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METHODS OF ENHANCEMENT OF HEAT TRANSFER THROUGH HEAT PIPE- A REVIEW

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ABSTRACT

Heat pipe is a passive two-phase heat transfer device for handling moderate to high heat fluxes typically suited for different applications. At least three thermo-mechanical boundary conditions have to be met for the device to function properly as heat pipe. This includes internal tube diameter, applied heat flux and filling ratio. Additionally the thermo-physical properties of working fluid also play a vital role in determining the thermal behaviour. This paper review the work carried out on closed loop heat pipe technology.

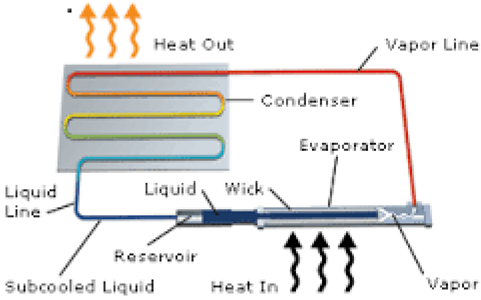
Keywords: Heat Pipe, Heat Transfer, Working Fluid.

I. INTRODUCTION

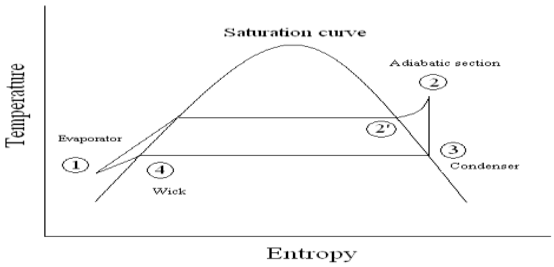
A heat pipe is a heat-transfer device that combines the principles of both thermal conductivity and phase transition to efficiently manage the transfer of heat between two solid interfaces. At the hot interface of a heat pipe a liquid in contact with a thermally conductive solid surface turns into a vapor by absorbing heat from that surface. Many researchers have investigated the performance of heat pipe. Some researcher has presented research on the design and experimental analysis of heat pipe. In this work different types of working fluids are taken for study. The different working fluid like Al_2O_3, CuO and SiC nanofluid with base fluid are used for enhancement of performance, this study observed the greater enhance in performance of heat pipe with nanofluids. [3][4][5][6].Some researcher has been worked on the

circular shape copper heat with commonly used working fluids. Chin-Chun Hsu et.al.[2] Performance testing of Micro Loop Heat Pipes. The MLHP is analyzed and tested for grooved wick structure; this study observed that small diameter of wick improved the performance of heat pipe. Some investigation of ultra-thin flattened heat pipes with sintered wick structure capillary and ternary fluid is used in the heat pipe for enhancing the performance of heat pipe [7][8][9].Shahryari et.al.[10] presented works on behavior of nanofluid in a cylindrical heat pipe with two heat sources is performed to analyze the nanofluid application in heat-dissipating satellite equipment cooling.

II. FUNDAMENTAL WORKING PRINCIPLES OF HEAT PIPES



A typical heat pipe consist of three main sections, which include an evaporator section, an adiabatic section, and a condenser section. Heat added at the evaporator section vaporizes the working fluid, which is in equilibrium with its own vapour. This creates a pressure difference between evaporator section and condenser section, which drives the vapour through the adiabatic section. At the condenser section, heat is removed by condensation and is ultimately dissipated through an external heat sink. The capillary effect of the wick structure will force the flow of the liquid from condenser to evaporator section.



1-2 Heat applied to evaporator through external sources vaporizes working fluid to a saturated (2') or superheated (2) vapor.
2-3 Vapor pressure drives vapor through adiabatic section to condenser.
3-4 Vapors condenses, releasing heat to a heat sink.
4-1 Capillary pressure created by menisci in wick pumps condensed fluid into evaporator section.

III. AIM AND OBJECTIVES

Aim of this reviews to present the status of various authors reviews the techniques in heat pipe and nano-fluids.

Objectives are as follows-

I) To analyse experimentally the thermal performance of closed loop heat pipe using different nano- fluids.

II)Nano-fluid causes a drastic change in the properties of the system, which ultimately increases the overall heat transfer or experimentally studies the behavior of nano-fluid to improve the performance of a closed loop heat pipe.

III) To compare the present experimental work with previously done work.

IV. LITERARURE ON THE HEAT PIPE

R.A. Hossain et.al. [1] Presented the works on the Design, Fabrication and Experimental Study of Heat Transfer Characteristics of a Micro Heat Pipe. In this study the heat transfer characteristics, a micro heat pipe (MHP) of circular geometry having inner diameter 1.8mm and length 150 mm is designed and fabricated. An experimental investigation is carried out also to investigate the performance of the MHP with different experimental parameters like inclination angle, coolant flow rate, working fluid and heat input. Three different types of working fluids are used; acetone, ethanol and methanol. For each working fluid, heat transfer characteristics are determined experimentally for different inclination angle and different coolant flow rate at different heat input. Acetone is proved to be better as working fluid. A correlation is also made for acetone to relate other experimental parameters for determination of heat transfer coefficient.

