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Research on Water Based Nano Fluids Effecting Thermal Performance of Heat Pipe

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ABSTRACT--- ***Heat transfer applications are most investigative area with the evolution of micro chips in electronics field; thermal equilibrium maintenance becomes a challenging task in heat pipes because of their reliability, simple structure as well as cost. Heat pipe is one of the well known heat transfer device, can transport large quantity of heat from one place to another without any additional power. Working fluid has its role on performance on the basis of its conductivity, because heat pipes have high thermal conductive nature. This review focuses on the submission of Nano-fluids in place of conventional fluids used in heat pipe. This paper reveals the researches on thermosyphons, heat pipes and oscillating heat pipes, for reduction in thermal resistance, enhancing the thermal efficiency and heat transfer coefficient of a heat pipe. Various input parameters and their ranges those affect the performance of heat pipe like heat input, angle of inclination, filling ratio, Nano-particle material, size, shape and concentration of Nano-fluid, considered in different studies has been reviewed.***

Keywords — Nano fluid applications, heat pipe, conductivity, heat transfer, thermal resistance, heat transfer coefficient.

I. INTRODUCTION:

Applications of heat transfer in electronics and another emerging fields heat pipes have their own significance, these are specific type of heat exchangers having high efficiency, compactness with less number of components **Brusly Solomon [1].** A part of that **Kesav Kumar Sridharan [2]** conducted experimental study on heat pipe with CuO (Nano-fluid) to check the heat transfer performance, he conducted tests on multi layer screen mesh wicks.

In developing the advanced techniques for heat pipes the micro and miniature of heat pipes and pulsating of heat pipes can be achieved. **Amir Faghri [3].** Nano fluids are to be examined in suspension of convectional fluids which are very potential in finding the thermal conductivity which is can be observed by capability of heat transfer. **R. Senthil kumar [4].** While we are comparing the pure water system with hybrid and Nano fluid systems the hybrid Nano fluid systems shows greater thermal resistance due to increase in Nano fluid concentration **Woo-Sung HAN [5].** Nano fluids are expected to be very ideal which can be suited in a practical manner that are incurred in a penalty pressure drop conditions that are very effective for NANO fluids

concentrations so that they are likely to be single-phase fluid than a mixture of solid–liquid.

Weerapun Daungthongsuk et al.[6]. In such case while we are selecting the PHP the use of bubbles can pulse out for promoting liquid slug which can promote working conditions of liquid flow in heat conductivity system.

A. M. J. Edwards [7], Borgermeyer, [8] concluded that dimensionless parameter playing an important role in micro heat pipe, the phase section applicability design can be easily obtain in performance of heat pipe.

II. HEAT TRANSFER PARAMETERS IN HEAT PIPES WITH NANO FLUID APPROACH:

Omer A et al.[[9] solid particles of NANO meter sized mixed with conventional fluids for theoretical and practical researches on heat pipes and conclusions are showing there is an enhancement in thermal characteristics like heat transfer in heat pipe.

In a condition of closed-loop oscillating heat pipe the internal flow patterns will have check values using different concentric fluids such as silver nano-ethanol and normal ethanol as working ones which can be experimentally observed in bubble flow with slug flow and annular flow to a dispersed bubble flow **N. Bhuwakietkum john [10].** According to **C. Wilson, B. Borgmeyer [11]** increase of NANO particle concentration causes the increase and decrease in heat transfer rate for a heat pipe.

When a highly performed cooling device of the Nano fluid in the oscillating heat pipe is taken into consideration the phenomenon can be stated that the OHP when charged with Nano fluid the capability of heat transfer rate significantly increases **H. B. Ma, C. Wilson [12].** In a concentric way for volume fraction inside the nano particles when taken as base fluid the heat input and thermal resistance is investigated **M.G. Mousa [13].** In a condition where Nano fluids are responsible the effective heat transfer rate work is done based on heat pipe conditions **Hrishikesh Hinge [14].** When a heat pipe with circular section, sensor, heater and control panel have used in the experimental set up then the control panal has to be included with temperature indicator, voltmeter in study case of Nano fluid on the thermal performance of the heat pipe **Jakubczyk, M. Zientara et al .[15].**

