Experimental Investigation of Conventional Heat Pipe using Different Working Fluids

EzhilVannan S[#1], Shravan P M[#2], Sandesh Kumar A[#3]

[1]Assistant Professor, Mechanical Engineering Department, SJCE, Karnataka, India
[2]Student B.EMechanical Engineering, Mechanical Engineering Department, SJCE, Karnataka, India
[3]Student B.EMechanical Engineering, Mechanical Engineering Department, SJCE, Karnataka, India

Abstract---*Heat pipes are heat transfer devices used to deal with the high density electronic cooling problem due to their high thermal conductivity, reliability and low weight. In recent years, the study of conventional heat pipes is more in demand because of the drastic development of electronicand computers industries.This work attempts to design,fabricate and analyze the performance of conventional heat pipe with different working fluids such as water, distilled water, methanol and acetone. To enhance the thermal performance of heat pipe Cupric Oxide, a Nano fluid has been used.The heat pipe is fabricated by a straight copper tube with a 12 mm diameter and 300 mm long, copper layered with two layers of screen mesh wick for better capillary action is used. The parameter considered in this study is heat input. Water is used in the condenser to cool the heat pipe. Heat supplied from the heater is controlled by using a dimmer stat. Temperature difference of the water flowing in and out of the condenser is measured using a thermometer. Heat dissipated for different working fluids is calculated. A comparative study is then made for different working fluids.From the experimental results, comparisons of thermal performance were made between the heat pipes using various working fluids. The heat pipe operated with CuONanofluid showed higher results compared with water, distilled water, methanol and acetone.*

Keywords *--Heat Pipe, Nano-fluid, Screen mesh, Thermal performance*

I. INTRODUCTION

The effective thermal management becomes one of the major serious challenges in many technologies because of constant demands for faster speeds and continuous reduction of device dimensions [1]. As reliable and efficient devices, heat pipes have been of keen interest for many years. A heat pipe consists of an evacuated container, the interior of which is lined with a wick that is saturated with a small amount of working fluid. The heat is essentially transferred as latent energy by evaporating the working fluid in the evaporator and condensing the vapor in a condenser [2]. The circulation of working medium in the heat pipe is completed by the return flow of the condensate to the heating zone (evaporator) through the wick under the driving action of capillary forces. As the heat pipe utilizes the phase change phenomenon of the working fluid to transfer the heat effectively from the evaporator section to the condenser section, the selection of working fluids is very important to attain the enhancement of the thermal performance [3]. Heat pipes can be used to enhance heat transfer due to the phase change of coolant. They found wide applications in domestic and industrial sectors. Nanofluids are rapidly emerging as alternatives to the usual heat transfer fluids. Choi (1995) newly introduced special class of heat transfer fluids that contain nanoparticles less than 100 nm of metallic or non-metallic substances uniformly and stably suspended in a conventional heat transfer liquid, that the term is called as 'Nanofluids'. The studies show that the thermo physical and transport properties of the conventional fluids are improved by adding thenanoparticles in base fluid [4-6]. The effective thermal conductivity of Nanofluids increases with increase in temperature. This finding makes Nanofluids even more attractive as a cooling fluid for heat transfer devices with high energy density [5].Heat Pipes are used in many applications all from cooling of the CPU in a computer, space application, energy storage for some solar thermal applications, air conditions etc [7]. Microheat pipes with diameters small as 100μm, high temperature heat pipes with silver as working fluid(temperature up to 2300°C) and low temperature heat pipes with helium(temperature down to -271°C). There are many different kinds of heat pipes but the working principle is similar. To design a heat pipe there are three main selections are to be made namely, working fluid, case material and wick [8]. These are closely linked to each other to achieve best conditions. In the presenta conventional heat pipe is developed and different working fluids are used to study the rate of heat dissipation.

II. EXPERIMENTAL METHOD

A heat pipe is fabricated by using a copper tube of 12mm diameter and 300mm length, which acts as the container for the heat pipe. Both the ends of the copper tube were fitted with a tube neck so as to close the ends of the copper tube with a cap. The condenser pipe is also a copper tube of 4mm diameter. Both of these copper tubes have a thickness of 1mm. A stainless steel mesh is used, and acts as the screen type mesh. Artificial source of heat is required for the experiment to be conducted, this is done by using a cartridge heater. Dimmer stat is used so as to control the heat supplied by the heater and also provide same thermal load for all the cases.

