An Experimental Study Of Heat Pipe Using CuO Nanofluid

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Abstract- *For the better performance of heat transfer in heat pipe nano fluid has vital role and new frontier in various engineering applications. In this paper the effect of copper oxide nano fluid (i.e copper nanoparticle with volume fraction of 0.05% mixed with pure water) on the heat transfer performance of heat pipe is studied. The heat pipe is straight copper tube with metal sintered powder wick structure .The heat pipe is tested at different orientation angles i.e* 0^0,30^0,60^0,90^0 *and for the different power inputs .This study presents the effect of heat input, inclination angle on the thermal efficiency and thermal resistance of heat pipe. Result shows that by filling nano fluid to the heat pipe, the thermal efficiency increases with increasing angle upto* 60^0 *and then decreases. It is maximum for* 60^0 *i.e. 60.2% when power supplied is 11.7W.*

Keywords- cylindrical heat pipe, CuO nanofluid, inclination angle, thermal enhancement.

I. INTRODUCTION

The heat pipes were developed especially for space applications during the early 60´ by the NASA. One main problem in space applications was to transport the temperature from the inside to the outside, because the heat conduction in a vacuum is very limited. Hence there is a necessity of development. Heat pipes are effective heat transfer devices in which the nanofluid operates in the two phases, evaporation and condensation. The heat pipe transfers the heat from the evaporator to condenser part. Nanofluids are mixtures consisting of nano particles and a base fluid. The various nanoparticles and nanofluids such as Aluminium oxide, Copper oxide, gold, silver, silica are used with the base fluid. There are three different regions present in the heat pipe i.e. evaporation section, adiabatic insulation section and condensation section. The heat input region of the heat pipe is called as evaporator and the output region is called as condenser. The region between evaporator and condenser is called as adiabatic insulator.

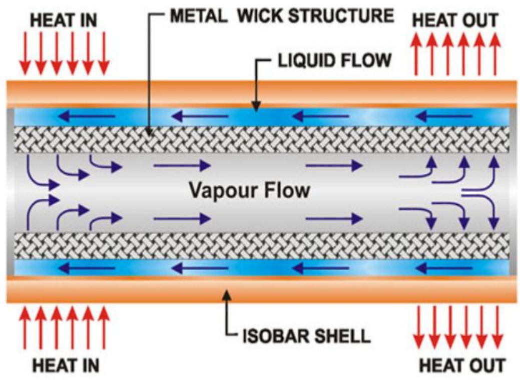


Figure:- Cross-Sectioned View of Heat Pipe

The orientation of a heat pipe plays an important role in its performance. The performance of a heat pipe under specific orientations is directly related to its wick structure. Wick structures with low capillary limit work best under gravity-assisted conditions, where the evaporator is located below the condenser. As compared to the heat pipe thermal performance is less affected by gravity and angle of orientation because of high capillary action of the wick . the heat pipe can change the orientation angle from -90° to +90°

II. LITERATURE REVIEW

Leonard M. Poplaski et al. [1] worked on Thermal performance of heat pipes using nano fluids. The performance of conventional thermal systems which use heat transfer fluid (HTF) may be improved by adding nanoparticles within the HTF (nano fluid).

A.A.Walunj et al [2] studied Heat Transfer Enhancement in Heat Pipe Using Nanofluid. For enhancement of heat transfer in heat pipe, Nano fluid found vital role and a new frontier in various engineering applications.

Taoufik Brahimn et al. [3] presented numerical case study of packed sphere wicked heat pipe using Al_2O_3 and CuO based water nano fluid. the thermal performance of a cylindrical heat pipe was numerically simulated in presence of water based nano fluid using a two dimensional proper numerical model.

P.R. Mashaei et al [4] worked on effect of nano fluid on thermal performance of heat pipe with two evaporators; application to satellite equipment cooling. A study on the behaviour of nano fluid in a cylindrical heat pipe with two heat sources is performed to analyse the nano fluid application in heat-dissipating satellite equipment cooling. Pure water, Al_2O_3-water and TiO_2-water nano fluids are used as working fluids

S. Venkatachalapathy et al [5] analyzed the thermal performance of a cylindrical copper mesh wick heat pipe using water based CuO nano fluids. Thermo physical properties of CuO / DI water nano fluids are also effectively analyzed.

G. Kumaresan S et al [6] studied enhancement in heat transfer characteristics of a copper sintered wick heat pipe with surfactant free CuO nanoparticles dispersed in DI water is experimentally studied. The effect of heat input, tilt angle and weight fractions of nanoparticles on the heat pipe thermal resistance, heat transfer coefficient in evaporator and condenser sections, thermal conductivity and thermal efficiency are investigated.