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The Nano particle within the liquid can enhance the thermal performance by reduction through enhancement in thermal performance of heat pipe by reducing the thermal resistance of heat load which can carry

Somasundaram [16]. A schematic approach is done that the fabrication of heat pipes are made out of copper to increase steady state faster than the aluminum pipes, while also having a smaller temperature differential between the evaporator and condenser **Eui Guk Jung[17].**

III. PERFORMANCE OF HEAT PIPE WITH DIFFERENT PARAMETERS:

When the parameters like width, thickness and the effective length of the ultra-thin heat pipe is reveled the experimental parameters characterization will give different thermal properties of the developed module **Shang, Liu, H.Z. Xian et al.[18]. Gabriela Huminic [19]** designed an advanced heat pipe in high gravitational fields for cooling microelectronic components, the effects were studied in presence of non-condensable gases.

The heat exhibition of the heat pipe for expanding and diminishing heat motions are contrasted and refined water while using 10 wt % of Al_2O_3 NF falls apart the heat pipe heat execution **Wang, Garimella [20].** When the heat transfer effectiveness with thermo siphon has own importance the rate of heat transfer can be calculated **Wilson, Q. Yu et al.[21].** Heat pipe with their effective heat transfer rate that can be available with deal to high density and high thermal conductivity with low weight and their principles for all these conditions will get changed **Khandekar, S., Schneider et al.[22]. Kyu Hyung Do Seok [23]** conducted experiments for space craft and electrical components for cooling purpose. He concluded that main parts in pipe i.e evaporator, adiabatic and condenser sections, the results are checked with working fluids in evaporation and condensation. Enhancement in Performance of heat pipe can be done on the basis of selection of various working fluids. The wick structure and the working fluid in the heat pipe play a very important role in thermal performance of heat pipe. Wick structure is responsible for capillary pumping force and is directly limited to capillary limit **Lanchao Lin [24].** For any heat pipe thermo mechanical boundary conditions have to met with better function, internal diameter of the tube filling ratio and applied heat flux also included in the research by **Las Vegas, Nevada [25].** To get the high efficiency in cooling methods, better process of research objective is heat pipe with reliability. For finding its heat transfer phenomenon Vortex generators are used for heat transfer enhancement of the modern thermal systems. So it shows that when compared to general flow there is an increase in heat dissipation using vortex flow **Lazarus Godson Asirvatham et al.[26**]. A comparative performance study of the WAHP system is done through other set of thermodynamic parameters like the supply air temperature, supply humidity ratio, specific coil load and recovered enthalpy **Madhusree Kole [27].** An ID of 2mm copper tube made for CLOHP/CV and two check valves inserted inside tube with meandering turns of 40. Length of the tube varied from 50mm with 50mm addition up to 150mm and a standard section of the three adiabatic, condenser, evaporator are of equal dimension researched by **Maryam Shafahi [28]** to validate results**.** According to the tests conducted by **Matthias H. Buschmann [29]** the temperature in the evaporator to condenser section found to be decreased throughout the length of heat pipe.

P. Davidovits, [30] in his research stated that no pump required for circulating fluid in the heat pipe, phase change parameters in evaporation and condensation can be done with the capillary structure of heat pipe**. Paisarn Naphon [31]** conducted tests by taking Reynolds number and pipe diameter as variant parameters and concluded that latent heat vaporization found by comparing overall heat transfer coefficient. Turbulent flow with constant heat flux and steady state, experiments carried out by **Patrik Nemec, Alexander et al.[32]** with different particle volume concentrations concluded that heat transfer enhancements taken place.