The working fluids used are water, distilled water, methanol, acetone and cupric oxide(Nano-fluid). These fluids are selected so as to make a comparative study to determine the performance of the heat pipe. Water is used as the coolant and is made to flow in the condenser pipe.

III. EXPERIMENTAL PROCEDURE

The heat pipe developed was divided into three sections; evaporator (or heater) section, condenser section and adiabatic section. The evaporator and condenser section lies near the ends of the heat pipe. The condenser section consists of a condenser, i.e., a copper tube of 4mm diameter with water flowing inside it, wound around the heat pipe. The evaporator section consists of heater of 100W capacity fixed to the heat pipe. In the experiment the performance of the heat pipe was measured for five different fluids (water, distilled water, methanol, acetone and cupric oxide-nano fluid). The heat pipe was fitted with two tube necks, which facilitated with the supplying and removing of the working fluids. Once the working fluid is supplied inside the heat pipe, both the tube necks are closed. Power to the heater was supplied through a line supply and was controlled by a dimmer stat. Water is made to flow through the condenser using a flow regulator. Temperature of the water entering the condenser and exiting it is noted using a thermometer, in each of the five cases.Fill ratio means the percentage of the evaporator section volume that is filled by the working fluids. The fill ratios used in this experiment was 100% of the evaporator volume for all five different working fluids.The temperature of the water coming out of the condenser was taken for all the five working fluid with 100% fill ratio after the system reached a steady state condition.

IV. RESULTS AND DISCUSSION

Experiments were carried out on the heat pipe developed using five different working fluids namely water, distilled water, methanol, acetone and cupric oxide using normal water as a coolant which have varying useful working range of temperature are tested in this study. Heat was supplied using a heater and controlled using a dimmer stat. The volume of fluid was regulated by using of a flow controller, as were performed by various previous researchers. The heat pipe in all these five cases was filled to 100% of evaporator volume, i.e. 100% fill ratio. Thus in all the five cases, 25ml of the working fluid is filled inside the heat pipe (as it is the volume of the evaporator section). It was observed that the heat transfer was different for different fluids as discussed below.

Following are the temperature readings obtained for different working fluids

TABLE I

DIFFERENT FLUIDS WITH TEMPERATURES

Fluids	Boiling pt. (°C)	Inlet water temp. (°C)	Outlet water temp. (°C)	Heat dissipated (°C)
Water	100	32	39	7
Distilled water	100	31	39	8
Methanol	64.7	32	42	10
Acetone	57	31	43	12
Nano Fluid(Cupric Oxide)	205	27	46	19

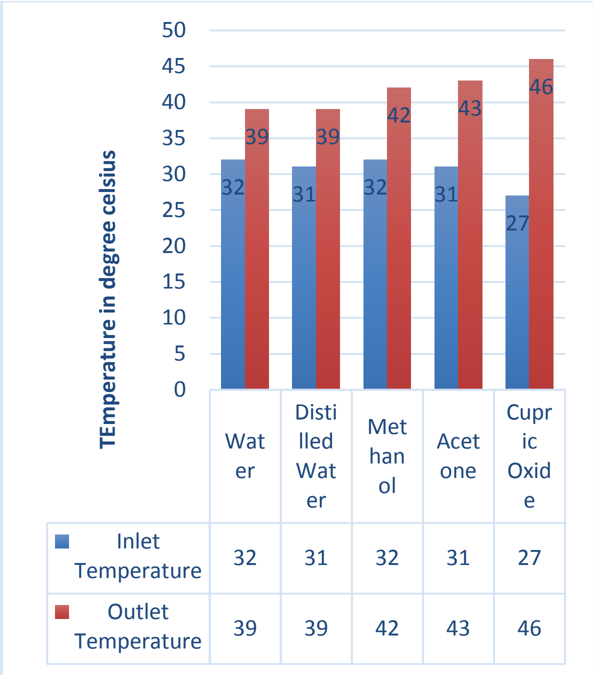

Fig.1 Graph representing the inlet and outlet temperatures of the condenser fluids for different working fluids

By comparing all the fluids, water gives 7 degree heat dissipation, distilled water gives 8 degree of heat dissipation, methanol gives 10 degree heat dissipation and acetone gives 12 degree heat dissipation. At last, when we tested for a Nano Fluid (Cupric Oxide), the amount of heat dissipation was found to be 19deg. By comparing all these results maximum heat dissipation is to be found among all these cases. Cupric Oxide provided the best results in terms of heat dissipation among these five fluids.

