Enhancement of Heat Transfer in Heat Pipe using Water/Tio_2 Nanofluid

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ABSTRACT: An experimental study was conducted to investigate the thermal performance of heat pipe by using Tio_2 Nanofluid. At present, the world is facing many problems in solving heat transfer issues in various systems. However fewer solutions are available to solve such problems. Nano fluid is used as one of the coolant to increase the efficiency of a heat pipe. Most of the electronic devices are releasing enormous amount of heat while in operation which affects the efficiency of a device. So heat pipes are used to remove the heat in electronic devices. The container and the wick were made of copper and stainless steel, where as the diameter and length of the heat pipe are 3 1mm and 500mm respectively. The maximum thermal load was 100w and the maximum temperature of heat pipe was around 373k. In that present work water, Tio_2 are used as coolants and investigated as at different temperatures. The experimental results are shown in graphs in the form of heat transfer, effective thermal conductivity and thermal resistance. The experimental results of Tio_2 are compared to base fluid Water.

Keywords: Heat transfer, Heat pipe, Nanofluid, Tio_2, Water.

I. INTRODUCTION

The idea of heat pipe was first suggested by Gaugler in 1942. Many other scientists also performed experiments on heat pipe and shown different results. A heat pipe is a device which transports heat at higher rate with a small temperature difference and it is a simple device with no moving parts. It is made of three sections with different lengths namely evaporator section, adiabatic and condenser section. At evaporator section the heat is absorbed and working fluid is vaporized and in adiabatic section heat is transferred to condenser section in the form of vapor. In condenser section the water is supplied to reject the heat and phase change takes place where as the vapor is condensed and turns into water. Wick is placed inside the heat pipe to provide capillary action for return of liquid to evaporator. Wick separates the vapor & liquid and flows opposite to each other in heat pipe where as vapor flows in between the wick and liquid returns to evaporator by above the wick. Wick structure has a strong effect on the performance of the heat pipe and design and structure of the wick is the most important factor.

The schematic diagram of heat pipe is shown in the below figure.

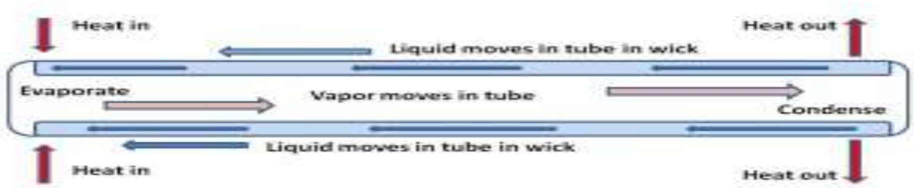


Fig.1: Schematic diagram of heat pipe

The heat transfer rate of heat pipe is increased by adding Nano fluid because of its heat transfer properties where as fluids like water, methanol, and glycol have poor heat transfer properties such as boiling limit, surface tension etc. The term Nanofluid was first used by Choi in 1995 and these nanofluids are formed by mixing nano particles with base fluid like water, ethanol, glycol and oil. The nano particles used in nano fluid are made of metals, oxides, carbons or nano tubes. Some of the nano fluids used in heat pipe are Al_2O_3, Cuo, Zno, and Tio_2.

II. EXPERIMENTAL SETUP

The experimental setup consists of heat pipe, heater, wick, ammeter, insulating material voltmeter, water storage tank, thermocouples and digital temperature indicator. The total length of heat pipe is 50cms and it is made of copper because copper is a good conductor of heat apart from silver and copper is cheaply available and economical than silver.

Table 1: Specifications of the heat pipe

Length in cms	Evaporator-16cms Adiabatic section10cms Condenser -24cms
Wick	stainless steel screen mesh 2 layers
Working fluid	water-270ml Tio_2 nanofluid-270ml Vol. concentration-0.1%
diameter in mm	Copper O.D-31.7mm I.D-25.2mm Stainless steel O.D-49.2mm I.D-45.3mm

Heat pipe consists of three sections which is evaporator section, adiabatic section, and condenser section where as evaporator section is heated by the electric heater by surrounding its circumference. The heat input is controlled by adjusting the ammeter and voltmeter and the maximum heat capacity of a heater is up to 100W. Temperature indicator is used to find the temperatures of a heat pipe at different sections by using thermo couples. Water storage tank is placed above the heat pipe for free flow of water and the maximum storage capacity of water tank is 15litres.

Fig.2: Experimental setup of the heat pipe

The screen mesh wick is placed inside the copper pipe which is made of stainless steel is shown in the fig.3 and the working fluid is water and Tio_2 (0.1% nano particles+ basefluid). Here the base fluid is water.

Fig.3: Stainless steel screen mesh

III. EXPERIMENTAL PROCEDURE

The experiment was conducted in horizontal position and the heat transfer by heat pipe occurs based on evaporation and condensation of working fluid. The heat pipe is filled with 270ml of water/Tio_2 and the heat input is given with the help of electric heater at the evaporator section. By varying with different heat inputs the heat pipe is heated and at the evaporator the liquid gets heated and it turns into vapor form.

