# Review Paper onSelection of Working Fluid and Parameters Affecting the Performance of Close Loop Pulsating Heat Pipe

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***Abstract*—Increasing numbers of electronic components in electronic device is resulting in higher heat generation which needs to be dissipated for better performance of device Otherwise device may get overheated. Various devices are used for cooling of electronic device in which Close loop pulsating heat pipes (CLPHPs) are the best solutions for the electronics cooling due to their low cost, small size, light weight, simple design and effectiveness due to their high heat transfer capacity. In Close loop pulsating heat pipe (CLPHPs) copper is used as a tube material in evaporator and condenser sections. Glass tube is used in adiabatic section in between evaporator and condenser sections.The present paper of CLPHP review on use of nanofluids instead of working fluid can be done to enhance heat transfer and how performance of CLPHP is increased.**

***IndexTerms*—Electronics Cooling, Close loop pulsating heat pipe, Nanoparticle, Nanofluid, MWCNT**

## I. INTRODUCTION

Increment the semiconductor transistor density heat generation by the electronic gadgets increment step by step. Every electronic gadget generates heat because of the current flow through them. Unless the heat is expelled always the temperature of the gadgets will ceaselessly expand prompting disappointment. The high heat worries in the patch joints of electronic segments mounted on circuit sheets coming about because of temperature varieties are real reasons for disappointment. Building up a smaller than usual, minimal effort and high effective heat exchange gadget is winding up increasingly essential because of the quick advancement of electronics and PC businesses. The traditional heat pipes, for example, copper grooved heat pipes and sintered particle heat pipes have assumed an essential part in the heat scattering in the PCs. Beginning in 2004, more than 100 million desktop PCs sold every year could possibly utilize the heat pipe innovation. Presently days numerous PC producers are utilizing heat pipe thermal solutions in their server PCs, note pad and desktop, which has opened a more noteworthy market to the heat pipe with a more prominent request. With the ceaseless increment of power density in the electronic gadget and PCs, it requires that the thermal designers or scientists to build up the propelled heat pipe innovation or other creative cooling advances for electronic gadgets.

Akachi [1] displayed a novel idea of heat and mass exchange gadget named as pulsating heat pipe. Attributable to its potential heat transport capacity, basic structure and ease of development, a great deal of specialists has explored it tentatively and hypothetically.The pulsating heat pipe (PHP) is an undeniably prevalent heat exchange component. PHPs are generally utilized as a part of aviation applications, electronic segments heat exchange and different fields due to its smaller size, basic structure, ease and different points of interest. The pulsating heat pipe works in a way altogether different from the operation of a ordinary heat pipe. Contrasted and conventional heat pipe which exchange heat through phase change, the PHP exchanges heat by means of phase change as well as exchanges the sensible heat by means of gas– fluid pulsating. Also, a PHP does not have the capillary heat exchange restriction by means of wick in a conventional heat pipe, and it can be bowed self-assertively.

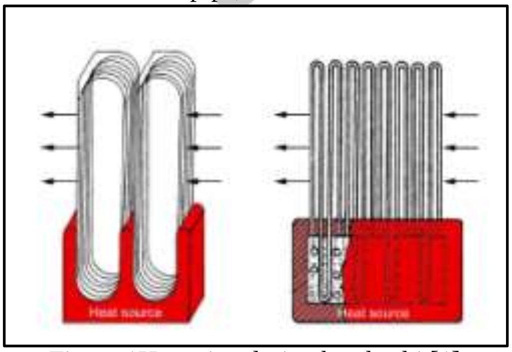


Figure 1Heat pipe design by akachi [1]

## II. PHPS ARE CHARACTERIZED BY THE FOLLOWING BASIC FEATURES

a) The structure is made of a meandering tube of capillary dimensions with many turns, filled partially with a suitable working fluid.

This tube may be either:

- Closed Loop : tube ends are connected to each other in an endless loop.
- Open Loop : tube ends are not connected to each other; essentially one long tube bent in multiple turns with both its ends sealed after filling the working fluid.

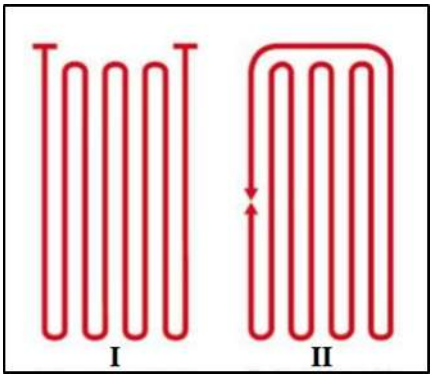


Figure 2 (I) Open loop CLPHP (II) Close loop CLPHP

Figure 1. 1 (I) Open loop CLPHP (II) Close loop CLPHP

b) There is no internal wick structure as in conventional heat pipes.
c) At least one heat-receiving zone (evaporator/heater) is present.
d) At least heat-dissipating zone (condenser/cooler) is present.
e) There can be an optional adiabatic zone is present in-between evaporator and condenser.

### III. CLOSED LOOP PULSATING HEAT PIPE (CLPHP)

Improvement of a minimal effort powerful inactive cooling framework is an ebb and flow territory of research to suit little sections and high heat flux requirements. CLPHP is a two- phase passive heat transfer device works on the phase-change phenomena. Amazing heat exchange execution, minimal structure and no outer power prerequisite make CLPHP as a promising cooling gadget in various applications from little electronic chips to the expansive sunlight based water heater. CLPHP discovers its application in electronic cooling as well as a few others, for example, heat move device in an air conditioning system, hybrid vehicle, and fuel cell cooling technology, heat exchanger and radiator.

