PARAMETER STUDY OF PULSATING HEAT PIPE

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ABSTRACT

The Pulsating heat pipe usually known as PHP is an innovative technology that has gained attention in the last five years. This is special type of heat pipe and driving force is the slug/plug motion of the working fluid in the tube, generated by evaporation. This two phase passive devices are proven solutions for modern microelectronics thermal

Management as the increase in performance of electronic components is resulting in higher heat flux dissipation. Moreover Pulsating heat pipe can be used to build heat exchangers to effectively harness most of heat generated in various process industries, nuclear reactors etc. Researches on PHP`s are undergoing towards the definition of design parameters ,influence of the working fluid and geometric characteristics on the PHP thermal behaviour etc.

This report also consists of experimental investigation of heat transfer characteristics and performance of the PHP for different filling ratio. The results indicate that the performance of device changes with changing of working fluid, filling ratio and heat input.

I sincerely hope all my effort put forward in recording this seminar report bears fruitful to my fellow students of the future to guide then in extremely complex and interesting situations.

Keywords: pulsating heat pipes, open and closed loop, heat transfer, electronics cooling.

I. INTRODUCTION

Evolution within the style of warmth pipe- a kind of passive 2 part thermal management device- has accelerated within the past decade because of continuous demands for quicker and smaller electronics systems. As fashionable pc chips and power physics become smaller and additional densely packed the requirement for additional economical cooling systems will increase. The new style of a pc chip Intel, as an example, can turn out localized heat flux over one hundred W/cm2, with the entire power prodigious 300W. additionally to the constraints on most chip temperature, any constraints is also obligatory on the amount of temperature uniformity in electronic elements. Heat pipes square measure a awfully promising technology for achieving high native heat-removal rates and uniform temperatures on pc chips.

True development of standard heat pipes (CHP) began within the 1960s; since then, varied geometries, operating fluids, and wick structures are projected. within the last twenty years, new sorts of heat pipes like capillary tense loops and loop heat pipes were introduced, seeking to separate the liquid and vapour flows to beat sure limitations inherent in standard heat pipes. within the Nineties, Akachi et al fancied a replacement style of heat pipe referred to as the pulsing or oscillatory heat pipe (PHP or OHP). the foremost in style applications of PHP square measure found in physics cooling as a result of it's going to be capable of dissipating the high heat fluxes needed by next generation physics. different projected applications embody victimization PHPs to heat up air or pump water. PHP may also be wont to build device.

Pulsating heat pipes, like standard heat pipes, are closed, two-phase systems capable of transporting heat with none further power input, however they take issue from standard heat Pipes in many major ways in which. A typical PHP could be a little indirect tube that's part stuffed with a operating fluid. The tube is bent back and forth parallel to itself, and also the ends of the tube is also connected to 1 another during a closed-loop system, or pinched off associated welded border an open loop. it's typically united by researchers that the closed-loop PHP has higher heat transfer performance. For this reason, most experimental work is finished with closed-loop system PHPs.

II. HEAT PIPE TECHNOLOGY

The heat pipe may be a device of terribly high thermal electrical phenomenon. the concept of the warmth pipe was initial instructed by Gaugler [1] in 1942. It was. the warmth pipe is comparable in some respects to the thermosyphon and it's useful to explain the operation of the latter before discussing the warmth pipe. The thermosyphon is shown in Fig. la. alittle amount of water is placed in an exceedingly tube from that the air is then exhausted and therefore the tube sealed. The lower finish of the tube is heated inflicting the liquid to vaporise and therefore the vapour to maneuver to the cold finish of the tube wherever it's condensed. The condensation is came back to the recent finish by gravity. Since the heat of transformation of evaporation is giant, hefty quantities of warmth are often transported with a awfully tiny temperature distinction from finish to finish. Thus, the structure also will have a high effective thermal electrical phenomenon. The thermosyphon has been used for several years and varied operating fluids are utilized.

