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Analysis of Heat Pipe

Bhavantu Karanjkar[1], Pratik Patil[2], Sanket khomane[3], Aditya Bobade[4], P. N. Patil[5]
Student, Department of Mechanical Engineering[1,2,3,4]
Guide, Department of Mechanical Engineering[5]
JSPM'S Jayawantrao Sawant College of Engineering, Pune, India

Abstract: *Heat pipes are one of the most effective procedures to transport thermal energy from one point to another, mostly used for cooling. It is based on a combination of conduction and convectiveheat transfer, what makes it to a complex heat transfer problem. This project work is to perform theoretical analyses and review literature for the sake of Heat Pipe Heat transfer enhancement using different nano fluids. For enhancement of heat transfer in heat pipe, Nano fluid foundvital role and a new frontier in various engineering applications. This paper reviews and summarizes the work on heat pipes using nano fluids as a working medium. Various types ofnano particle with different base fluids as proved its potential to improve thermal properties of working medium in heat pipe. The effect of filling ratio, volume fraction of nano practices on thermal performance in various kinds of heat pipe with different base fluids under various operating conditions has been discussed. Mechanism of enhancement of heat transfer after utilization of nano fluids in heat pipe has been explained. Also, influence of dimensionless on thermal resistance in terms of correlation has been studied.*

Keywords: Analysis heat in pipe, transfer heat form one object to other end

I. INTRODUCTION

.Heat pipes should be more accurately termed heat transfer pipes since they make use of a circulating liquid-vapour phase change to transfer heat rather than generate heat. The term "heat pipe" has been widely used, and evidently acceptable to preserve. Of the many different types of systems which transport heat, the heat pipe is one of the most efficient systems known today. The advantage of using a heat pipe over other conventional methods is that large quantities of heat can be transported through a small cross-sectional area over a considerable distance with no additional power input to the system. Furthermore, design and manufacturing simplicity, small end-to-end temperature drops, and the ability to control and transport high heat rates at various temperature levels are all unique features of heat pipes. Research and development for new heat pipes such as loop heat pipes, micro and miniature heat pipes, and pulsating heat pipes, has matured enough for use in various applications. In addition, there are many archival and non-archival publications and reports related to heat pipes, dating back over the last four decades. The predecessor of the heatpipe, the Perkins tube, was introduced by the Perkins family from the mid-nineteenth to the twentieth century through a series of patents in the United Kingdom. Most of the Perkins tubes were wickless gravity-assisted heat pipes (thermosyphons), in which heat transfer was achieved by a change of phase (latent heat of evaporation).

II. LITERATURE SURVEY

Nano particles (nearly all types of nano particles) usage helps to enhance heat transfer effect due to working fluid and was critically examined through literature. Though nano fluids increases the heat transfer rate, but presence of nano particles in
flowing fluid causes negative effects also like pump and piping system damage due to high velocity impacts of particles, increased density of base fluid will result into higher power requirement to circulate the working fluid, pressure drop.
Power requirement based on nano addition, effect of temperature, viscosity, flow on radiator/heat exchanger/nano fluid effectiveness and the relation among them is not explored adequately to give significant conclusions.
Effect of nano addition is studied in detail for thermal performance of cooling system but very less work is done on effect of nano particles on system components and their performance.

2.1 Objective

1. Investigate of effect of varying length on heat transfer rate of Heat Pipe.
2. Study of effect of Nano fluid on performance of Heat Pipe.
3. Development of vacuum station with available vacuum pump for charging and replacing the working fluid in the Heat pipe.
4. Development and experimental analysis of Heat Pipe with CuO Nano fluid of concentration 2%, specific gravity 1.01 Kg/m3, and pH 9 for screen covered Axially Grooved wick structure.
5. Investigation performance of DI water Heat Pipe and CuO-water Heat Pipes under various working conditions and parameters like Angle of inclination, Method of cooling Natural and Forced, Length wise heat transfer rate, Thermal Conductivity, Thermal Resistance, Efficiency