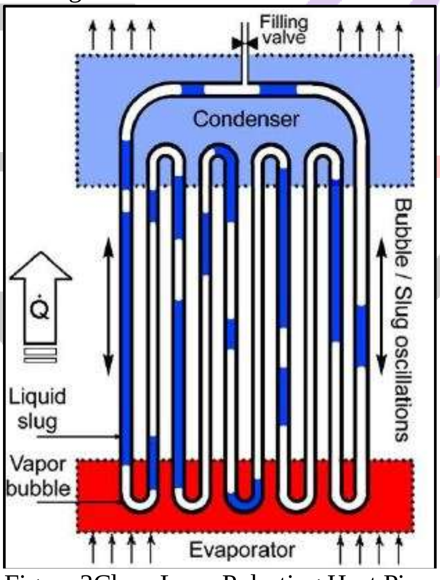


Figure 3Close Loop Pulsating Heat Pipe

Closed loop pulsating heat pipe (CLPHP) is a serpentine channel of capillary size consisting of an evaporator, a condenser and an adiabatic section as shown in Fig. 1. CLPHP is cleared and incompletely loaded with the working fluid Evaporator segment gets heat. As surface tension force surpasses the gravitational force in the capillary, liquid slugs and vapor bubbles are generated in the evaporator section. Due to high vapour pressure generated in the evaporator, Vapor bubble pushes the liquid slug towards the condenser section. Adiabatic area goes about as a protected channel to transport liquid slugs and vapor bubbles rises amongst evaporator and condenser areas. Heat dismissal happens in the condenser segment. Vapor bubbles cool here, change over into fluid and transported back to the evaporator. The pressure distinction amongst evaporator and condenser turns into the main thrust to support to and forward movement of gas-fluid two-phase stream in a CLPHP.

### IV. NANOPARTICLE AND NANOFLUID

The man in his quest for knowledge has been conceiving and developing physical world and its components in bigger than the biggest and smaller than the smallest dimensions of mass, length and time. Though the smallest entity with individual characteristic features that was established happened to be an atom of an element but realization of the single atom in physical form and serving mankind remained a dream till recently. It is achieved through the development of nanocrystaline materials, discovery of concept of quantum confined atom and synthesis of doped nanocrystaline materials. Investigation of growth mechanism of nanoparticles is present large scientific and practical interest. As, nanoparticles with given size and characteristics are required in nanotechnology. Nanoparticles are particles between 1 to 100 nanometers (nm) in size. A small object that behaves as a whole unit with respect to its transport and properties. Ultrafine particles are the same as nanoparticles and between 1 and 100 nm in size, fine particles are sized between 100 and 2,500 nm, and coarse particles cover a range between 2,500 and 10,000 nm. Scientific research on nanoparticles is intense as they have many potential applications in medicine, physics, optics, and electronics.

Heat transfer efficiency can improve by increasing the thermal conductivity of the working fluid. Commonly used working fluids are acetone, water, ethanol, methanol etc. which have low thermal conductivity. To improve thermal conductivity of base fluid, solid nanoparticles are added which have high thermal conductivity. The mixture of Nanoparticles and base fluid is known as nanofluid.

## V. PARAMETERS AFFECTING CLPHP PERFORMANCE

### i. Working fluid thermo-physical properties

Picking an appropriate working fluid for a CLPHP is turning into an essential component for the heat pipe to work well. Until now Water , acetone , Methanol , Ethanol , Kerosene , R141b , R123 , FC-72 , Propene , HFC134a and Butane have been tested as a working fluid in CLPHP.

Desirable properties of working fluid

The experience gained so far by earlier studies suggests that the working fluid employed for pulsating heat pipes should have the following properties:

- High value of $(dP/dT)_{sat}$: Guaranteeing that a little change in evaporator temperature creates a vast change in $P_{sat}$ inside the generated bubble which aids in the bubble pumping action of the device. The same is valid in switch way in the condenser.
- Low dynamic viscosity: This produces lower shear stress.
- Low latent heat: This should be desirable, aiding quick bubble generation and collapse, given the fact that sensible heat is the predominant heat transfer mode.
- High specific heat: This is alluring complimenting the low latent heat necessity; in spite of the fact that there are no particular examinations which expressly recommend the impact of specific heat of liquid on the heat execution. It is to be noticed that if a flow regime change from slug to annular happens, the separate parts of latent and sensible heat transport component may extensively change, as clarified prior. This perspective requires advance examination.
- Low surface tension: This, in conjunction with dynamic contact angle hysteresis may make extra pressure drop.

Table 1Close Loop Pulsating Heat Pipe

| Property | DI water | Ethanol | Methanol | Acetone |
|---|---|---|---|---|
| **Boiling point(°C)** | 100 | 78 | 64 | **56** |
| **Liquid density(Kg/m$^3$)** | 997.1 | 785.5 | 786.3 | **784.6** |
| **Liquid specific heat(KJ/Kg °C)** | **4.183** | 2.513 | 2.535 | 2.34 |
| **Latent heat (KJ/Kg)** | 2257 | 846 | 1101 | **518** |
| **dP/dT (Pa/°C) at 80°C** | 1946 | 4299 | **6395** | 6262 |
| **Dynamic viscosity(Pa-sec)×10$^{-3}$** | 0.8905 | 1.082 | 0.5455 | **0.3166** |
| **Surface tension(N/m)×10$^{-3}$** | 71.97 | 22.28 | **22.26** | 22.99 |

Maximum requirement for working fluid is fulfilled by acetone.so acetone is select as a working fluid.