IV. PERFORMANCE OF HEAT PIPE USING NANO FLUIDS:

For getting higher thermal performance NANO fluids are used in pulsating heat pipe as alternative fluids by **Peng Cheng Scott Thompson [33].** Investigations on thermo-hydrodynamic performance of heat pipe depend on various parameters like volumetric filling ratio of working fluid, heat flux input concluded by **R. Boukhanouf [34].** An addition of 0.1% volume NANO particles shows 12% increase in thermal conductivity ratios, transient hot wire device used to measure particle size and concluded that conductivity inversely proportionate to the particle size by **R. Ranjan, J.Y. Murthy [35]** conducted experiments on grooved heat pipe with hybrid NANO fluids, the volume concentrations add with Ag-H_2O and Al_2O_3- H_2O for better results than normal fluid. The thermal characteristics of the heat pipe are enhanced using Nano fluids in comparison to conventional working fluids. **R. Senthil , D. Ratchagaraja [36].** In these process NANO fiber particles gives stability to NANO fluids and given good results in the area of thermal conductivity as well as convection coefficient than pure fluids or suspension containing large diameter particles, superiorities investigated by **R.B. Ganvir, P.V. Walke [37].** As looking in to the application criteria of fluids in industries like air conditioning, pharmacy, power generation and micro electronics most of the heat transfer fluids were ethylene glycol, mineral oil and water assessed by

Rakesh Hari, C. Muraleedharan [38]. A very low concentrations of NANO fluid concentrations gives good efficiency, experiments conducted on ethylene glycol and water mixture at a ratio of 40:80% followed by NANO fluids and getting a heat transfer up to 40% compare to base fluid by **M. Chandra Sekhara Reddy [39].** With the Cutting edge time of downsizing of equipment's, heat pipe have pulled in genuine thought in the field of heat exchanger. **Ricardo F.P. Tiecher, José et al.[40].** A typical advancement of materials like stainless steel and copper heat pipes investigated by using NANO fluid with titanium oxide particles thermal efficiencies are increased **S. Suresha,, P. Selvakumara [41].**

Water based NANO fluid tested in a micro heat exchanger for micro cooling process by **S. Wannapakhe [42].** Performances evaluated with NANO fluids in a heat pipe by **S.U.S. Choi, Z.G. [43]** to compare the enhancement of heat transfer when compared with base fluids and got significant difference. Heat transport capability significantly increased in OHP tested with NANO fluids by **Saeed A.A. Ibrahim [44**]. A significant conclusion by **Sandesh S. Chougule et al. [45]** the parameters like NANO material, size, its concentration with base fluid, heater size and its orientation will deploy the enhancement of CHF.

V. DIFFERENT EXPERIMENTAL APPROACHES ON HEAT PIPE WITH DIFFERENT STATISTICAL PARAMETERS:

Paramatthanuwat [46] conducted experiments with silver NANO particles mixed to base fluid DI-water to measure particle distribution and heat transfer rate in thermo siphon heat pipe. **Thompson, S. M., Ma, H. B et al. [47]** conducted experiment on three dimensional flat plate heat pipe for comparison of heat transfer in different directions. **Wilson, B. Borgmeyer [48]** conducted experiments on oscillating heat pipe by using NANO fluids and compared the enhancement of heat transfer coefficient with base fluids. **Woo-Sung HAN [49]** investigated on heat transfer performance by using Al_2O_3-DI water NANO fluid in a heat pipe and concluded that they found much variation after using NANO fluid.

Xue-Fei Yang, Zhen-Hua Liu [50] a thin formation of layer coated for porous medium gives high heat transfer performance by inputting optimum fluid with NANO particle volume fraction and the experiments run at NANO scale. **Y. Chen, C. Zhang, [51]** in his research concluded that there is not much deviation in micro regions in a miniature heat pipe , centrifugal forces on axial triangular grooves the internal surface deviations are not much significant influence in internal surface. **Y. Chen[52]** conducted some experiments on heat pipe where the working position of the pipe fixed to be vertical and horizontal, he concluded that there is not much difference in heat transfer in all positions in a capillary structure with fluid input. **Yong Jiang, Gerardo [53**] investigates on copper manicure vapour chamber with wiked pillers the thermal resistivity observed with NANO fluid filling. **Yu-Hsing Lin a,b, Shung et al. [54]** conducted experimental studies with pulssetting heat pipe with metallic oxides nd conventional fluids , NANO fluids study given enhancement results for wide range inlet applications. **Yulong Ji, Corey Wilson et al.[55]** conducted experiments with NANO fluids concluded that the particle size effected the heat transfer rate in heat pipes, even though works are in a recognised way the economical viability have to check with performances of NANO fluids in heat transfer applications.

