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To Investigate Heat Transfer Performance in Heat Pipe Using Iron Oxide as A Nano Fluid with Di Water

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ABSTRACT
In this project work the effort can be made for experimental investigation on the copper heat pipe using iron oxide nano fluid. The copper heat pipe is efficient for achieving the maximum heat transfer. The copper heat pipe of suitable dimension is taken into the consideration, in which the working fluid like iron oxide is used. The performance of copper heat pipe is tested and compared with different two working with different fill ratios.

Keywords: Heat Transfer, Nano Fluid, Copper Heat Pipe, Iron Oxide, fill ratios.

I.INTRODUCTION

Heat pipes are simple heat transfer devices with high, effective thermal conductivity and the capability to transport a large amount of heat over considerable distances. Owing to the simplicity of design, and ease of manufacture and maintenance, these devices have found applications in many areas, including solar energy systems, heat recovery systems, air conditioning systems, cooling of energy storage and electronic equipment, industrial applications and space apparatus. Heat pipes can be designed and constructed with various cross- sectional areas and geometries ranging from 0.6 mm × 0.6 mm and 25 mm in length to 2 mm in diameter and 1 m in length, or even 100 m in length. All heat pipes have an evaporator and condenser section where the working fluid evaporates and condenses, respectively. Many heat pipes also have a transport or adiabatic section, which separates the evaporator and condenser sections by an appropriate distance, intended to satisfy the heat pipe limitations and the design constraints of the application. A given heat pipe may have multiple evaporators, condensers and adiabatic sections. A working fluid usually circulates due to the influence of capillary forces in a wick. However, gravitational, centrifugal, electrostatic, and osmotic forces can also be used to return the liquid from the condenser to the evaporator. The transfer to heat pipe is carried out on the basis evaporativecooling.

II. LITERATURE REVIEWMANIMARAET.AL[1] -.

He concluded that the heat pipe operation is affected by the boiling and capillary limitations. The fluid charge has a direct impact on the void fraction if the evaporator core varies. Results indicate that heat pipe shows greaterenhancementinheattransferwhenthefillingratiois40%to85%.Thewickstructurehasadominant effect on the heat pipe performance which provides capillary pressure difference for the liquid–vapor flow between evaporator and condenser sections.

Shubro Sen et.al[2]- He concluded that the thermal performance of heat pipes using nano fluids is better than that of distilled water but, higher concentration of nano fluids beyond the optimum value leads to reduction of thermal performance due to adsorption of water forming a coated layer over the excess nano particles which are caused by the nano particle sedimentation over the evaporator section of the heat pipe

Bhawna Verma et.al[3] -. Results of experiment performed to study the effect of Nano fluid concentration on thermal resistance of PHP have also been discussed. It is concluded that nano fluids are potential fluids to be used as working fluid in PHP.

S.G. Khedkar1 et.al[4]-This includes the internal tube diameter, the applied heat flux and amount of the working fluid in the system. Additionally the numbers of turns of the device and thermo-physical properties of the working fluid also play a vital role in determining the thermal behavior. PHPs are highly attractive heat transfer elements, due to their simple design, cost effectiveness and excellent thermal performance may find wideapplications.,

B.N.Kharad et.al[5]- Nano fluids are suspensions of nano particles in fluids that show significant enhancement of their properties at modest nano particle concentrations. Nano fluids are quasi single phase medium containing stable colloidal dispersion of ultrafine or nanometric metallic or ceramic particles in a given fluid. .Finally dangerous and many unknown sides of the Nano fluids utilization must be addressed to ensure about impressive role of this advanced technology in driving the life on planet earth towards more prosperity.

Koh Kai Liang Peter et.al[6] - This aims to investigate whether the use of nano fluids as a working fluid, as opposed to using water/oil, will reduce the pipe dimensions in an industrial set up. An understanding of the thermal conductivity in nano fluids is discussed before a suitable heat analysis method is developed to give relationships for the Nusselt number. After which, an analysis on the thin-walled pipe with constant wall temperature is applied to evaluate whether the required pipe dimensions are smaller if nano fluids are employed as the working fluid. He concludes the thermal conductivity of nano fluids is observed to increase with increase volume fraction predominantly because it provides an increase in relative surface area for heat transfer.

Behi and Mirmohammadiet.al[7] – It is concluded that difficulties in finding the optimal synthesis of nano fluids, concentration level of nano particles and the filling ratio of nano fluids in heat pipes, set bound the commercial use of nano fluids in heat pipes.It is suggested that, in order to enhance the heat transfer performance of nano fluids in heat pipe to conduct further research concerning e.g. Synthesis of nano fluids and concentration level nano particles in nanofluids.