### ii. Internal diameter of the CLPHP tube

The internal tube diameter is one of the parameters which essentially define a PHP. The physical behavior adheres to the ‘pulsating’ mode only under a certain range of diameters. The critical Bond number (or Eötvös) criterion gives the tentative design rule for the diameter.

$$(E\ddot{o}) = \frac{Dcri^2 g(\rho_{liq} - \rho_{vap})}{\boldsymbol{\sigma}} = 4$$

$$D_{crit} = 2\sqrt{\frac{\boldsymbol{\sigma}}{g(\boldsymbol{\rho}liq - \boldsymbol{\rho}vap)}}$$

All value taken for acetone and find out the critical diameter for Close Loop Pulsating Heat pipe
Where,

$D_{cri}$ =Critical diameter, m
g =Gravitational acceleration = 9.81 m/s$^2$
$\boldsymbol{\sigma}$ =Surface tension = 0.0231 N/m
$\rho_{liq}$ =Mass density of liquid = 791.24 kg/m$^3$
$\rho_{vap}$ =Mass density of vapor = 2

$$D_{crit} = 3.45 * 10^{-3} \text{ m}$$

$$D_{crit} = 3.45 \text{ mm}$$

**iii. Input heat flux to the device**

The applied heat flux affects the following

a) Internal bubble dynamics, sizes and agglomeration/breaking patterns
b) Level of perturbations and flow instabilities
c) Flow pattern transition from capillary slug flow to semi-annular and annular.

CLPHP is characteristically reasonable for high heat flux operation. Since the input heat provides the pumping power, below a certain level, no oscillations commence. In case of CLPHPs, a unidirectional circulating flow has been observed at high heat fluxes. In addition, the flow also gets transformed from oscillating slug flow to annular flow. Once a flow direction is established, alternating tubes sections become hot and cold (hot fluid flows from evaporator in one tube and cold fluid from the condenser flows in the adjacent tube). Further increase of heat flux will lead to some dry out mechanism(s) induced by thermo-hydrodynamic limitations. These have not been clearly identified and studied so far.

**iv. Volumetric filling ratio of the working fluid**

The filling ratio (FR) of a CLPHP is defined as the ratio of working fluid volume actually present in the device to that of the total volume of the device (at room temperature). In this manner, a given CLPHP has two operational furthest points as for the filling ratio, an unfilled gadget with no working fluid i.e. FR = 0 and a completely filled gadget i.e. FR = 1. Clearly at FR = 0, the exhaust CLPHP tubes constitute wasteful conduction balances and clearly have a high heat resistance. A completely filled PHP (FR = 1) is indistinguishable in operation to a single phase thermosyphon. There exist no rises bubbles thus no 'pulsating' impact is available. Considerable sensible heat exchange can in any case occur because of liquid course in the tubes by thermally induced buoyancy.

A. Nearly 100% fill proportion: In this mode there are just not very many bubbles display rest being all liquid phase. These bubbles are not adequate to create the required annoyances and the general level of flexibility is little. The buoyancy induces liquid circulation, which was available in a 100% filled PHP, gets frustrated because of extra flow resistance because of a couple of bubbles. In this manner, the gadget execution is genuinely hampered and the heat resistance is considerably higher than for FR = 1.
B. Nearly 0% fill ratio: In this mode there is next to no liquid to frame enough particular slugs and there is a propensity towards dry-out of the evaporator. The operational attributes are flimsy. The gadget may, under some working conditions, fill in as a two-stage thermosyphon exhibit.
C. PHP genuine working range: Between around 10% to 90% fill charge the PHP works as a genuine pulsatingheat pipe. The correct range will contrast for various working liquids, working parameters and constructional points of interest. The more bubbles (bring down fill charges), the higher is the level of flexibility yet at the same time there is less liquid mass for sensible heat exchange. Less bubbles (higher fill charges) cause less annoyances and the bubble pumping activity is lessened in this manner bringing down the execution. In this way an ideal fill charge exists. It can in this manner be inferred that the filling ratio is likewise a free parameter which characterizes a close loop pulsating heat pipe.

**v. Total number of turns**

The number of turns increases the level of perturbations inside the gadget. In the event that the number of turns is not as much as a basic esteem, at that point there is a probability of a stop-over phenomenon to happen. In such a condition, all the evaporator U-segments have a vapor bubble and whatever is left of the PHP has liquid. This condition basically prompts a dry out and little irritations can't intensify to influence the framework to work self-managed. On the off chance that the aggregate heat throughput is characterized, expanding the quantity of turns prompts a lessening in heat flux transition per turn. In this way, an ideal number of turns exits for a given heat throughput.

**vi. Device orientation with respect to gravity**

Aside from straightforwardness of design, one of the strongest cases for pulsating heat pipe is that their thermal performance is autonomous of the working orientation. In any case there are some repudiating patterns in the literature. In a few investigations either there was a substantial variety of performance with gadget orientation, or level or also anti-gravity force (heater-up) operation was not accomplished by any means. A few outcomes from different sources for a multi-turn CLPHP recommend that flat operation is conceivable yet not in the same class as the vertical operation. These evidently opposing and uncomplimentary outcomes appear to recommend that prerequisites for an introduction free operation are:

a) Sufficiently large number of PHP turns, which is responsible for a higher degree of internal perturbations and inhomogeneity of the system.
b) A high input heat flux leading to higher ‘pumping power’ and enhanced instabilities.
c) These two aspects are not mutually exclusive and must simultaneously be satisfied.