G. Kumaresan S et al [7] worked on comparative study on heat transfer characteristics of sintered and mesh wick heat pipes using CuO nano fluids. An experimental investigation has been carried out to compare the enhancement in the thermal performance of sintered and mesh wick heat pipes by varying the working fluid, inclination angle and heat input.

III. METHODOLOGY

It is proposed to complete a study in the interface between in order to understand the importance and functionality of nano fluids and the effect of nano fluids in heat pipes, an adequate nano fluids and heat pipe with focus on heat transfer principles e.g. thermal resistance and thermal conductivity, through a literature study and model analysis.

[A] Experimental Methodology

The heat pipe is mounted on a platform with changeable tilt angle. Thermal couples are installed to measure the temperatures at different points. Evaporator section is made up of said material in Table 1 which has electric heater, provided with fixed heating power. There is a cooling water passage at condenser section, allowing the external thermostatic device to provide cooling water at fixed temperature. The heat pipes have their vacuum pumped out, and are charged with nano fluids of different charge amounts as discussed later and weight fractions. Many researchers has calculated the ratio of removed energy of cooling water by condenser section to the heating power by evaporator section with different charge amounts, weight fraction of nanoparticle, and tilt angle of heat pipe, the effects of thermal efficiency under different experimental parameters has been evaluated.

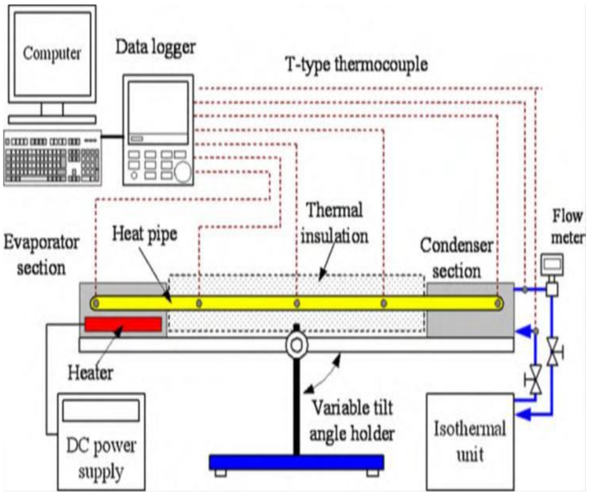


Figure:- Experimental Setup

[A] Heat Pipe

There are three different regions present in the heat pipe i.e. evaporation section, adiabatic insulation section and condensation section. The heat input region of the heat pipe is called as evaporator and the output region is called as condenser. The region between evaporator and condenser is called as adiabatic insulator.

Technical Specification:

1) Length of Heat pipe=500mm
2) Diameter=16mm
3) Condenser Length=80mm
4) Adiabatic Length=390mm
5) Evaporator Length=30mm

Figure:- Heat Pipe

[B] Band Heater

Band heaters are elements with different diameters and heights, designed to heat and to maintain the temperature of cylindrical parts. Heat transfer is achieved by conduction or by radiation for high power heaters

Technical Specifications:

1) Diameter= 25mm
2) length=25mm
3) wattage=500W

Figure:-Band Heater

[C] Rotameter:

A rotameter is a device that measures the volumetric flow rate of fluid in a closed tube. It belongs to a class of meters called variable area meters, which measure flow rate by allowing the cross-sectional area the fluid travels through to vary, causing a measurable effect.

[D] Voltage and ammeter digitial indicator:

It is a device that measure voltage ,ampere and frequency which can be vary by using dimmer whose values are shown on screen .

Technical Parameters:

1) 3 phase wire
2) Range: 5A/15VAC
3) AUX Supply:230VAC

[E] Submersible Pump

A submersible pump (or sub pump, electric submersible pump (ESP)) is a device which has a hermetically sealed motor close-coupled to the pump body.

Technical Specifications:

1) voltage:165/220 v
2) frequency: 50Hz
3) power=12/18w
4) H max=1.85 mtr
5) output=1100LPH
6) weight=730gms

[F] Digital Temperature Indicator

The temperature indicator indicates temperature and shows in the digital format. The thermocouple is attached which passes the signal to indicator.