III. WORKING PRINCIPLE

A heat pipe is a closed device containing a liquid that transfers heat under isothermal conditions. It operates through vaporization of liquid in an evaporator, transport and condensation of the vapor, and return flow of liquid by capillary action through a wick structure back to an evaporator. Due to geometrical requirements, the adiabatic section is designed to fit within spacing limitations of the heat pipe. Adiabatic implies zero heat transfer, as in a well-insulated section. Thermal energy from the external source is transferred to the working fluid in the heat pipe at the evaporator section. At the end of the heat pipe, a buffer volume may be constructed to enclose a non-condensable gas (such as helium or argon) for controlling the operating temperature, based on control of pressure within the inert gas. Flow of vapor occurs through the core interior region of the heat pipe at high velocities to the condensing section (up to 500 MPH in some cases).Along the inner wall of the container of the heat pipe, a porous wick material with small, random interconnected channels is constructed for capillary pumping. The pores in the wick act as a capillary "pump," which acts analogously to regular pumping action on fluids in pipes by pumps. The wick provides an effective means of transporting liquid back to the evaporator through surface tension forces acting within the wick. Also, it serves as an effective separator between vapor and liquid phases, thereby allowing more heat to be carried over greater distances than other pipe arrangements..

In a typical example of a heat pipe with water as the working fluid and a vessel material of copper-nickel, an axial heat flux of about 0.67 kW/cm2 at 473 K and a surface heat flux of about 146 W/cm2 at 473 K are generated. For moderate operating temperatures (i.e., 400-700 K), water is the most suitable and widely used working fluid in heat pipes. The vapor pressure changes along the heat pipe are due to friction, inertia and blowing(evaporation) and suction (condensation) effects, while the liquid pressure changes mainly as a result of friction. The liquid-vapor interface is flat near the condenser end cap corresponding to a zero local pressure gradient at very low vapor flow rates