## VI. NANOFLUID PREPARATION

Nanofluids are weaken colloidal suspensions of nanoparticles in a base liquid that show magnificent upgrade in heat transfer execution in different applications. Be that as it may, nanofluids arrangement and adjustment are without a doubt a matter of worry since the properties of nanofluids are reliant on the dependability of the suspensions.

Preparation of nanofluids is the key advance to the trial investigations of nanofluids. Two sorts of strategies have been utilized in creating nanofluids. One is a single-step strategy and the other is a two-step technique. A short discourse on nanofluids readiness forms is given underneath.

- **Single-step direct evaporation method**

In this strategy, the immediate vanishing and buildup of the nanoparticulate materials in the base fluid are gotten to deliver stable nanofluids. A few single-step strategies have been landed for nanofluids arrangement.

- **Two-step method**

In this strategy, first the nanoparticles are gotten by various techniques and after that are scattered into the base fluid with or without surfactant. Two-step technique to get homogeneous and stable suspensions of nanoparticles blended with base liquid with or without surfactants.

## VII. LITERATURE SURVEY

**Wenqing Wang et al. [4]** examines the thermal resistance qualities of the PHP accused of acetone based binary mixture, where deionized water, methanol and ethanol were added to and blended with acetone, separately. The volume blending proportions were 2:1, 4:1 and 7:1, and the heating power change from 10 to 100 W with filling proportions of 45, 55, 62 and 70% and he infer that (1)At high filling ratio (62 and 70%), the heat exchange exhibitions of the PHP with acetone based blends are not on a par with that with pure acetone.(2)The flow resistance inside the PHP with the acetone– water blends is more prominent than that with pure aceone, the flow rate inside the PHP is generally moderate and the heat exchange execution of the PHP with acetone– water blend is more awful than that with pure acetone.

**Vipul M. Patel et al. [5]** were Experimental examinations on a Closed Loop Pulsating Heat Pipe (CLPHP). The impact of working liquids on startup system and thermal performance of a CLPHP are done on 2 mm, nine turn copper tube. Add up to eleven (11) working fluids are arranged and researched.Deionized (DI) Water ($H_2O$), ethanol ($C_2H_6O$), methanol ($CH_3OH$) and acetone ($C_3H_6O$) are utilized as pure fluids. The water-based blend (1:1) of acetone, methanol and ethanol are utilized as binary fluids. Sodium Dodecyl Sulphate (SDS, $NaC_{12}H_{25}SO_4$) is used as a surfactant to prepare the water-based surfactant solutions of 30 PPM, 45 PPM, 60 PPM and 100 PPM. The filling ratio is kept as 50%. The vertical base heating position of a CLPHP is considered. Heat input is changed in the scope of 10-110 W and they conclude that Startup heat flux is watched bring down for acetone contrasted with every other fluid because of its persuading thermo-physical properties to start vapor bubble and liquid slug in the tube. Acetone gives a superior execution of a CLPHP contrasted with methanol, ethanol and water as pure working fluids.

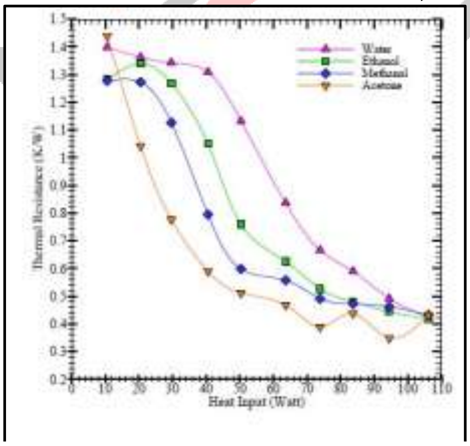


Figure 4Thermal resistance versus heating power input for different pure fluids

**Pramod R. Pachghare et al. [6]** were trial result on the thermal performance of CLPHP is presented. The CLPHP is made of copper tubes, having internal and outer diameter of 2.0 mm and 3.6 mm respectively. The working fluids utilized are water, ethanol, methanol and acetone additionally binary mixture (1:1 by volume) of water-ethanol, water-methanol and water-acetone. For all experimentations, filling ratio (FR) half, two-turns and vertical base heating mode position was kept up. The lengths of evaporator, condenser and adiabatic segment are chosen as 42 mm, 50 mm and 170 mm, respectively. The transparent adiabatic segment is made of glass tube having length 80 mm, for flow visualization. Thermal performance of binary fluid is superior to anything pure working fluid of its constituents for high heat input; however for the low heat input working fluid is superior to binary fluid.

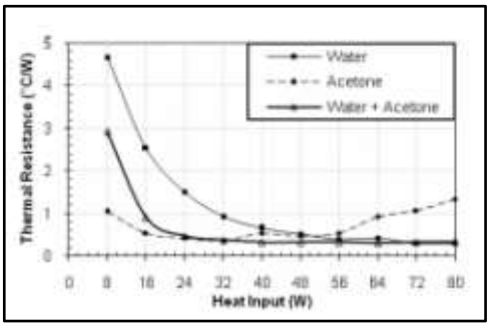


Figure 5 Thermal resistance versus heating power input for different fluids

**Yue Zhu et al**. **[7]** were tentatively examination directed to research the start-up and heat exchange execution of a CLPHP with water-acetone blends (at blending proportions of 13:1, 4:1, 1:1, 1:4 and 1:13) and pure water and acetone under different filling ratio (35-70%) and heat inputs(10-100 W). The CLPHP was vertically set and base heating (i.e., heating wires were wrapped on the dissipation area) with internal and external diameters 2.0 and 4.0 mm, respectively. the heat exchange exhibitions of the CLPHP with water-acetone blends (at blending proportions of 13:1, 4:1, 1:1, 1:4 and 1:13) were not as effective as that of the CLPHP with pure liquids. Conversely with the minima of blends under certain heat inputs, the maximum thermal resistance of pure water and acetone diminished by 45.8% and 38.7%, respectively.