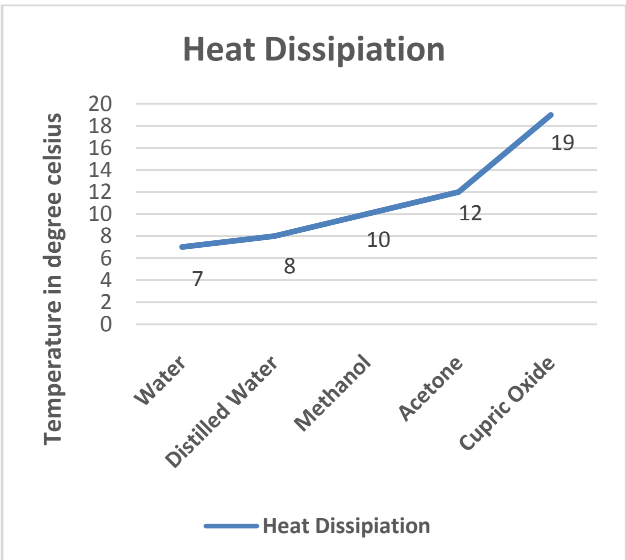

Fig. 2 Graph representing heat dissipation trend for different working fluids.

V. CONCLUSION

A conventional heat pipe was successfully developed, fabricated and tested with 100% fill ratio with water, distilled water, methanol, acetone and cupric oxide as working fluids.The review on heat pipes reveals that a detailed analysis on heat pipe can be done by working on different parameters like working fluid, wick structure, pipe material, and temperature profiles of heat source and heat sink and environmental conditions. From the investigation, the following findings are obtained:

- The working fluid properties affect the ability to transfer heat and the compatibility with the case and wickmaterial. Working fluid needs a compatible vessel material to prevent corrosion or chemical reaction.
- The Nano Fluid (Cupric Oxide) used provides the highest heat dissipation when tested, compared to the other working fluids like water, distilled water, acetone and methanol.
- Working fluids can be effectively functional at certain temperature ranges.
- Working fluid with higher heat dissipation property can be used to solve the rising heating problem in electronic devices, such as Cupric Oxide in this case.

REFERENCES

[1]. S. W. Chi, Heat pipe theory and practice, McGraw-Hill, Washington (1976).

[2]. G. P. Peterson, An Introduction to Heat Pipes, Wiley and Sons (1994).

[3]. KambleD.P, Gadhave P.S, M.A.Anwar Enhancement of Thermal Performance Of Heat Pipe Using Hybrid Nanofluid.International Journal of Engineering Trends and Technology (IJETT) – Volume17 Number 9–Nov2014

[4]. Wang X and Mujumdar A S, 2007 “Heat transfer characteristics of nanofluids: A review,” International Journal of Thermal Science, 46(1), 1–19.

[5]. A. K. Mozumder, A. F. Akon, M. S. H. Chowdhuryand S. C. Banik, Performance of heat pipe for different working fluids and fill ratios. Journal of Mechanical Engineering, Vol. ME 41, No. 2, December 2010

[6]. M.N.Khan, Utkarsh Gupta, Shubhansh Sinha, Shubhendu Prakash Singh, Sandeep Pathak. “PARAMETRIC STUDY OF THE PERFORMANCE OF HEAT PIPE – A REVIEW”. International Journal of Mechanical Engineering and Technology (IJMET), Volume 4, Issue 1, January- February (2013), pp. 173-184

[7]. Kavitha T, Rajendran A, Durairajan A and Shanmugam A, “Heat Transfer Enhancement Using Nano Fluids And Innovative Methods - An Overview” International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 2, 2012, pp. 769 - 782, Published by IAEME.

[8]. Y. Xuan and Q.Li, “Heat Transfer enhancement of Nano fluids”, International Journal of Heat and fluid Flow, vol.21, pg: 58-64, 2000.