results in an periodic motion within the tube. Heat is transferred through latent heat of the vapour and sensible heat transported by the liquid slugs. When one end of the bundle of turns of the undulating tube is subjected to high temperature, the working fluid within evaporates and will increases the vapour pressure, which causes the bubbles in the evaporator zone to grow. This pushes the liquid column toward the low temperature end (condenser). The condensation at the coldness finish can additional end increase the pressure difference distiction the two ends. As a result of the interconnection of the tubes, motion of liquid slugs and vapour bubbles at one section of the tube toward the condenser conjointly ends up in the motion of slugs and bubbles within the next section toward the high temperature end (evaporator). This works as a result of the restoring force.

II. LITERATURE SURVEY

Pramod R. Pachghare et al [1]. In 2013, investigate impact of pure and binary fluids on closed loop system pulsating heat pipe thermal performance using copper tube having internal and external diameter with 2.0 mm and 3.6 mm respectively. For all experimentation, filling magnitude relation ratio (FR) was 50 %, ten turns and totally different heat inputs of 10 to 100W was supplied to PHP. The position of the PHP is to be vertical bottom heat mode. The equal length of evaporator, adiabatic and condenser section was maintained 50 mm. Operating fluids are selected as Methanol, ethanol, acetone, water and totally different binary mixtures. So as to check, characteristics of the thermal resistance and average evaporator temperatures at different heat input for various working fluids. And investigate that A PHP of water-methanol binary mixture offers good thermal performance over other working fluids. And For the pure operating fluids PHP, the sequence of the thermal resistances is acetone, methanol, ethanol and water from tiny to massive. Whereas in binary mixture operating fluid PHPs, the sequence of the thermal resistances is water-methanol, water-acetone and water-ethanol from tiny to massive. In this PHP, pure acetone gives best thermal performance in comparisons with the opposite pure and binary mixtures operating fluid. No measurable distinction has been recorded between the PHP running with pure and binary mixture operating fluids, in terms of overall thermal resistance.

Himel Barua et al [2]. In 2013, investigate on Effect of filling ratio on heat transfer characteristics and performance of a closed loop pulsating heat pipe. Experiments are conducted on a CLPHP made from capillary tubing of 2.2mm inner diameter. The heat transfer characteristics and the performance of the CLPHP are investigated for filling ratios of 100 %, 82.5%, 63%, 41.3% and 28%. The results indicate that the performance of this device changes with the ever-changing of operating fluid, filling ratios and heat input and conclude that For water, each at lower and higher heat input, lower filling magnitude relation shows less thermal resistance and optimum heat transfer is obtained at nearly 30% filling ratio. For ethanol, at low heat input, the simplest performance is obtained at high filling ratio beyond 50% in the basis of heat transfer.

V.K. Karthikeyan et al [3]. In 2014, conducted an experiment to analyses the result of nano-fluids on the closed loop pulsating heat pipe (CLPHP) performance using copper and silver colloidal nano-fluids. An experimental program has been carried out on the thermal performance of the CLPHP with completely different operating fluids (DI water, copper and silver mixture nano-fluids). The thermal performance of the device has been investigated with variable heat power within the range of 50–240 W, for different operating fluids within the vertical orientation. The general thermal resistance and effective thermal conductivity are evaluated to predict the thermal performance of the device. Experimental results show that the nano-fluid gives the heat transfer limit more by 33.3% and have lower evaporator wall temperature compared to DI water.

Rudresha S. et al [4]. In 2014, use SiO2 /DI water and Al2O3/DI water nano-fluid. This served as the working nano-fluids with concentrations by different mass 10g/lit, 20g/lit, 30g/lit in heat pipe. The heat pipe is unreal by a straight copper tube with an outer diameter 3mm, thickness 1mm and length of 1785mm. Experiment is carried out for various performing parameters by varied totally different heat inputs additionally as nano-fluids concentration as sio2/di water and Al2O3/DI water. Experimental results show that at a heating power of 10w, 14w, 18w, 22w and thermal resistance, thermal heat transfer co-efficient, thermal conductivity and efficiency for CLPHP SiO2/DI water & Al2O3/DI water heat pipe are 69.37%, 75.99% and 11.98% DI water severally, which are better than that of pipes using DI water as a result of the operative nano-fluids.

Jian Qu et al [5]. In 2010, investigated the thermal performance of an oscillating heat pipe (OHP) charged with base water and spherical Al2O3 particles of 56 nm in diameter. The results of filling ratios, mass fractions of alumina particles, and power inputs on the full thermal resistance of the OHP were investigated. Experimental results showed that the alumina nano-fluids considerably improved the thermal performance of the OHP, with an optimal mass fraction of 0.9 wt % for maximal heat transfer improvement. Compared with pure water, the maximal thermal resistance was decreased by 0.14^{0}C/W (or 32.5%) once the ability input was 58.8Watt 70% filling ratio and 0.9% mass fraction.

Dharmapal A Baitule, et al, [6] conducted a transient and steady state experiments are conducted on a two turn closed loop PHP. Copper is used as the capillary tubing material within the evaporator and condenser sections with inner diameter of 2 mm and outer diameter of 3 mm. The total length of the closed loop pulsating heat pipe is 1080 mm. The evaporator and condenser sections are 360 mm and 280 mm severally. The experiments are conducted on vertical orientations for various heat loads varying from 10 W to 100 W in steps of 10 W. The PHP is tested on Ethanol, Methanol, Acetone and Water as operating fluids for various fill ratios from 0% to 100% in steps of 20%. The performance parameters like temperature difference between evaporator and condenser, thermal resistance and the overall heat transfer coefficient are evaluated. The experimental results demonstrate the heat transfer characteristics, lower thermal resistance and higher heat transfer coefficient of PHP are found to be better at a fill ratio of 60% for varied heat input. The thermal resistance of closed loop pulsating heat pipe decrease with the increase of heat input. At the lower heat input ($Q \leq 60$ W) the thermal resistance is decreased slowly and at higher heat input ($Q \leq 60$ W) the difference is smaller. The thermal resistances have the results of Racetone < Rmethanol < Rethanol < Rwater. This condition is occurs up to 48 W and above the

48 W the thermal Resistance of Acetone is increased slightly. The filling ratio is a critical parameter, which needs to be optimized to attain maximum thermal performance and minimum thermal resistance for a given operating condition. From this experimental setup we are conclude that at 60% filling of PHP provide the optimum result.

III. Conclusion

In research papers experimental model was made to analyse the performance of PHP in electronic cooling. The heat transfer rate is increases with increase in inlet temperature where as thermal resistance is decreases with increase in inlet temperature for all filling ratio. The best results are obtained at 75% filling ratio. The maximum value of heat transfer rate at 75% f. R is 6.2 W and thermal resistance is decreases. Among the novel methods for thermal management of the high heat fluxes found in electronic devices, PHPs are most effective for heat removal. Thermal performance of PHP strongly depends on thermo physical properties of operating fluids. ZnO/water nano-fluid PHP gives the better thermal performance than water PHP.

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