# Performance Evaluation of Heat Pipe using $TiO_2$ – CuO Nanofluid

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*Abstract*— The project work investigate thermal performance of heat pipe is carried out with using hybrid nanofluid, which is the combination of TiO2 and CuO with DI water. And compare it with the result of single nanofluid in heat pipe. The TiO2 is no toxic, easily available with great dispersion stability and CuO gives the maximum thermal conductivity. So the performance of these two with combination as hybrid Nano fluid in heat pipe will carried out. The heat pipe is very effective tool used for the heat transport as well as cooling purpose. Heat Pipe gives better performance and the rate of heat transfer enhancing by enhancing the thermal conductivity of working fluid. Result gives the higher thermal conductivity decrease the thermal resistance and improves the heat transport capacity of heat pipe.

***Key words:*** Heat Pipe, TiO2 and CuO

## I. INTRODUCTION

The heat pipe play vital role in cooling performance and heat transfer. The design of such effective heat exchanger are mainly depend on the thermo-physical properties of working fluid which is used for the flow in pipe. Nanofluid is very much useful or from many years it proves the role in transfer devices these are small size particle of metal such that the size is from 1-100nm. There is number of researcher proves the importance of nanoparticle in the heat transfer performance .TiO2 nanoparticle gives better thermal conductivity also it has very good dispensability. The composite or hybrid nanofluid can be defined as the composition of two nanoparticles in a base fluid. There are three types of composite nanofluid are as metal matrix nanocomposites, ceramic matrix nanocomposites, and polymer matrix Nano composites. Hybrid nanofluids have excellent properties which have been studied at various concentrations and temperatures. The thermal performance of heat pipe can be increased by addition of nanoparticle in base fluid. The CuO can improve the efficiency of heat pipe up to the 30.42% while also the heat pipe with CuO gives low thermal resistance. It gives best performance in heat pipe.

### A. Problem Statement

Performance of heat pipe is mainly depend on nanofluid , when choosing nanofluid the conductivity and heat transfer capacity are the main properties but at same time there are another characteristics are also important and that should be consider when choose the nanofluid such as wettability, optimum vapor pressure, high latent heat , compatibility, stability, dispersibility, cost ,availability, toxicity etc. Dispersibility of nanoparticle is very important parameter because the problem of sedimentation will arise due to less dispersibility of nanoparticle. So the nanofluid should possess the thermal properties as well as it should have good dispersibility.

### B. Proposed Work

The present work is investigate the performance of heat pipe with using hybrid nanofluid which is the combination of TiO2 and CuO with base fluid water. The TiO2 is available as well as non-toxic and it has a better dispersibility and stability and CuO has great thermo-physical properties which can improve heat transfer rate and increase the efficiency of heat pipe. So in this present work the performance of heat pipe will investigate with TiO2-CuO nanofluid.

## II. METHODOLOGY

### A. Materials

In this work, titanium oxide powder (TiO2) & Copper oxide was procured from Gandhi Chemicals Puna Research Laboratory Bhori Aali Pune. This Nanoparticle mixed with water at proportion 50% TiO2 &50% Copper oxide All relevant physical properties of the materials used are listed in Table 1

| Sr. No. | Nano Particle/ Fluid | Density (kg/m3 ) | Thermal Conductivity(W/mK) | Specific Heat (J/kgK) |
|---|---|---|---|---|
| 1 | CuO | 6310 | 32.9 | 550.5 |
| 2 | TiO2 | 4.05 | 11.8 | 697 |
| 3 | Water | 997.5 | 0.628 | 4178 |

Table 1: Thermo-Physical Properties of Nanofluid

### B. Nanofluid Preparation

The particle of TiO2 and CuO are prepared as nanofluid for the preparation the blending method was used. Blending is the mechanical mixtures such as paddles, beaters and, of course, pumping. Mechanical mixers and pumps require routine maintenance and those mechanical mixers which are available may require additional external tank reinforcement to support the drive mechanism as well as the internal components which provide agitation. Experimentations-The single heat pipe is used to conduct the experiment with the temperature sensors for the measurement of temperature. Rotameter is used for the measurement of flow.

## III. EXPERIMENTATION

The working fluid used here is Distilled water. The heat pipe is some length and outer diameter Copper tube and both the ends sealed with end caps. One end cap carries the filling tube for charging the working fluid. The heat pipe is charged with 32 ml of working fluid, which approximately corresponds to the amount required to fill the evaporator. The evaporator, adiabatic and condenser sections are of length 100, 100 and 150 mm respectively. Heat input was applied at the evaporator section using a cartridge electrical heater attached to it with proper insulation and the heater has been energized with an AC supply through a variac. Water jacket was provided at the condenser end to remove the heat from the heat pipe. The cooling condenser was used to condense the vapor. The condenser section was cooled by cooling water. The water chilling unit was fixed at a constant temperature and a cold bath was used to provide cooling water.