IV. DESIGN

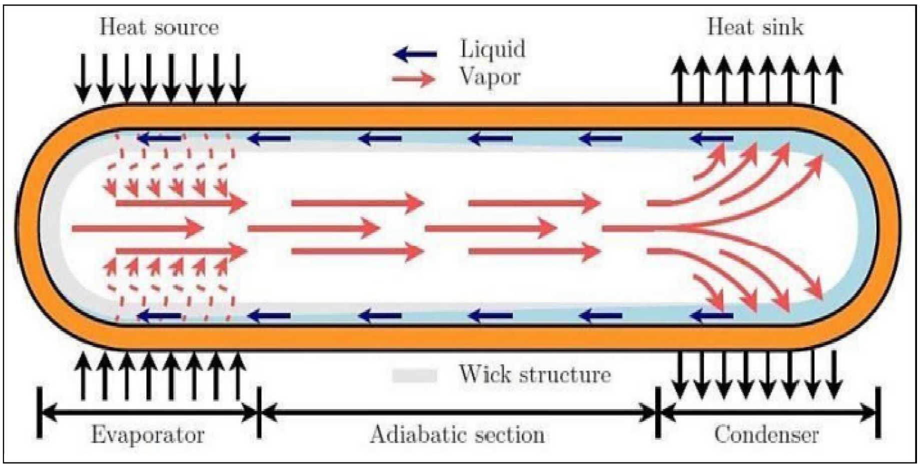

Fig.1 Schematic representation of Heat Pipe with working principle

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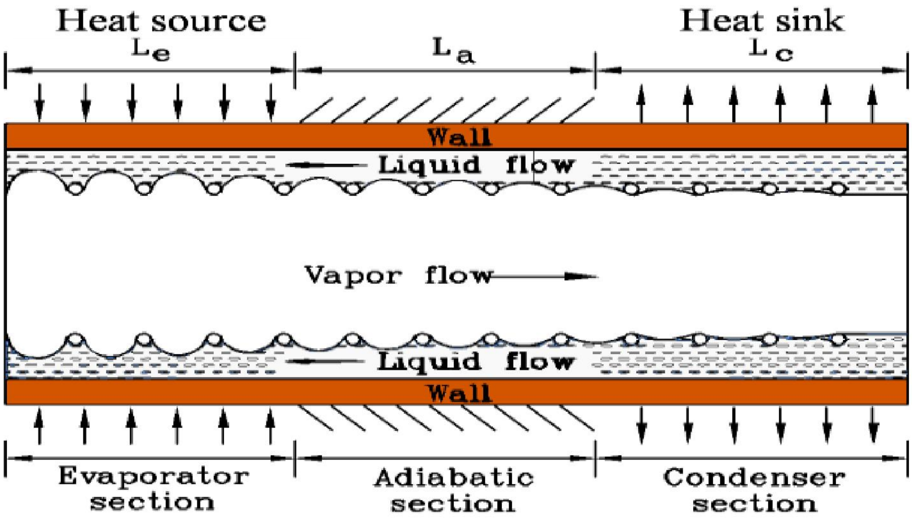
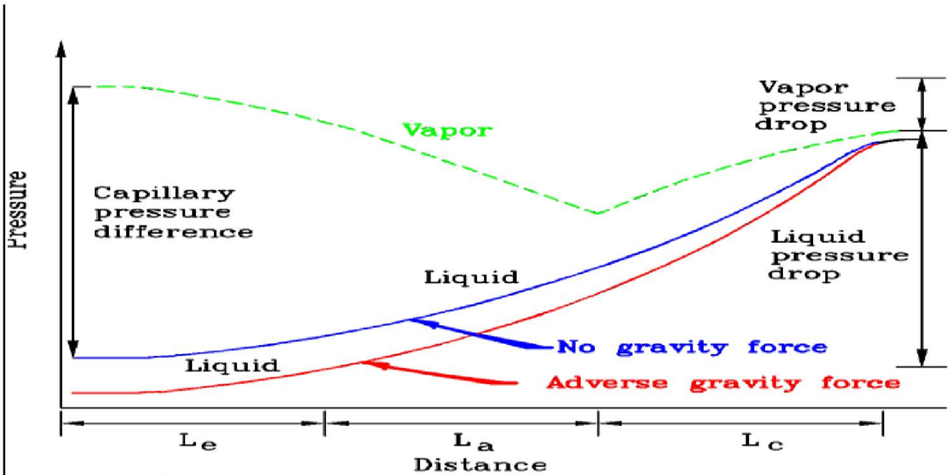


a) Liquid–vapor interface



b) Vapor and liquid pressure distributions

Calculations

Sr. No.	Volume concentration, Φ (%)	Weight of nanoparticles (W_{CuO}), Grams
1	0.1	0.60872
2	0.2	1.21865
3	0.3	1.82981
4	0.4	2.44220
5	0.5	3.05582
6	0.6	3.6706
7	0.7	4.28676
8	0.8	4.90409

Table 1 - Volume concentrations of CuO nanoparticle with corresponding weight

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Cp VALUE FOR WATER = 4187 J / Kg. k
Area (Heat Pipe) = 4.8287*10-4 mm2
Axially Rectangular Groove Dimension = 1.4 mm * 0.3 mm
Area for Internally Bored Cu Pipe = 3.132*10-4 mm2
Mass flow rate = 2.4 * 10-3 Kg/