The adiabatic section is insulated with the asbestos material to stop the heat loss from pipe wall surroundings. And in condenser section the heat is rejected by cooling process where as the cooling process is done by constant supply of water from the water storage tank to condenser inlet and the heat is rejected from condenser outlet in the form of water. Here in condenser section the phase change occurs and vapor turns into liquid.

The screen mesh wick is placed inside the heat pipe for free flow of liquid and it allows the liquid to return to evaporator section from condenser section. The heat input is increased and the decreased consecutively and the heat pipe surface temperatures are measured and recorded at steady state conditions. This process is repeated with different heat inputs & different base fluids and the temperature readings are obtained by using thermocouples which is attached at evaporator section, adiabatic section, condenser section, and water inlet & outlet. This process is repeated for both water and Tio_2. The temperature at the heat pipe is increases along with increase in heat input and the temperature difference between evaporator and condenser is increases larger. Heating load (Q_L) and temperature difference (ΔT) of input and output is measured. The water & water based nano fluid Tio_2 with mass concentration 1% is used to investigate the heat transfer rate, thermal resistance and effective thermal conductivity.

The amount of heat transfer occurred in heat pipe is calculated by measuring the temperature at evaporator section and condenser section and the flow rate of liquid in condenser. The unit for heat transfer rate is Kg/s.

$$Q = m\, c_p (T_{evp} - T_{con})$$

Where m is mass flow rate of liquid in Kg/s

c_p is specific heat of liquid in j/KgK

T_{evp},T_{con} are temperatures at evaporator and condenser section respectively in K.

The thermal resistance represents the effectiveness of a heat pipe and is denoted by R.

$$R = \frac{\Delta T}{Q_L}$$

and the units for thermal resistance is K/W

Where Q_L is heat input and $\Delta T = T_{evp} - T_{con}$

The effective thermal conductivity is calculated by using the below formula

$$K_{eff} = \frac{L_{eff} \times Q_L}{A_c \times \Delta T}$$

Where K_{eff} = effective thermal conductivity in W/mK.

$L_{eff} = 0.5 (L_{evp} + L_{cond}) + L_{adi}$

L_{eff} = effective heat transfer length of the heat pipe in mts.

L_{evp} = length of the evaporator section in mts.

L_{con}= length of the condenser section in mts.

L_{adi}= length of the adiabatic section in mts.

And $A_c = \frac{\pi}{4}(d_0^2 - d_i^2)$

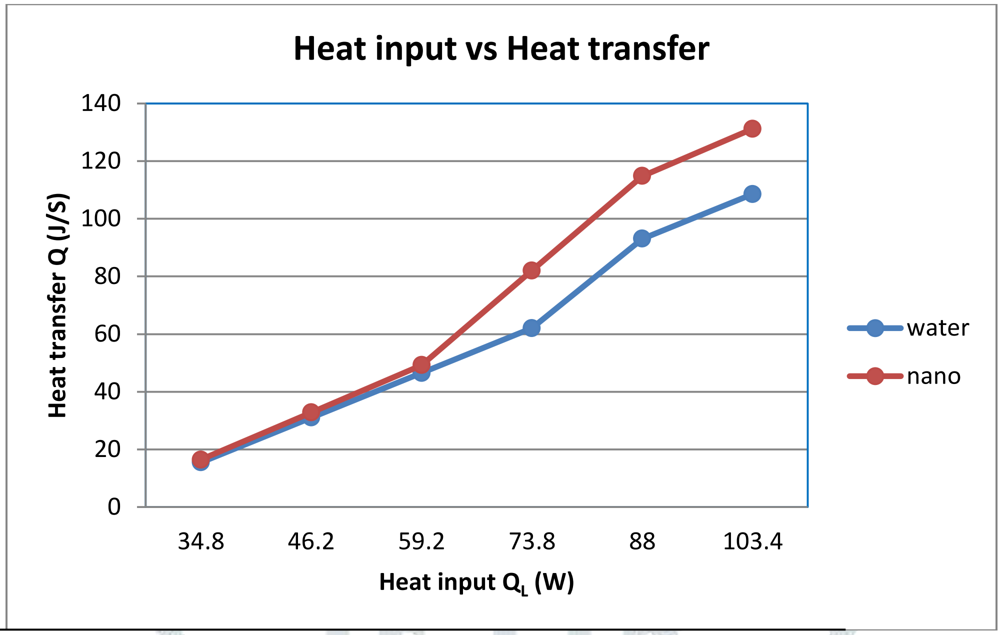
Where as

A_c= cross sectional area of pipe in m^2.