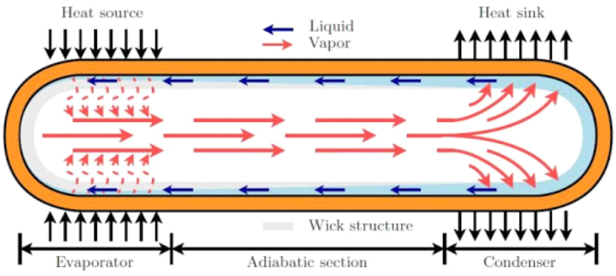

Figure 1.1: Heat Pipe

One limitation of the fundamental thermosyphon is that so as for the condensation to be came back to the evaporator region by gravity, the latter should be located at the bottom purpose. the fundamental heat pipe differs from the thermosyphon in this a wick, made as an example from many layers of fine gauze, is mounted to the within surface and capillary forces come the condensation to the evaporator. within the heat pipe the evaporator position isn't restricted and it should be utilized in any orientation. If, of course, the warmth pipe evaporator happens to be within the lowest position, gravitative forces can assist the capillary forces. The term 'heat pipe' is additionally accustomed describe high thermal electrical phenomenon devices within which the condensation come is achieved by different suggests that. fors example force, electro-hydrodynamics.

III. INFLUENCE PARAMETERS

Looking into the accessible literature, it are often seen that six major thermo-mechanical parameters have emerged because the primary style parameters moving the PHP system dynamics these include:

a. Internal diameter of the PHP tube,

b. Input heat flux to the device,

c. volumetrical filling quantitative relation of the operating fluid,

d. Total range of turns,

e. Device orientation with relevancy gravity, and

f. operating fluid thermo-physical properties.

3.1 Hydraulic Diameter

The internal tube diameter is one in all the parameters that basically outline a PHP. The physical behaviour adheres to the 'pulsating' mode solely below a precise vary of diameters. Theoretical most tolerable inner diameter, D max, of PHP capillary was derived supported the balance of capillary and gravity forces by Akachi and polasek as:

$$D_{max} = 2\sqrt{\frac{\sigma}{g(\rho_l - \rho_{vap})}}$$

Where ρ, g, and p area unit physical phenomenon, attraction acceleration, and density, severally. If D <D gamma hydroxybutyrate physical phenomenon forces tend to dominate and stable liquid slugs area unit fashioned. PHP tube diameter will increase on the far side the D gamma hydroxybutyrate, the physical phenomenon is reduced and every one the operating fluid can tend to stratify by gravity and therefore the heat pipe can stop functioning as a PHP, and therefore the device could operate as AN interconnected array of two-phase thermosyphon.

3.2 Applied Heat Flux

The applied heat flux affects the following:

(a) Internal bubble dynamics, sizes and agglomeration/breaking patterns,

(b) level of perturbations and flow instabilities, and

(c) Flow pattern transition from capillary slug flow to semi-annular and ring-shaped.

PHPs square measure inherently appropriate for prime heat flux operation. Since the input heat provides the pumping power, below a precise level, no oscillations start. just in case of CLPHPs, a simplex current flow has been determined at high heat fluxes. additionally, the flow conjointly gets reworked from periodical slug flow to ring-shaped flow. Once a flow direction is determined, alternating tubes sections become hot and cold (hot fluid flows from evaporation one tube and cold fluid from the condenser flows within the adjacent tube).

3.3 Working Fluid Filling Ratio

Filled quantitative relation is that the fraction (by volume) of the warmth pipe that at first stuffed with liquid .There square measure 2 operational crammed quantitative relation limits. At 1/3 crammed quantitative relation, a heat pipe structure solely vacant tubes and no operating fluid, could be a pure conductivity mode heat transfer device with a really high undesirable thermal resistance. A 100%fully crammed heat pipe is identical operational to one section thermosyphon. The rhythmic result is non-existent however; substantial heat canbe transferred as a result of liquid circulation within the tubes by thermally evoked buoyancy. Thethermosyphon action is most for a vertical heat pipe and stops for a horizontal heat pipe and warmth transfer takes place strictly by axial conductivity. If the warmth transfer rate needs to be increased, a logical step is to introduce a two-phase flow regime instead of one section system. By partly filling the PHP, it's expected to attain a heat advantage as a result of the evaporation and condensation of bubbles. Also, the gradient between heater and cooler let alone bubble growth and collapse can generate self-sufficing pressure perturbations, as explained earlier, inflicting liquid plug transport and therefore smart heat transfer. This feature is additionally expected to form the PHP performance to be orientation freelance.