Calculation table

Pipe	ΔT {^{0}c}	LENGTH {m}	Q out {W}	RTh	slop	Q avg	K	η %
300 mm - 0^0	7.5	0.3	75.37	$99.51*10^{-3}$	109.62	87.685	1656.48	75.37
300 mm - 45^0	8.4	0.3	84.41	$99.51*10^{-3}$	156.12	92.205	1223.06	84.41
300 mm - 90^0	6.8	0.3	68.33	$99.51*10^{-3}$	206.21	84.165	845.23	68.33
400 mm - 0^0	7.4	0.4	74.36	$99.51*10^{-3}$	79.55	87.18	2269.49	74.36
400 mm - 45^0	7.9	0.4	79.39	$99.51*10^{-3}$	149.3	89.695	1244.11	79.39
400 mm - 90^0	6.2	0.4	62.3	$99.51*10^{-3}$	169.4	81.15	992.03	62.3
500 mm - 0^0	7.6	0.5	76.37	$99.51*10^{-3}$	32.21	88.185	5669.64	76.37
500 mm - 45^0	8.7	0.5	87.42	$99.51*10^{-3}$	17.41	93.71	11146.51	87.42
500 mm - 90^0	7.4	0.5	74.36	$99.51*10^{-3}$	21.12	87.18	8548.2	74.36
500 mm - 0^0 – CuO nanofluid	6.5	0.5	78.38	$99.51*10^{-3}$	18.813	89.19	9817.7	78.38
500 mm - 45^0 -CuO nanofluid	9.1	0.5	91.44	$99.51*10^{-3}$	13.937	95.72	14222.8	85.42
500 mm - 90^0 – CuO nanofluid	4.7	0.5	61.3	$99.51*10^{-3}$	15.267	80.65	10939.62	61.3
600 mm - 0^0 – bored Cu Pipe	5.7	0.6	57.28	$99.51*10^{-3}$	121.6	78.64	1317.478	57.28
600 mm - 45^0 -Bored Cu Pipe	6.2	0.6	62.3	$99.51*10^{-3}$	89.4	81.15	1849.2	62.3
600 mm - 90^0 -Bored Cu Pipe	4.4	0.6	44.21	$99.51*10^{-3}$	122.1	72.105	1203.05	44.21