Technical Specifications:

1) Temperature Indicator:4
2) Range:600 deg cel
3) Supply:240 V

Figure: - Rota meter

Figure:- Ammeter

Figure:- Submersible Pump

Figure:- Digital Temperature Indicator

i) The heat pipe is mounted on a platform with changeable tilt angle. ii) The heat pipe orientations are 0^0, 30^0, 60^0, 90^0. The heat pipe is insulated with foam i.e. heat resistant foam which consist a k type thermocouple for measuring adiabatic section temperature. iii) There is a cooling water passage at condenser section, allowing the external thermostatic device to provide cooling water at fixed temperature. iv) The heat pipes have their vacuum pumped out, and is charged with CuO nanofluid. v) The setup contains temperature indicator, Digital volmeter and ammeter, rotameter , voltage regulator (fan regulator) , band heater for heating purpose , submersible pump for water circulations , ball valve and water pipe. vi) In first step heat pipe is set at 0^0 and voltage regulator has been set at particular volt, after setting it we take the temperature reading of band heater (T1), adiabatic section(T2) , inlet water temp (T3) and outlet water temp(T4). vii) After taking these four readings at constant lpm again we increase voltage and repeat same procedure for different angles and different heat input.

viii) The calculations are done for following parameters,

i) Thermal Efficiency
ii) Thermal Resistance

1) For 0^0

Table 3.2.1

V	I	T_1	T_2	T_3	T_4
69	0.17	44	29	30	31
70	0.25	50	29	30.5	32
110	0.39	70	29	31.5	34
160	0.4	85	29	31	34

2) For 30^0

Table 3.2.2

V	I	T_1	T_2	T_3	T_4
69	0.17	62	29	30.5	31
70	0.25	70	29	30.5	31
110	0.39	82	29	31.5	32
160	0.4	90	29	31.5	33

3) For 60^0

Table 3.2.3

V	I	T_1	T_2	T_3	T_4
69	0.17	75	29	31	32
70	0.25	82	29	31	33
110	0.39	97	29	32.5	34
160	0.4	106	29	32	34

4) For 90^0

Table 3.2.4

V	I	T_1	T_2	T_3	T_4
69	0.17	80	29	30	31
70	0.25	88	29	30	32
110	0.39	102	29	31	33
160	0.4	112	29	31	33

II) For Titanium-Oxide Nanofluid

1) For 0^0

Table 3.2.5

V	I	T_1	T_2	T_3	T_4
69	0.17	47	29	30	32
70	0.25	54	29	30	32
110	0.39	76	29	31	33
160	0.4	91	29	30.5	34

2) For 30^0

Table 3.2.6

V	I	T_1	T_2	T_3	T_4
69	0.17	64	29	30	32
70	0.25	74	29	30.5	33
110	0.39	85	29	31	33
160	0.4	96	29	30.5	34

3) For 60^0

Table 3.2.7

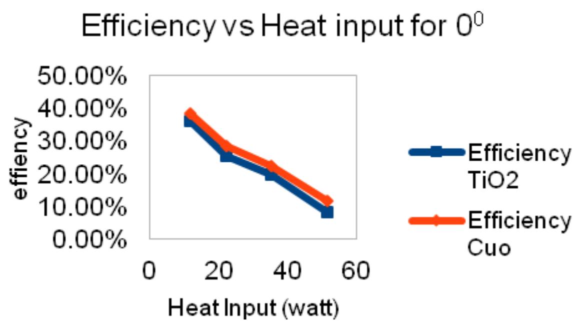
V	I	T_1	T_2	T_3	T_4
69	0.17	81	29	30.5	33
70	0.25	88	29	30.5	32
110	0.39	103	29	31.5	33
160	0.4	111	29	31	34

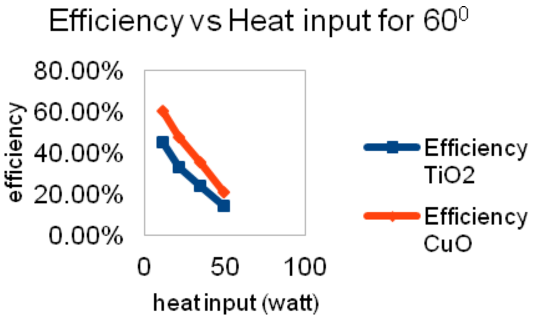
4) For 90^0

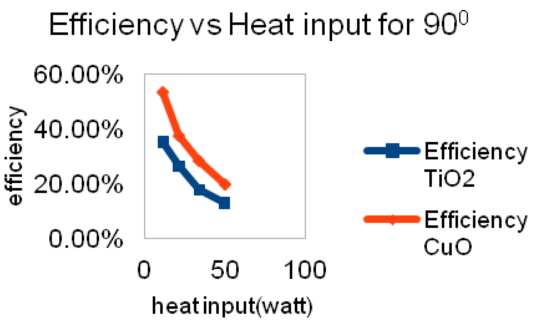
Table3.2.8

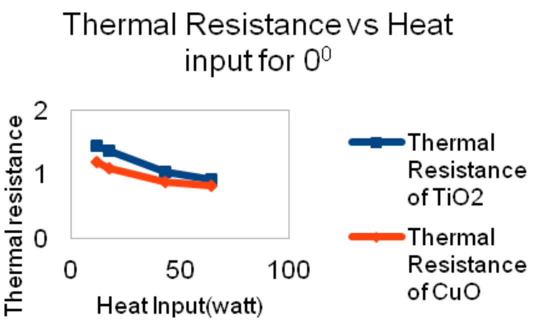
V	I	T_1	T_2	T_3	T_4
69	0.17	87	29	30	31
70	0.25	95	29	30	32
110	0.39	109	29	31	32
160	0.4	121	29	31	33