Ashvini Rana et.al[8] - The objective of this paper is to present an overview of literature dealing with the study of heat transfer using nano fluids in heat pipes. Influence of various factors such as heat input, fill ratio, % concentration, heat flux, dry run condition, wet run condition, inclination angle, nano particles size and its effect on thermal performance.

Jubin V Jose, A. Ramesh, EbinJoshyet.al[9] - This review aim to compile the effect of nano fluid in heat pipes. Performance of different nano particles and different base-fluids are investigated. Most of the papers reviewed here reported an enhancement in performance of heat pipes. Existence of an optimum concentration of nano particles in base fluid was also reported. Paper also presents perspective on possible research application.

Rudresha S, Vijee Kumar et.al.[10]This paper presents a discussion on the effect of various perform-ing parameters by varying different heat inputs as well as nano fluids concen-tration as SiO2/DI Water and Al2O3/DI Water. CFD results analysis to com-parison for Experimental results show that at a heating power of 10w, 14w, 18w, 22w the Thermal resistance, Thermal heat transfer Co-efficient, Ther-mal Thermal conductivity and Efficiency for CLPHP SiO2/DI Water and Al2O3/DI Water heat pipe are 69.37%, 75.99% and 11.98% DI water respectively, which are better than that of pipes using DI water as the working nano fluids.

III. LITRERATUREGAP:

In the recent studies the nano fluids have been regularly used in the heat pipe. After reviewing above researches [1-10] it is found that the nano fluids which are been used are expensive. New substitute for nano fluids should be developed which increases the performance of heat pipe and readily acceptable for applications. Tests have been conducted on iron oxide (Fe_2O_3).as a nano fluid at different fill ratios and it was found that the thermal resistance of heat pipe has been successfully decreased.

IV. PROBLEMDEFINITION

Resent nano fluids are quite expensive and are not acceptable by the manufacturer because of its properties and the availability of it and it also take more time for its preparation also due to high Climate temperature the temperature of the working equipment also gets affected. Selection of working fluid is directly linked to the properties of the fluid. The properties are going to both affect the ability to transfer heat and the compare ability with the case and wick material.

V. OBJECTIVE

- To study the working principle ofthe heat pipe and different affecting parameters associated with it through different literaturestudy.
- To study the effective and condition for the use of workingfluids.
- To design the heat pipe for the use of nano

fluids as workingmedium.

- Obtained performance results with used of different working fluids and compareit.

VI. PRESENTWORK

a. Preparation of NanoFluid

The performance of the heat pipe is quantified with used of iron oxide nano fluid mixed with DI water. The amount of liquid filled is varied and the variation of the performance for different concentration is observed. The nano fluid is prepared with different concentration by considering the total volume evaporator section. The iron oxide particle are added into DI water and it is stirrer still all particles are settled. The following are the composition of nano fluid by its weight.

- **For 30 % Filling Ratio**

Iron Oxide - 75 mgm DI Water-10 ml

- **For 50 % Filling Ratio**

Iron Oxide -1 gm DI Water-15 ml

- **For 70 % Filling Ratio**

Iron Oxide -1.5 gm DI Water-20 ml

- **For 100 % Filling Ratio**:

Iron Oxide -2 gm DI Water-30 ml

6.2 Experimental Part

a. ExperimentalSetup

The schematic diagram of the heat pipe under consideration is shown in Fig.6.1 along with thermocouple locations .The experiment part consists of a 25.40 mm outer diameter copper-water heat pipe with a length of 1000 mm and a wall thickness of 1.2 mm. The wick consists of two wraps of a copper wire mesh with a wire diameter of 0.183 mm and 2365 strands per meter. The heat pipe is charged with 10 ml of working fluid, which approximately corresponds to the amount required to fill the evaporator. The wall temperature distribution of the heat pipe in adiabatic zone is measured using K-type thermocouples with an uncertainty of ±0.1^{o}C, at an equal distance from the evaporator. In addition the thermocouples are also located in evaporator surface (two locations), condenser surface (two locations), and fins of condenser section. The electrical power input is applied at the evaporator section using cylindrical electric heater attached to it with proper electrical insulation and the heater is energized with 230V AC supply using a variance and measured using a power transducer with an uncertainty of ±1W.