Table 17: Experiment Result Table

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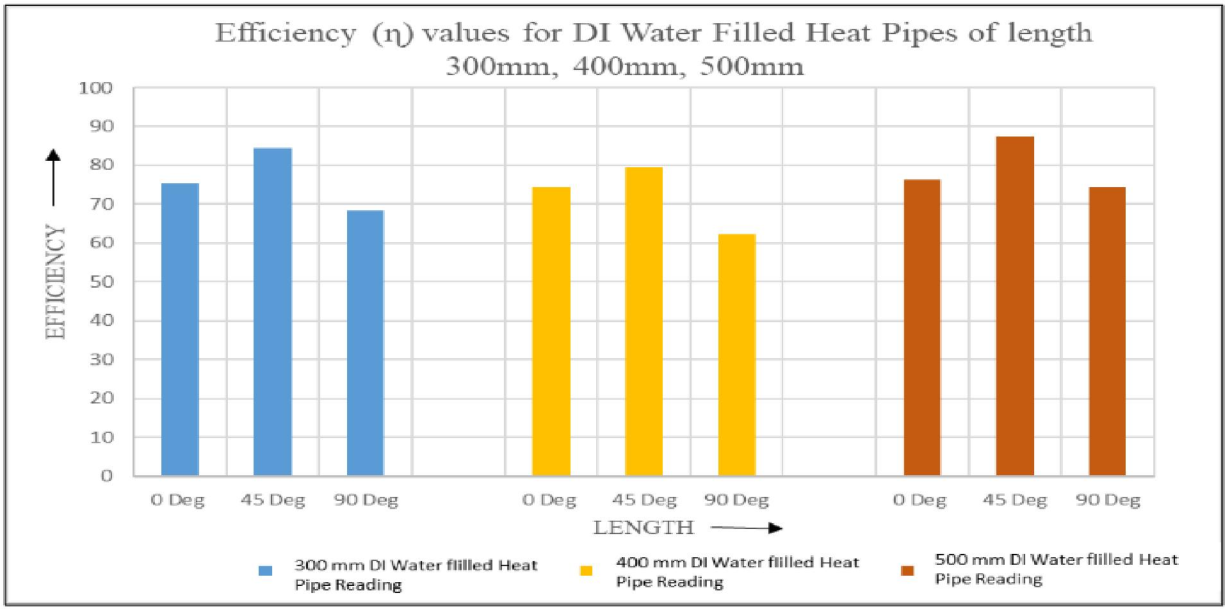
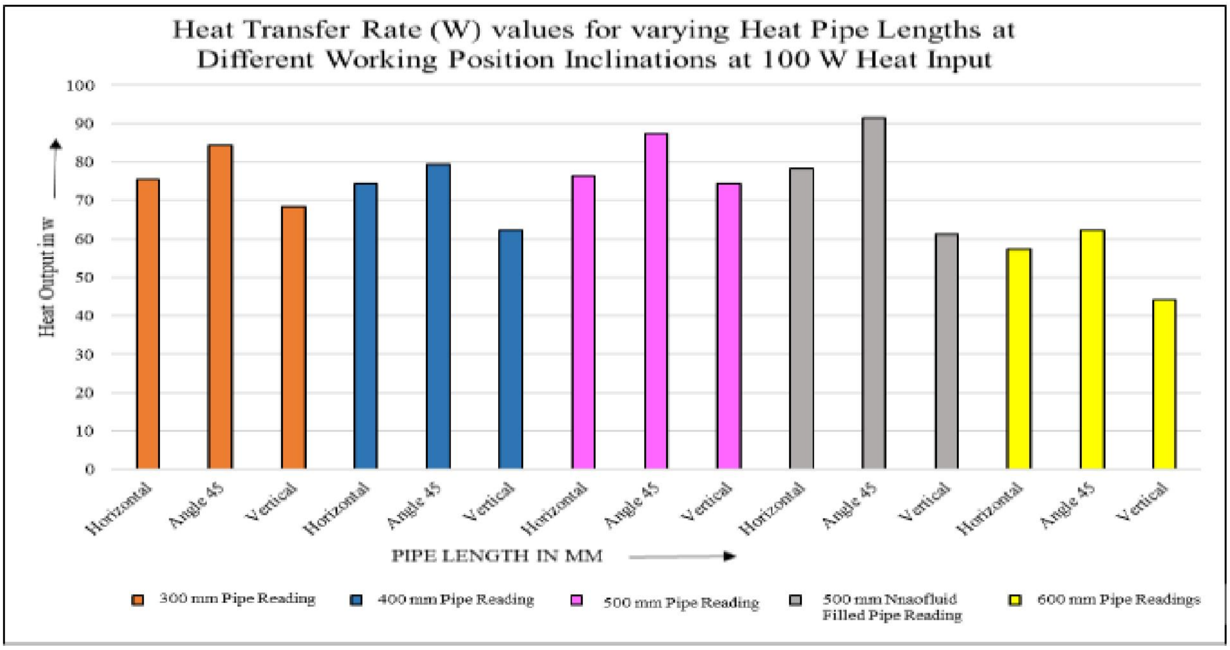
EFFECT OF HEAT PIPE LENGTH ON EFFICIENCY



Efficiency values for DI Water Filled Heat pipes of length 300mm, 400mm and500mm



Heat Transfer Rate For varying Length at different working positioninclinations at 100 W Heat Input