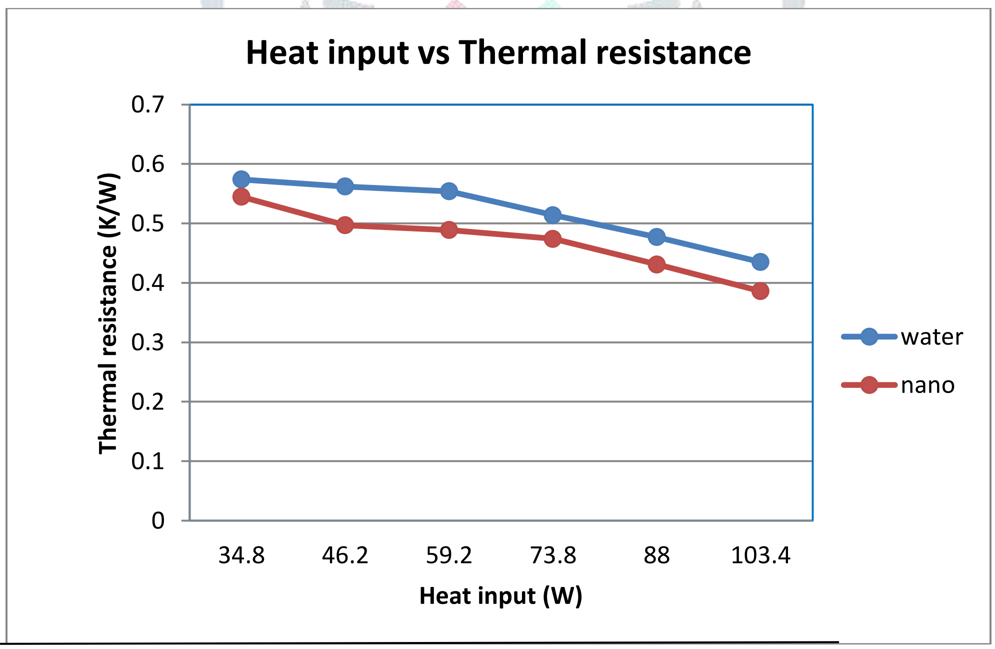
d_0= outer diameter of pipe in mm.

d_i= inner diameter of pipe in mm.

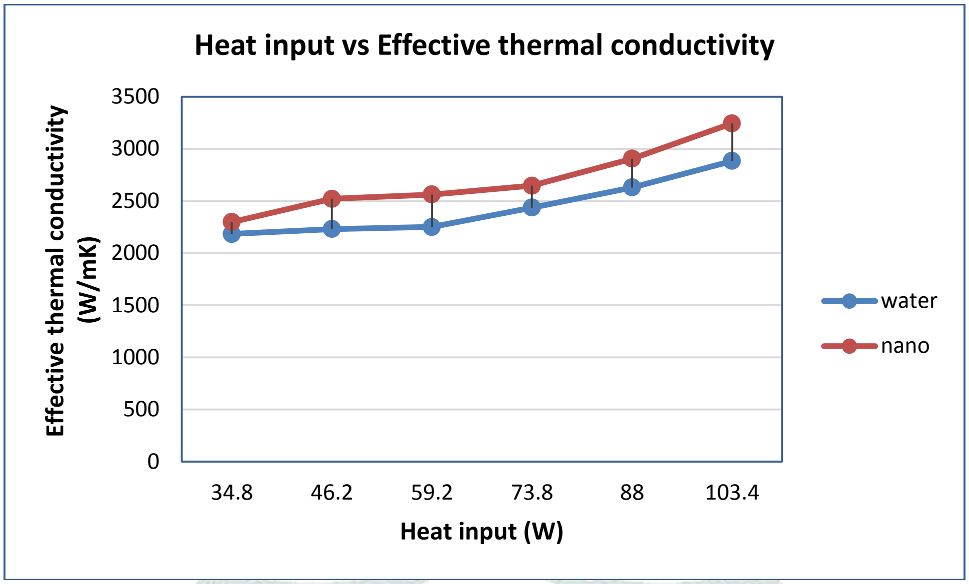
IV. GRAPHS



Graph 1: Comparing heat transfer rate of water and titanium dioxide (TiO_2)



Graph 2: comparing thermal resistance of water and Titanium dioxide (TiO_2)



Graph 3: comparing effective thermal conductivity of water and titanium dioxide (Tio_2)

V. RESULTS & CONCLUSION

An experimental study was performed to investigate the thermal enhancement of screen mesh heat pipe using water and Tio_2 nanofluids with mass concentration of 1%, focusing on heat pipes the thermal behavior by heat power input. The following conclusions are drawn from this study:

- The thermal performance of heat pipe increases while using titanium dioxide rather than water.
- The thermal resistance of heat pipe with titanium dioxide is lower than that of pure water heat pipe.
- The effective thermal conductivity of the heat pipe with Tio_2 gave optimum values to flow on the heat pipe compared with water.
- The heat transfer rate of titanium dioxide heat pipe as increases by 21% compared with the water heat pipe.
- While observing all the results the cooling effect has increased. Hence the performance of the heat pipe was enhanced.

VI. REFERENCES

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