**A TarigondaHari Prasad et al. [8]** were test examination on a Closed Loop Pulsating Heat Pipe (CLPHP) utilizing water as a working fluid is considered and is subjected to half filling ratio. The parameters, for example, thermal resistance ($R_{th}$), heat transfer coefficient (h), and variety of temperature as for time for the given contribution at various slants, for example, 0º, 45º, and 90º are taken for the present work. he reason that For a given heat input the thermal resistance is less in vertical orientation when contrasted and other level and 45 degree slants on account of pulsating action of working fluid in 90 degree slant. CLPHP is best at vertical orientation i.e., at 90 degree slant , in light of the fact that all the more pulsating action is made place at this slant and from this time forward, heat exchange rate is speedier at this slant.

**Shuangfeng Wang et al. [9]** were exploratory examination is directed to investigate the heat transport ability of PHP working with functional thermal fluid (FS-39E microcapsule liquid and $Al_2O_3$ nanofluid), by contrasting them with pure water. The test tube is a four-turn php, made of a copper tube with an outer diameter of 2.5 mm, and an internal diameter of 1.3 mm. The outcomes demonstrate that the heat transport ability of PHP can be upgraded by utilizing FS-39E microcapsule liquid and $Al_2O_3$ nanofluid as working fluid under particular conditions. When utilizing vertical base heating mode, FS-39E microcapsule fluid is the best working fluid and its best fixation is 1 wt.%; when utilizing flat heating mode, $Al_2O_3$ nanofluid is the best working fluid and its best concentration is 0.1 wt.%.

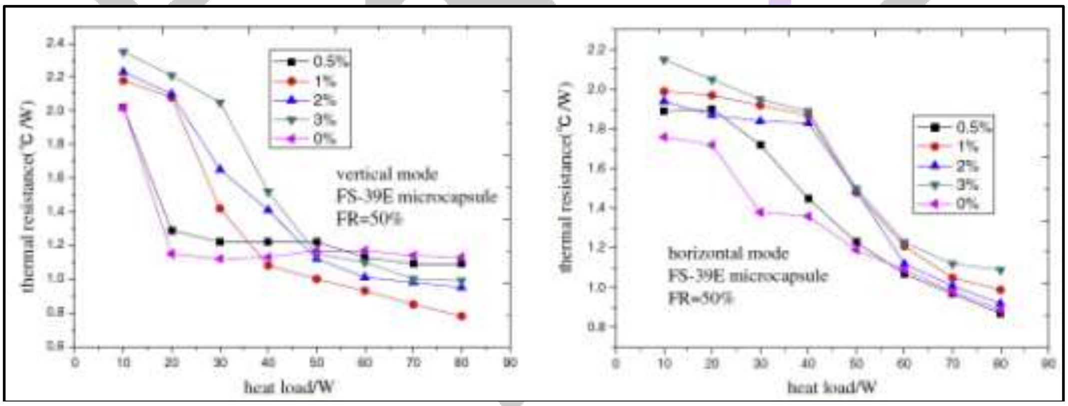


Figure 6 heat load versus thermal resistance of FS-39E microcapsule fluid: (a) vertical mode and (b) horizontal mode.

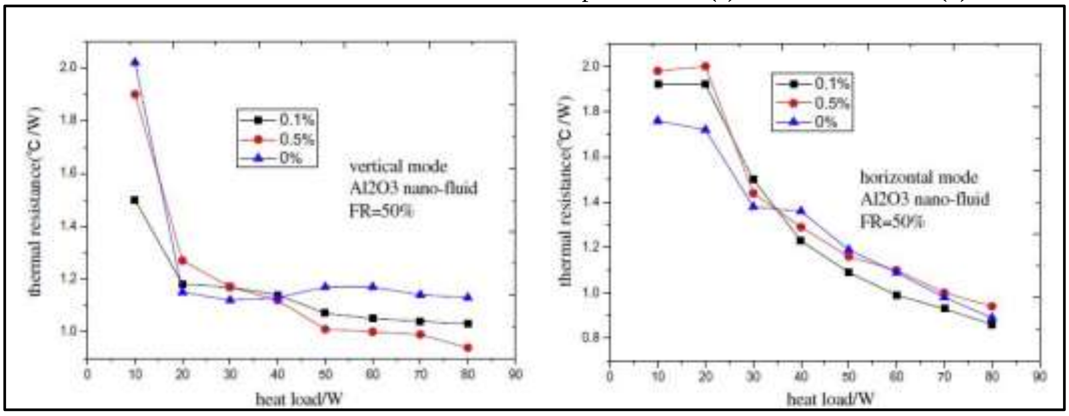


Figure 7 heat load versus thermal resistance of $Al_2O_3$ nanofluid: (a) vertical mode and (b) horizontal mode.