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FINAL MODEL OF THE PROJECT

IV. CONCLUSION

1. The operating temperature of the evaporator of a heat pipe should be such that the evaporation of the working fluid can occur in it and in the condenser; the condensation occurs in it. This is important, because, without phase change, heatpipe cannot be used as an effective device for enhancement of heat transfer.
2. The study reveals that the dominating parameters for the heat transfer of a heat pipe are saturated boiling temperature of the liquid, evaporator surface temperature, latent heat of vaporization of the working fluids.
3. The trend observed in varying length of pipes that, the thermal conductivity changes in accordance with length. The % increase in thermal conductivity is 73.16%,27.6%, 27.98% respectively for 00, 450 and 900 for 500 mm CuO nano fluid (2%)filled heat pipe compared to DI water Heat Pipe.
4. From experimentation, for 300mm and 400 mm pipe thermal conductivity is high at 0 deg and for 500 mm pipe it is high at 45 deg.
5. Efficiency of heat pipe is less at 900 and high at 450. It can be stated that efficiency is high in range of 00 to 450 and lesser at 900.
6. In this work, the thermal resistance of heat pipe remains same as the pipe material Copper remain unchanged in experiment.
7. The heat transfer capacity of copper tube is proportional to pipes cross sectional area.
8. Forced convection cooling provided to heat pipe increases the effectiveness along the length but decreases the efficiency of Heat pipe

V. FUTURE SCOPE OF THE PROJECT

1. The working fluid in heat pipe i.e. DI water and CuO Nano Fluid with base fluid water can be replaced with different working fluids as Al2O3, SiO, Ethelene Glycol, Ammonia, and readings can be taken to ananlyse effect of various nano fluids on heat pipe heat transfer.
2. Heat pipes with different wick structures can be investigated to determine effective and economic wick structure for specific or generalised operation.
3. From literature review, we can surely say that there are chances of better Heat transfer rate, Less Thermal Resistance and High Thermal Conductivity isobserved over the length by using CuO Nano Particle with water as a base fluid.
4. The parametric alteration like change in angle of inclination, heat input variation, Working fluid filling ratio, nano fluid concentration can be done to examine their effect on heat pipe heat transfer rate, efficiency, thermal resistance and Thermal conductivity

REFERENCES

[1]. Asirvatham et al. (2013) experimentally investigated the effects of using silverwaternanofluid on the heat transfer performance of a heat pipe and showed a substantialreduction in thermal resistance of 76.2% and an enhancement in the evaporation heattransfer coefficient of 52.7% for 0.009% silver nanofluid. Their results demonestrated that the use of nanoparticles enhances the operating range of heat pipe by 21%compared with that of DI (De-Ionized) water.

[2]. Hung et al. (2013) experimentally demonstrated the enhancement of the thermalperformance of a heat pipe charged with Al2O3/water nanofluid. The heat pipe in thisstudy was a straight copper tube with an outer diameter of 9.52 mm and different lengthsof 0.3 m, 0.45 m, and 0.6 m. Their results showed that at a heating power of 40 W, theoptimal thermal performance of heat pipes measuring 0.3 m, 0.45 m, and 0.6 m withAl2O3/water nanofluid was 22.7%, 56.3%, and 35.1%, respectively, better than thatwith heat pipes using distilled water as the working fluid. They also stated that thethermal performance of the heat pipe decreases with nanoparticle volume concentrationat the concentrations higher than the optimum. It is due to the fact that the highconcentrations of nanoparticles lead to high water absorption, which in turn facilitatesforming a coating layer through the sedimentation of nanoparticles on the surface of theevaporation section.

[3]. Kole and Dey (2013) prepared surfactant-free and fairly stable Cu-distilled waternanofluids and observed an enhancement of ~ 15% in the thermal conductivity for 0.5%copper nanofluid at room temperature. In their experiment, the thermal resistance of thevertically mounted heat pipe with the addition of 0.5% copper nanoparticles in distilledwater was reduced by ~ 27% and also the average wall temperature of the evaporator was reduced to 14°C at an input power level of 100 W

[4]. Shafahi et al., (2010) Studied the DI water filled Heat Pipe for various angles ofinclination. For the value of heat input 80 W and inclination angle 750 deep study wasdone and DI water, CuO nanofluids were used for experimentation. By using CuO NanoFluid the temperature gradient was obtained for different lengths of pipes