VI. OVERALL DATA ASSESSMENT:

Experimental investigations continued to assess the heat transfer coefficients in heat pipe, some modelling results were compared to predict the accuracy in steady state dry out limit for two different test pipes, the axial heat transportation capacity studied by **Z.H. Liu, J.G. Xiong [56].** By varying design dimensions micro heat pipe are small to be structured and the results of heat transport depend on hydraulic diameter of the tube, both experimental and model simulation results submitted by **Zhang, Y. and Faghri [57].** Transient numerical model developed by **Zhen-hua Liu [58]** predicting that maximum transportation capacity is on set of dry out. **Zhen-Hua Yuan-Yang Li [59]** used fluids as a working medium for passive cooling in the heat pipe such that it transfer heat from hot source to a heat sink.

Rudresha S, Vijee Kumar [60] fabricated vapour deposited micro heat pipe as an integral part for semi conductors, it acts as a heat spreader by reducing thermal path between heat sink and heat source. **R.Reji Kumar, k.Sridhar, M. Narasimha, [61]** study on industrial application according to the given structural parameter and operating pressure, accurate filling ratio of the working fluid give empirical results to met the heat transfer requirement.

Mangal Singh Lodhi [62] observed results for rotating stepped wall heat pipe has annular flow, the results checked for condensation. **K.Rama Narasimha [63**] investigated on the heat pipe with NANO fluids observed that by analyzing the compressibility of the fluid found a change in speed but the possibility of Brownian particles in convection is unlikely.

M.Hojjat, S.Gh. Etemad et al. [64] investigated on micro models with device level model mass fluxes at the liquid vapour inter-phase depends on wick micro structures integration on evaporation and condensation. **M.Hojjat, S.Gh. Etemad et al. [64]** research on thermal resistance and the heat input with different volume fractions of NANO fluid and filling ratio and suggested that both are influencing in results. **S.Vaidyanathan [65], Jian Q, Qian Wang et al.[66]** stated that in steady state conditions by using NANO fluids and heat inputs can increased, decreased consequently to check thermal performance in heat pipe, surface temperatures should be measured to give better inputs. Electronic equipment dissipates enormous amount of heat while in operation which affect the working efficiency of the systems. **Yandi Song, JinliangXu [67]** concluded that NANO fluids improve the performance of heat pipe, even though enhancements taken place more than base fluid many objectives like particle size, concentration, shape and materials and its thermal conductivity will affect the final results. **HimelBarua, Chowdhury et al. [68]** worked on pulsating heat pipe characterization rapid cooling and heating applications depends on the thermal conductivity of the material used. **Rahul S.Borkar, Pramod et al. [69]** In case of applying a surface complication model for the measurement data the hydrodynamic size, u potential and thermal conductivity automatically changes and influences the surface parametric conditions which are incorporated with factors of all mechanisms in closed loop pulsating heat pipe. **P. Yeunyongkul, P. Sakulchangsatjatai et al.[70**] worked on VCR systems with closed loop and oscillating heat pipe, heat transfer fluids are a crucial parameter that affects the size and costs of heat pipes.

The performance of heat is enhanced at different positions of heat pipe. **A. Kamyar, et al. [71]** in their research with thermosyphon
heat pipe with two phase stated that pipes are the devices which can transfer heat from heat sink with a minute temperature difference most of these heat pipes fabricated with screen mesh, sintered powder or machined grooves as wick

VII. CONSIDERABLE RESULTS

To prepare NANO particle concentrations two methods are mostly implemented one is volume concentration of fluid with compensation of weight and PPM (parts per million). The experiments often taken concentration ranges between 0.003 to 5.3 as volume percentage, 0.1 0.5 weight percentage and 1 to 10^4 PPM.