Chin-Chun Hsu et.al [2] have been studied on Performance Testing of Micro Loop Heat Pipes, in this work A 60 mm x 33 mm x 0.8 mm micro loop heat pipe (MLHP), consisting of an evaporator, vapor line, condenser and two liquid lines, was fabricated and characterized. In this work the heat pipe is with wicking structure consists of parallel V-grooves with a hydraulic diameter of 47m, 67m and 83m, and is formed by bulk silicon etching. The working fluid used in this heat pipe is Water and methanol. The test results showed that water demonstrates a wider heat load performance range(3.3 W~12.96 W) than methanol (1.2 W~5.85 W) for the MLHP with an evaporator area of 1 cm^2 and condenser temperature of 17 ^{0}C.The results shows that The smaller diameter grooves caused the higher liquid capillarity and enhanced transfer capacity. It was observed that the presence of non-condensable gas negatively affected the reliability of the MLHP and significantly reduced the performance.

M. Ghanbarpour et.al. [3] have been worked on the thermal performance of screen mesh heat pipe with Al2O3 nanofluid. This study presents the effect of Al2O3 nanofluid (NF) on thermal performance of screen mesh heat pipe in cooling applications. Three cylindrical copper heat pipes of 200 mm length and 6.35 mm outer diameter containing two layers of screen mesh were fabricated and tested with distilled water and water based Al2O3NF with mass concentrations of 5% and 10% as working fluids. The results show that using 5 wt.% of Al2O3 NF improves the thermal performance of the heat pipe for increasing and decreasing heat fluxes compared with distilled water, while utilizing 10 wt.% of Al2O3 NF deteriorates the heat pipe thermal performance. For heat pipe with 5 wt.% Al2O3 NF the reduction in thermal resistance of the heat pipe is found to be between 6% and 24% for increasing and between 20% and 55% for decreasing heat fluxes, while the thermal resistance increased between 187% and 206% for increasing and between 155% and 175% for decreasing steps in heat pipe with 10 wt.% of Al2O3 NF.

Kyung Mo Kim et.al. [4] have been worked on the Comparison of thermal performances of water-filled, SiC nanofluid-filled and SiC nano particles-coated heat pipes. In the present study, thermal performances of water-filled and 0.01 and 0.1 vol% SiC/water nanofluids-filled heat pipes with a screen mesh wick and water-filled heat pipe with a SiC nanoparticles-coated screen mesh wick were compared in order to investigate the effects of nanoparticles depositions on inner surface structures of heat pipes. The wall temperatures of the SiC nanoparticles-coated heat pipe were found to be higher than those of an uncoated heat pipe while the thermal performance for the heat pipe using a SiC/water nanofluid was not enhanced compared to the heat pipe using water as a working fluid.

Hamdy Hassan et.al. [5] studied on the effect of using nanofluids on the performance of rotating heat pipe. In this work nanofluids have novel properties that make them potentially useful in many heat transfer applications. This paper presents a study on the effect of using nanofluids on the performance of rotating heat pipe. The effect of using nanofluids on the heat transfer and liquid film thickness is carried out. Three solid nanoparticles are used Cu, CuO and Al2O3 at different nanoparticles radiuses and volume fractions with water as working fluid were presented. The results of study proved that rotating heat pipes with Cu–water nanofluid have maximum heat transfer compared with CuO–water and Al2O3–water nanofluids. The maximum heat transfer by rotating heat pipe at $\Delta T = 20$ °C and $\omega = 3000$ rpm increases by about 56% due to using Cu–water nanofluid with Cu nanoparticles of volume fraction 0.04 and radius 5 nm.

Xinjun Su et.al. [6] have been worked on enhancement of heat transport in oscillating heat pipe with ternary fluid. In this work heat transfer performance of an oscillating heat pipe (OHP) is the presented. The heat transport performance of the OHP is investigated using two types of binary fluids and a type of ternary fluid as the working fluids. The working fluids include a nanofluid, self-rewetting fluid, and a mixed solution of self-rewetting fluid and a nanofluid called self-rewetting nanofluid. The tilt angle of the OHP is 90° with a charge ratio of 50%. In contrast to de-ionized water used as a base working fluid in the OHP, all working fluids can enhance the heat transport performance of the OHP. However, through an analysis of the enhancement ratios, it is found that nanofluids can only enhance the performance of an OHP within a heat load range of 30–70 W. The maximal enhancement ratio is about 11% as the heat load is 60 W. If the heat load exceeds 70 W, the heat transport performance of the OHP degrades. For a self-rewetting fluid, the maximum of enhancement ratio is only 6% as the heat loads is less than 30 W, and then, as the heat load increases, the enhancement ratio decreases gradually.