**Hamid Reza Goshayeshi et al. [10]** were explore the impact of heat transfer coefficient in a oscillating heat pipe for $Fe_3O_4$/water and ɤ (gamma) $Fe_2O_3$/kerosene. Test examines were performed to research the thermal performance of three oscillating heat pipe working with heating power contribution to a scope of 0–140 W. The tried OHPs are altogether produced using copper tubes with internal diameter (IDs) of 2, 2.5 and 3 mm with various numbers of turns. Two working fluid, $Fe_3O_4$/water and ɤ (gamma) $Fe_2O_3$/kerosene, were utilized by filling ratio of half, by volume and they reason that Nanofluids can diminish the thermal resistance with respect to kerosene and in this manner increment the thermal performance and heat transfer coefficient of the OHPs. This change is considerably more noteworthy for the nanofluid of $Fe_3O_4$ contrast with ɤ$Fe_2O_3$. The thermal resistance of the 2 mm ID, 2.5 mm ID and 3 mm ID CLPHPs accused of $Fe_3O_4$ and ɤ$Fe_2O_3$ were lower than that of water, demonstrating higher thermal performance; though $Fe_3O_4$ as opposed to ɤ$Fe_2O_3$ was more valuable to enhance the thermal performance of the 2.5 mm ID CLPHP.

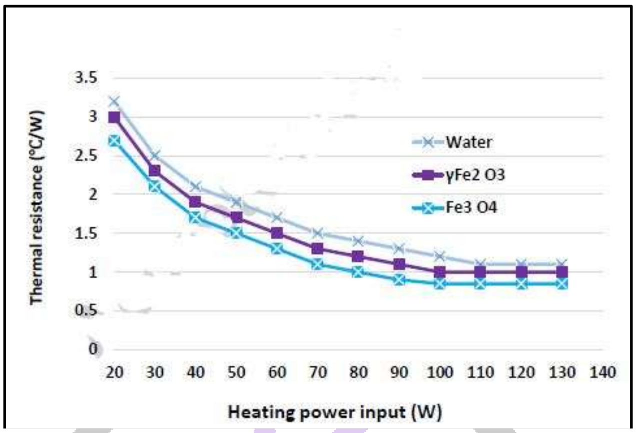


Figure 8 Thermal resistance of the heat pipe for 2 mm tube internal diameter

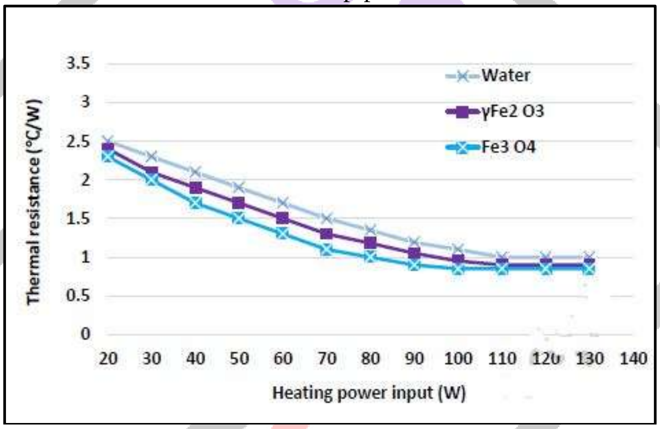


Figure 9 Thermal resistance of the heat pipe for 2.5 mm tube internal diameter

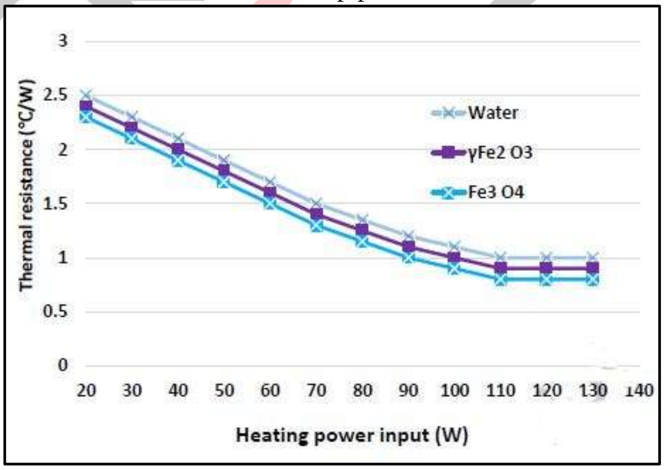


Figure 10 Thermal resistance of the heat pipe for 3 mm tube internal diameter

**Mohanraj et al. [11]** were tentatively examination was done for flat plate heat pipe with CuONanofluid. The flat plate heat pipe was manufactured by utilizing copper which has great heat exchange qualities. The Nanofluid was set up with CuO and DI water. This procedure was done by ultrasonic vibrator. The experimentation was done for two distinctive working fluid that was DI water and (DI water and Nanoparticle). The heat discharge rate was seen by data logger with various heat inputs. At long last the two outcomes were contrasted for heat pipe and Nanofluid was given great heat discharge rate than DI water. CuO particles were moved into a glass container, and after that water is filled it. The arrangement was kept in sonicator, and the sonication procedure is improved the situation 2 to 3 hour to guarantee the uniform scattering of CuO nanoparticles in the water, after sonication the required nanofluid arrangement is prepared for the application. He concludes that Temperature contrasts of heat pipe were dropped marginally with nanofluid which comes about thermal resistance was diminished with nanofluid. So thermal performance of FPHP increse.