 

### *A. Specification of Heat Pipe*

The material used and the dimensions of heat pipe are given in table2.

| | |
|---|---|
| Container Material | Copper |
| Cooling jacket Material | Stainless steel |
| Geometry | Diameter of heat pipe- 25mm<br>Cooling jacket Diameter- 40mm |
| Total length of pipe (L) | 350mm |
| Length of evaporator section (Le) | 100mm |
| Length of adiabatic section (La) | 100mm |
| Length of condenser section (Lc) | 150mm |

Table 2: Specification of Heat Pipe

### *B. Experimental Set Up*

As shown in set up the experiment is carried out by taking reading of temperatures of various point of heat pipe such the evaporator section adiabatic section and condenser section also the flow rate of water is varied by using the flow regulating valve and that flow is measured by using Rota meter. The reading at various flow are taken to calculate the thermal conductivity and thermal efficiency.

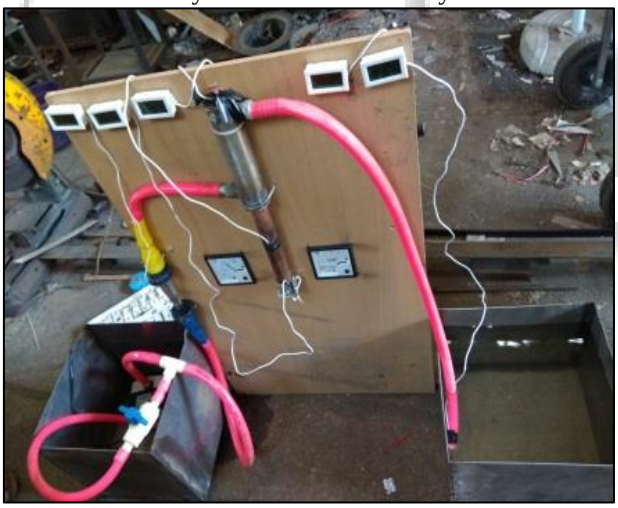

Fig. 1: Experimental Set Up

## IV. CALCULATIONS

The following formulas are used to do calculations and find out the thermal conductivity and efficiency.

1. Thermal Resistance (R)

$$R = \frac{Te - Tc}{Q}$$

R - Thermal resistance

$T_e$ - Evaporator temperature

$T_c$ :- Condenser temperature

Q- Heat Input.

2. The effective thermal conductivity

$$K_{eff} = \frac{L_{eff}}{A.R}$$

Where,

$L_{eff} = L_a + 0.5(L_e + L_c)$

$L_a$ – length of adiabatic section

$L_e$ – length of evaporated section

$L_c$ – length of condenser section, A-cross section area of pipe

By doing the calculations the following results are obtained which are given in table no .3

| Flow rate | $T_e$ | $T_c$ | $T_{in}$ | $T_{out}$ | R | $K_{eff}$ |
|---|---|---|---|---|---|---|
| 60 | 56.3 | 38.1 | 31.9 | 33.7 | 0.56 | 0.81 |
| 120 | 88.1 | 62.9 | 31.9 | 33.4 | 0.77 | 0.59 |
| 180 | 92.9 | 74.6 | 31.9 | 33.5 | 0.56 | 0.81 |
| 240 | 95.9 | 80.7 | 31.9 | 33.7 | 0.47 | 0.98 |
| 300 | 97.8 | 81.8 | 31.9 | 33.9 | 0.49 | 0.93 |

Table 3: Observation Table

## V. RESULTS & DISCUSSION

As shown in observation table the value of effective conductivity is increased as compare to the single nanofluid used, it is increased about 10-11% more than the single nanofluid gives the value of effective thermal conductivity.

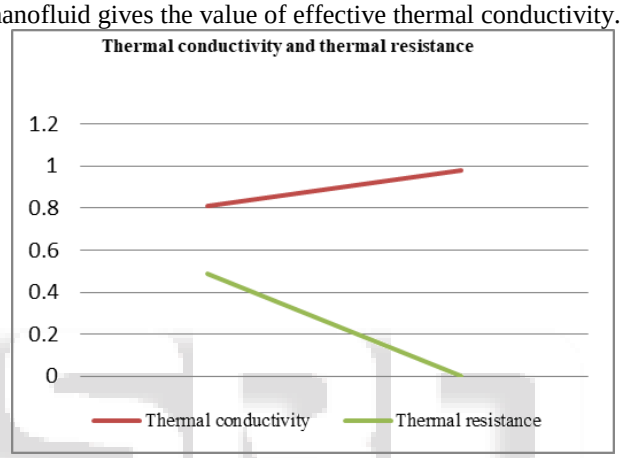


Fig. 2:

## VI. CONCLUSION

In this study and project work the hybrid nanofluid is prepared by taking the mixture of $TiO_2$ and CuO the water is used as base fluid and whole nanofluid was prepared by blending method. In this experiment the flow rate is varied and the studied the thermal conductivity and thermal resistance. By the observations and reading there are mainly two conclusions are made that the thermal conductivity increased according to the flow and the thermal resistance get decreased. It can be conclude that the hybrid nanofluid gives better improvement in thermal conductivity and that's why the heat transfer rate also increased.

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