Yong Li et.al.[7] have been studied on the Investigation of ultra-thin flattened heat pipes with sintered wick structure. This study proposes a novel sintered wick structure called bilateral arch-shaped sintered wick (BASSW) for the improvement of the ultra-thin heat pipes (UTHPs).An experimental apparatus was set up to investigate the thermal performance of the UTHP samples under

the impacts of incremental heat loads. The effects of each processing parameter on the thermal performance of the UTHP samples were analyzed and compared with a mathematical model incorporating effects of the evaporation and condensation heat transfer in a copper-water wick, results indicate that the most critical factor for thermal performance of UTHP is flattened thickness, as it decreases, the heat transport capability drastically decreases and the thermal resistance increases.

K.V. Paiva et.al. [8] have been worked on the Wire-plate and sintered hybrid heat pipes. In this work a new hybrid heat pipe technology that associates high liquid pumping capacity of sintered metal powder structures with the low liquid pressure drop of diffusion welded wire-plate grooves is proposed in this work. It consists of covering both internal surfaces of the heat pipe casing plates, in the evaporator region, with layers of sintered metal powder wicks, while the wick of the adiabatic and condenser sections consist of grooved structures, sandwiched between the metallic casing plates and wires welded by diffusion process. The results obtained from new heat pipe design compared with therotical available data.

Shen-Chun et.al. [9] have been worked on the use biporous wick with two pore sizes to enhance the performance of loop heat pipe (LHP). This work varied the mixing ratio between high polymer PMMA, which was used to make large pores, and nickel powder, which was used to make small pores. The different PMMA configuration was used for produce the biporous wick, the product was put into LHP for performance testing and measurements. Experimental results indicated that a higher content of PMMA particles corresponds to better performance, but beyond a maximum and optimal content the performance worsens; results also indicated that larger powder size leads to better vapor transport and evaporation, but beyond a certain point the large pores can cause weakened structure.

Sihu Hong et.al.[10] have been worked on Experiment study on heat transfer capability of an innovative gravity assisted ultra-thin looped heat pipe. In this present work they have introduced a kind of gravity assisted ultra-thin looped heat pipe (ULHP) with 1.5 mm thick wickless flat evaporator that can be applied for power battery thermal management system, and investigated the heat transfer capability of the ULHP. Air cooling was used as the condensation method considering its advantage of low price and wide application in all walks of life. A series of experiments were conducted under different condensation powers during the same heating load range which started from 20 W to 80 W, to find out the best condensation condition of the ULHP. The experiment results indicated that the ULHP can work most effectively as the fan voltage was 9 V, under which the ULHP can start up at minimum heat flux of 0.22 W/cm2, with the start-up temperature of 47 °C, and the minimum thermal resistance was just 0.097 W/K during the heat load range from 20 W to120 W.

V. Ayel, L. et.al.[11] have been worked on closed loop Flat Plate Pulsating Heat Pipe (FPPHP) tested on ground and on board of an aircraft during the 60th ESA parabolic flight campaign, during which hyper- and microgravity conditions were reproduced. It is of a continuous rectangular channel (1.6 × 1.7 mm2) with 12 bends in the evaporator is machined. The channel is filled with FC-72 as working fluid with a volumetric filling ratio of 50%. Tests have been conducted with the FPPHP positioned both horizontally and vertically (bottom-heated).The results of study recorded thermal resistance and heat transfer coefficient for both consideration, and recorded improve value for horizontal position.

Table- Comparison of different working fluid, different length and diameter of heat pipe.

Sr No.	Authors	Diameter and length of pipe	Working fluids	Results
1	R.A.Hossain	Dia.-1.8mm, Length-150 mm.	Acetone, Ethanol And Methanol.	Acetone is proved to be better working than the ethanol and methanol.
2	Chin-Chun Hsu	Dia.-0.8mm, Length-180 mm.	Water and Methanol.	The test results shows that water demonstrates a wider heat load performance range (33 W-12.96W) than methanol (1.2W-5.85W).
3	M.Ghanbarpour	Dia.-1.6mm, Length-200 mm.	Al_2O_3 and Distilled water.	Result shows that using 5% of Al_2O_3 improves the thermal performance of heat pipe
4	Kyung Mo.Kim	Dia.-1mm, Length-150 mm.	SiC Nanofluid and SiC nanoparticles coated heat pipe.	Thermal performance for the heat pipe SiC/water nanofluid was not enhanced compare to heat pipe using water as a working fluid.
5	Hamdy Hassan	Dia.-1mm, Length-100 mm.	Cu,CuO, Al_2O_3.	Cu-water nanofluid have maximum heat transfer compared with CuO water and Al_2O_3-water Nanofluid.
6	Xinjun Su	Dia.-1.5mm, Length-150 mm.	Two binary fluid And one turnary Fluid as a working Fluid.	It is found that, nanofluid can only enhance the performance of an oscillating heat pipe within the heat load range of 30-70W.

V. CONCLUSION

In this paper, the effort has been made to review the work carried out by researchers on the heat pipe technology .It is observed that ,the use of nano-fluids in the heat pipe can give the better performance.

I. With the use of nano-fluids, it increases the thermal performance of the system.

II. Use of nano-fluids give better result than the other fluids.

III. It also help to increase the heat transfer rate.

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