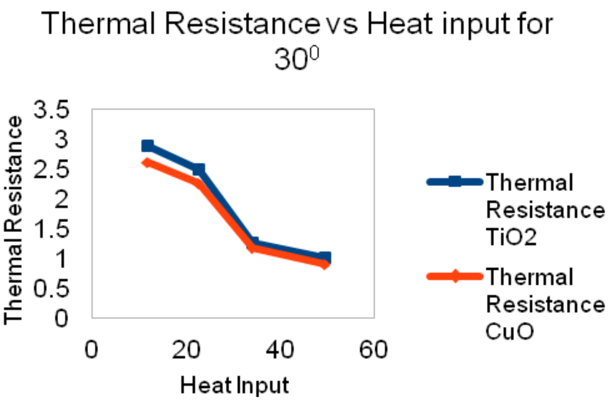
IV. RESULTS

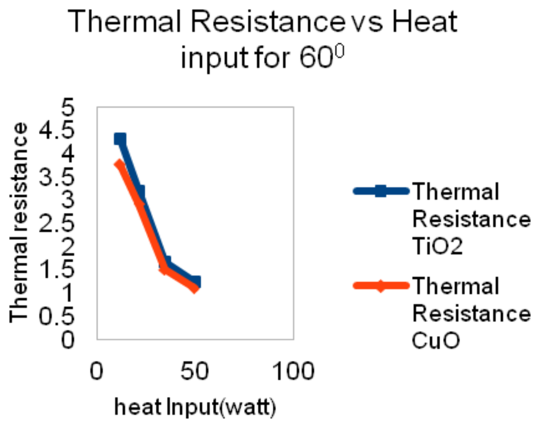


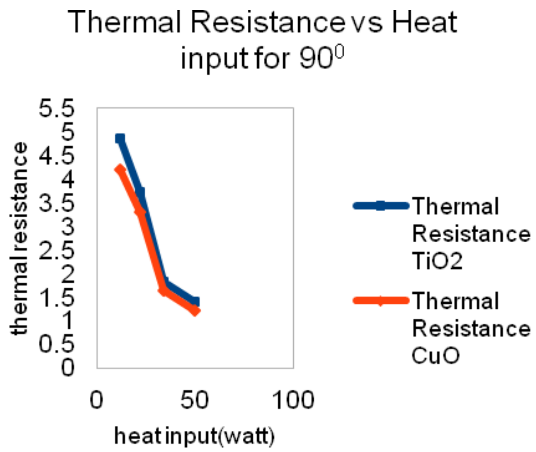


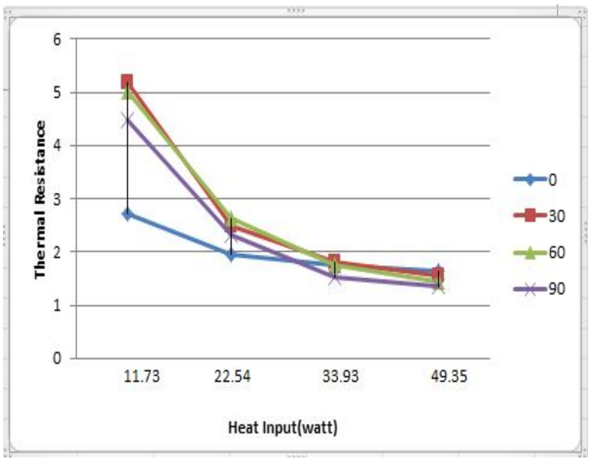












V. CONCLUSIONS

CuO-water nanofluids can bring a lower total resistance value and also contributes to make the temperature more uniform along the heat pipe. The CuO-water nanofluids can promote the thermal enhancement of around 30-40% even when prepared by 2-steps method if a reasonable sonication time is applied. It seems there is an ideal mass fraction wt.% or volume fraction vol.% for each application, which must be carefully investigated according to experiment and application parameters. The thermal enhancement of CuO-water nanofluid can vary with mass fraction wt.% variation

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