In a PHP there square measure 3 distinct operational regions:

a. close to 100% crammed ratio:

In this case there square measure only a few bubbles gift that square measure insufficient to come up with the specified perturbations. Even the buoyancy evoked liquid circulation, that was gift at100% crammed quantitative relation, gets hindered as a result of extra physical phenomenon generated friction of the bubbles. therefore the performance of the devise is seriously hampered.

b. close to 1/3 crammed ratio:

In this mode there's little liquid to make enough distinct slugs and there's a bent towards dry-out of the evaporator. Therefore, the PHP introduces AN undesirable thermal resistance.

c. PHP true operating range:

Between regarding twenty to seventieth crammed quantitative relation, the PHP operates as a real rhythmic device. the precise vary can disagree for various operating fluid, operational parameters and construction. a lot of the bubbles (lower crammed ratio), a lot of intense square measure the pulsation however the at the same time there's less liquid mass for smart heat transfer. Fewer bubbles at extremely crammed quantitative relation cause less pulsations and bubble pumping action is reduced thereby lowering the performance. therefore AN optimum fill charge exists.

3.4Total Number of Turns

The number of turns will increase the amount of perturbations within the device. If the quantity of turns is a smaller amount than a crucial worth, then there's an opening of a stop-over development to occur. In such a condition, all the evaporator U-sections encompasses a vapour bubble and therefore the remainder of the PHP has liquid. This condition primarily results in a dry out and little perturbations cannot amplify to create the system operate unfueled. If the full heat turnout is outlined, increasing the quantity of flips results in a decrease in heat flux handled per turn. Thus, AN optimum range of turns exits for a given heat turnout.

3.5 Device Orientation

Apart from simplicity of style, one amongst the strongest cases in favour of rhythmic heat pipes is that their thermal performance is freelance of the operative orientation. Heat transfer rate in gravity orientation was a lot of larger than the anti-gravity orientation.

3.6.Working Fluid

A first thought within the identification of the operating fluid is that the operative vapour temperature and its inherent thermal conduction. at intervals the suitable temperature vary many fluids will show the required property and a spread of characteristics has got to be examined so as to see the foremost acceptable fluid. The prime needs square measure as follows:

a. sensible thermal stability

b. Moderate vapor pressure on the operative temperature vary

c. High heat

d. High thermal conduction

e. High physical phenomenon

f. Acceptable temperature

g. Low liquid and vapour body

IV. CONCLUSIONS

FROM THIS REPORT IT'S ALL OVER THAT

1. Heat Transfer Capability Of Rhythmic Heat Pipe Is Way Above The Traditional Heat Pipe With Low Thermal Resistance.
2. Between Twenty To Eightieth Filling Magnitude Relation Php Operates As True Rhythmic Device.
3. The Thermal Resistance Decreases With The Increase Of Heating Power As A Result Of The Increase Of Current Speed, Resulting In Heat Transfer Sweetening.
4. For The Rise Of Inclinations Among The Take A Look At Clphps, The Thermal Resistance Decrease With The Increase Of Inclinations As A Result Of Gravity Impact.
5. The Experimental Results Of The Horizontal Orientation Square Measure Vital Completely Different From Their Operation Conditions And Inclinations.
6. The Uniform Channel Clphp Shows Poor Heat Transfer Performance At Horizontal Orientation.
7. Heat Transfer With Operating Fluid Crammed Php Was A Lot Of Above Dry Php.
8. Heat Transfer Capability In Gravity Orientation A Lot Of Above The Anti-Gravity Orientation.
9. If The Fabric Is Compatible With Operating Fluid, They'll Be Expected To Supply Extremely Reliable Heat Transfer Performance Among Their Operational Limit For Years.

Since Their Invention, There Are A Substantial Variety Of Studies About Rhythmic Heat Pipes, And Their Ability To Transfer Heat At Terribly Low Effective Thermal Resistances Has Been Verified. The Work Compiled Here Considerably Will Increase The Understanding Of The Phenomena And Parameters That Govern The Thermal Performance Of Rhythmic Heat Pipes. Several Unresolved Problems Still Exist, However

Continued Exploration Ought To Be Able To Overcome These Challenges. The Event Of Comprehensive Style Tools For The Prediction Of Rhythmic Heat Pipe Performance Continues To Be Lacking.

V. FUTURE SCOPE

To Solve The Heat-Build Up Drawback In Electronics Device, Future Electronic Devices May Be Like Php's In Their Chips

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