Author	Heat Input (w)	$D_i/L_{hp}/L_e/L_c$ (mm)	Inclination (^{0})	Fill ratio in %	Suspension	d_{nf} (nm)	Volume % (or) Weight%
Peng Cheng Scott Thompson	50-100	6.35/200/50/50	0,30,60,90	……	H_2O/Ag	30	0.25,0.5,0.75 vol%
Lanchao Lin and Amir Faghri	40-60	20/120/40/40	90	25-100	H_2O/Al_2O_3	40	0.25,0.5,0.75,1 .2 vol%
Woo-Sung HAN	3-15	3/300/50/150	0	…..	H_2O/Al_2O_3	0	1.0,3.0 vol%
Chu Nie W.H. Marlow	10-140	12/330/100/150	0,30,45,60,90	Saturated	H_2O/CuO	50	0.5,1.0,1.5 wt. %
Las Vegas	30-70	20.8/600/150/1 50	0,30,60,90	20,40,60	H_2O/Al_2O_3	50	0.1 vol%
M.G. Mousa	20-40	9.52/0.3,0.45,0. 6/	10,40,70,90	20,40,60,80	H_2O/Al_2O_3	10-30	0.5,1.0,3.0 wt%

Karim Alizad, Kambiz et al. [72] investigated the performance of heat pipe with silver Nano fluid in D.I water. Vapour temperature get reduced due to high conductivity of Nano fluid. Reduction in evaporator surface temperature with increase in concentration of nanoparticle is due to augmented heat transfer and increase in evaporator surface area.

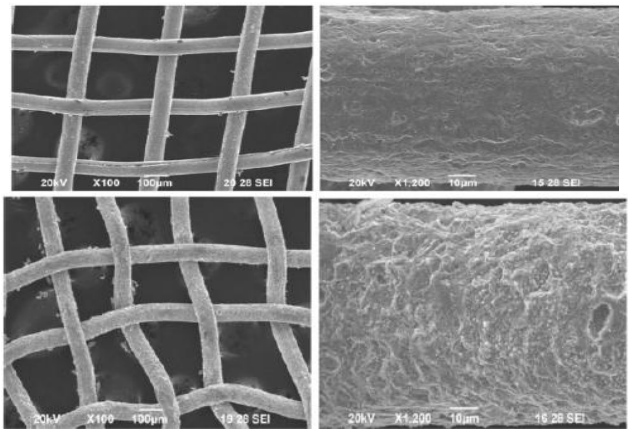
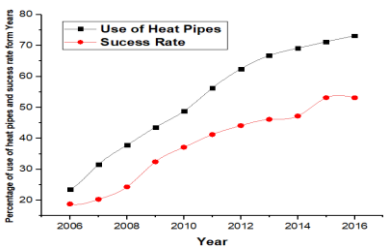


Figure SEM image of the screen mesh wick surface after the experiment with Nano fluid as working fluid



Graph: shows use of heat pipes and their rate of success during the past decade.

VIII. CONCLUSIONS:

Experimental and simulative investigations on cylindrical screen mesh wick heat pipe. The investigations mostly on the water based fluids, some enhancements of NANO particle additions also taken in to consideration. In that most are closed loop and two phase heat pipes. Some investigations revealed that NANO particle addition to the base fluid improve the performance of heat pipe. Investigations on mesh wick heat pipe with oscillating type needs some more enhancements to fulfill the requirement. The addition of NANO particles to water based fluids given better results than deionised water. In most of the researches optimal filling ratios are same, the existence of filling ratio between 45 to 85% similar to the water. While in some work, an optimum inclination angle is arrived at, others see a continuous change of thermal performance with changing angle. But they investigated in between 0^0 and 90^0. Heat input values at evaporation section ranged from as minimum as 3 W to a maximum of 140 W in different works. Nano fluid particle concentrations ranging from 0.003 to 5.3 vol% from 0.1 to 0.5 wt% from 1 to 10^4 ppm are utilized in the experiments. Nano fluids experimented in the studies carried out till now include Al_2O_3, CuO, Ag, TiO_2 etc., but still there is a lack of multiple angle inclination experiments and its characterization with NANO fluids.

The concentration of the NANO fluid for multiple intervals of angle for fixing

heat pipe, thermal performances need to evaluate for better conclusions with mesh attachment in cylindrical heat pipe.

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