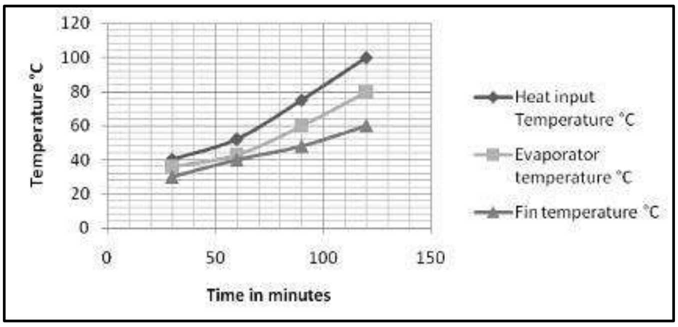


Figure 11 Plots with DI water

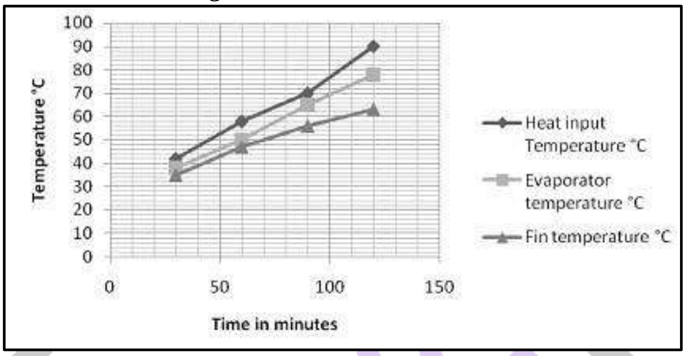


Figure 12 Plots with $H_2O$ + CuO Nano fluids

**Mohamed I. Hassan et al. [12]** were research for heat pipe in which Water based nanofluids with 1, 2 and 3 vol% alumina nanoparticles are arranged and portrayed. These nanofluids are charged to a total vacuumed copper heat pipe made out of copper tube and lined by a wick structure. The heat pipe is furnished with a vacuum pressure and temperature sensors for surveying its execution under various working conditions. He infer that at the starting, the heat pipe execution demonstrated a noteworthy upgrade around half to use the nanofluids over the pure water. This improvement is later deteriorated after a few utilized and raised the worry of the steadiness of the nanoparticles suspension stability in the base fluid because of the phase change of the water. Scan electron microscope (SEM) pictures are taken for the heat pipe wick after tedious utilize; the pictures uncovered a stored layer of collected nanoparticles on the wick mesh surface. These particles aggregation built up a genuine capillary and thermal resistance which thus impacts the heat pipe execution.

**Hyun Jin Kim et al. [13]** were exploring tentatively research the impact of the state of nanoparticles in acetone based $Al_2O_3$ nanofluids on the thermal resistance of flat plate heat pipe. Acetone based $Al_2O_3$ nanofluids containing sphere, brick and cylinder shaped nanoparticles were prepared, utilizing the two-advance technique with no surfactants or additives. The flat plate heat pipes are fabricated with the prepared three nanofluids. The thermal resistance of the flat plate heat pipes is tentatively obtained. The outcomes demonstrate that the thermal resistance of the flat plate heat pipes with nanofluids containing sphere, brick and cylinder shaped nanoparticles are diminished to 33%, 29%, and 16%, respectively, contrasted and the thermal resistance of the flat plate heat pipe with pure acetone. In view of the outcomes, we show that the state of nanoparticles in working nanofluids essentially influences the thermal resistance of the heat pipe.

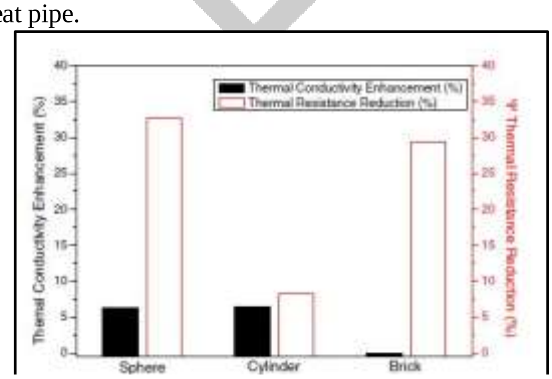


Figure 13 Comparison between the thermal conductivity enhancements of different nanofluid

**Yu-Hsing Lin et al. [14]** were explore preparatory trial comes about on utilizing copper tube having inward and outside diameter with 2.4 mm and 3 mm, respectively, to complete the exploratory pulsating heat pipe. The working fluid incorporates the silver nanoparticle with water arrangement and pure water. Keeping in mind the end goal to study and measure the efficiency, they compare with 20 nm silver nanofluid at various concentration (100 ppm and 450 ppm) and different filling ratio (20%, 40%, 60%, 80%), additionally applying with various heating power (5 W, 15 W, 25 W, 35 W, 45 W, 55 W, 65 W, 75 W, 85 W). As indicated by the trial result in the midterm esteem (i.e. 40%, 60%) of filling ratio demonstrates better. In the larger part 60% of efficiency is viewed as much better. The heat dispersal impact is practically equivalent to in sensible heat transfer, 60% has more liquid slugs that will turn and convey more sensible heat, so in 60% of filling ratio, heat dissemination result is superior to 40%, and the best filled fluid is 100 ppm in silver nanofluid.

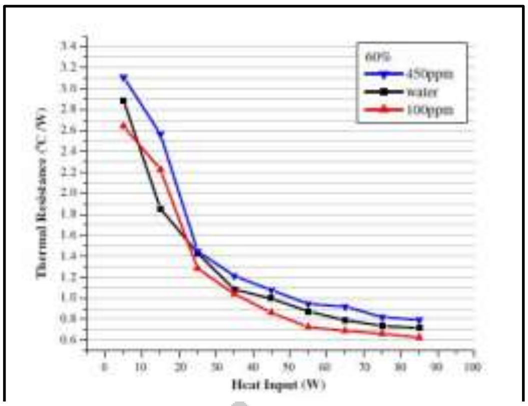


Figure 14 Heat input vs. Thermal resistance for 60% in filled ratio.

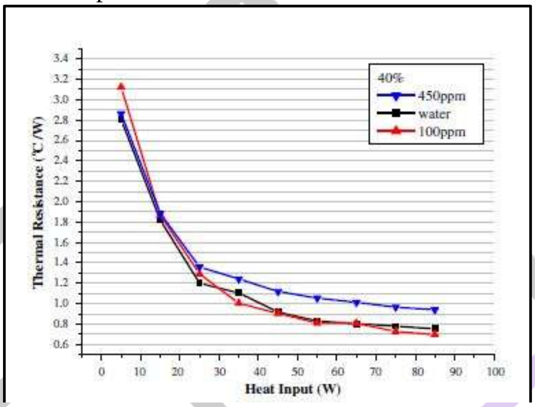


Figure 15 Heat input vs. Thermal resistance for 40% in filled ratio.

**Roger R. Riehl et.al[15]** was play out an exploratory open loop PHP (OLPHP) was tried with water-copper nanofluid, with an expansion of 5% by mass of copper nanoparticles. The nanofluid is made out of a water, with strong nanoparticles normally blended with mass portions from 1 to 5%. The nanoparticles are materials with measure below than 100 nm in size. The nearness of strong nanoparticles in the working liquid adds to expand the nucleation locales essential for bubble formation. Since more bubbles were produced, more extreme pulsation was seen amid the PHP operation, which brought about more nearness of vapor in the channels. In this way, higher thermal conductance were watched when contrasted with the PHP operation with pure water, notwithstanding the change on the general thermal performance watched.

**Hamid Reza Goshayeshi et al.[16]** was tentatively assessed the impact of γ (gamma) and α (alpha) $Fe_2O_3$/Kerosene nanofluid for a CLPHP under the magnetic field. The nanoparticles had a size extended from 10 nm to 30 nm. The heat exchange rate and the temperature dissemination of the heat pipe were inspected with and without the magnetic field. Moreover, the $Fe_2O_3$ base nanofluids were presented to a magnetic field to quantify the vapor temperature at the center point of the pulsating heat pipe straightforwardly. The outcomes demonstrated that both heat transfer coefficient and thermal performance of the heat pipe are upgraded by the expansion of $Fe_2O_3$ nanoparticles, particularly when the magnetic field is available. The expanded info heat input raises the heat transfer coefficient of the condenser and the evaporator. Lower evaporator heat transfer coefficient and higher temperature contrast amongst condenser and evaporator were seen as a result of α-$Fe_2O_3$ nanoparticles when contrasted with γ-$Fe_2O_3$ nanoparticles. Among six nanoparticles examined in this examination, the ideal sort and size of Iron oxide nanoparticles under comparative conditions for accomplishing the best thermal performance was 20 nm γ-$Fe_2O_3$ nanoparticles.

**Jian Qu et al.[17]** were tentatively examination was performed on the thermal performance of a OHP charge with base water and spherical $Al_2O_3$ particles of 56 nm in diameter. The impacts of filling ratio, mass fraction of alumina particles, and power input on the thermal resistance of the OHP were examined. Trial comes about demonstrated that the alumina nanofluids fundamentally enhanced the thermal performance of the OHP, with an ideal mass fraction of 0.9 wt. % for maximal heat exchange increases. Contrasted with pure water, the maximal thermal resistance was diminished by 0.14 °C/W (or 32.5%) when the power input was 58.8Wat 70% filling ratio and 0.9% mass fraction. By inspecting the internal wall tests, it was discovered that the nanoparticle settlement basically occurred at the evaporator.

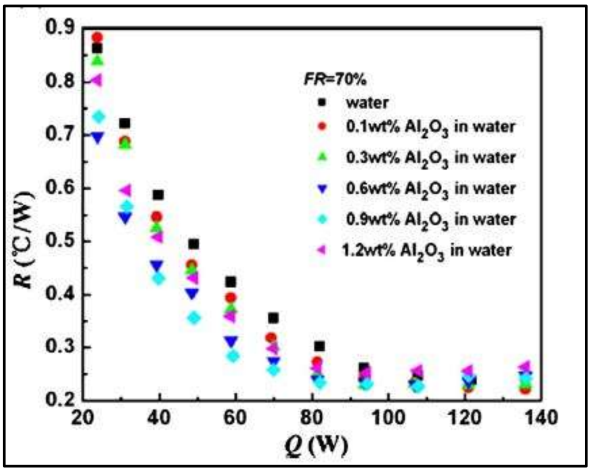


Figure 16 Thermal resistance vs. heat input

## VIII. Conclusion

Pure acetone gives best performance compared to other working fluids compared to other pure and binary fluids.From the literature survey it is concluded that in CLPHP generally, water is used as a working fluid, while acetone is a far better working fluid than water.By literature survey, it is found that PHP is preferable at vertical orientation.Mixing of nanoparticles with a working fluid decreases the thermal resistance of CLPHP so increases the performance of the CLPHP.In nanofluid different shape (sphere, brick, and cylinder) of nanoparticles can be use in which spherical shape is found to be better than other two shapes.As the size of nanoparticle reduces, the thermal conductivity of the nanofluid increases so performance of CLPHP increase.

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