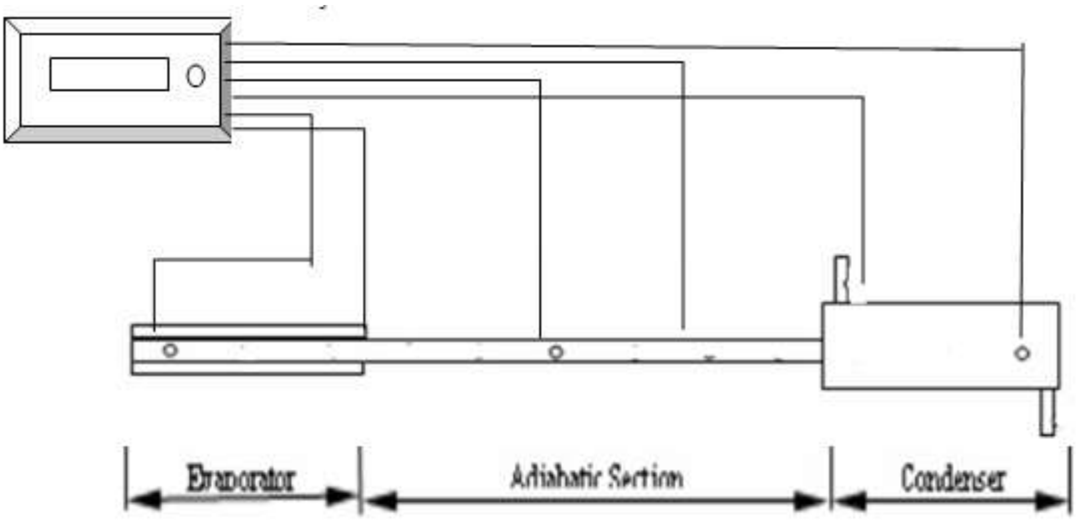


Fig: 6.1 Thermocouple Locations of Heat Pipe

b. ExperimentalProcedure

The experiments are conducted using heat pipe which is manufactured as per mentioned dimensions. The heat pipe is initially filled with de-ionized water, secondly with solution de-ionized water and iron oxide nano fluid. The power input to the heat pipe is gradually raised to the desired power level. When the heat is supplied to the evaporator end by means of heating source, the surface temperatures along the adiabatic section of heat pipe are measured at regular time intervals until the heat pipe reaches the steady state condition. Simultaneously the evaporator wall temperatures and condenser wall temperatures are measured. Once the steady state is reached, the input power is turned off and cooling water is allowed to flow through the condenser to cool the heat pipe and to make it ready for further experimental purpose. Then the power is increased to the next level and the heat pipe is tested for its performance. The output heat transfer rate from the condenser is computed by applying an energy balance to the condenser flow.

The test section consists of three parts, as mentioned earlier, evaporator, adiabatic and condenser sections. In the experiment the heat transfer characteristics were measured for three different liquids (distilled water and Distilled water with iron oxide). Also the characteristics were measured for dry run condition (without any liquid). So, two heat pipes were fabricated. For dry run condition the heat pipe was sealed at bottom and top. In case of the heat pipe where liquids were used the bottom was sealed and top was at the end. The evaporator section equipped with the band heater. Power to the heater was provided from line supply through a variance. Fins were attached at the condenser section and a fan was directed towards the fins for forced convection to occur at this section. Six sets of thermocouple wires were fixed with the body by means of glue. At first each thermocouple sets were fused together at the top point and it was ensured that except the top point, they do not touch at any other points. Then they were attached with the body. The other ends of the thermocouple wires were connected with the digital thermocouple reader by means of connecting wires. Thermocouples were placed at six points on the surface of the heatpipe,

Two at evaporator section, two at adiabatic sections and two at condenser section. Thermocouples at each section were placed at an interval of 250 mm. Experiments were conducted with dry run (without any working fluid in the tube) and wet run (with working fluid inside). The heat pipe without working fluid essentially represents metallic conductor. Its performance is considered as the base for the evaluation of the heat pipe (with working fluid in it). The transient tests were conducted on the heat pipe, in which heater was put on and the temperature rise was observed at regular intervals till the steady state was achieved. After achievement of steady state the temperatures at the six points were noted by changing the positions of the selector switch. This experiment was repeated for different heat inputs, different fill ratios and for different working fluids. Various plots were drawn to study the performance of the miniature heat pipe to optimize the fluid inventory. The different heat inputs were achieved by changing the outputvoltage.

Fill ratio means the percentage of the evaporator section volume that is filled by the working fluids. The fill ratios used in this experiment were 30%, 50%, 70% and 100% of the evaporator volume for all three different working fluids. All the temperature readings, at the six points on the heat pipe surface, were taken for all three working fluids for all the fill ratios after reaching steady state condition.

6.3. Calculation for Effectiveness of HeatPipe

a. Effectiveness of the heat pipe is indirectly brought in terms of thermalresistance

$$R = \frac{T_e - T_c}{Q} \, {}^{\circ}\frac{C}{W} \qquad [01]$$

b. The overall heat transfer co-efficient is givenby

$$h = \frac{Q}{A(T_e - T_c)} \quad \frac{W}{m^2 {}^{o}C} \qquad [02]$$

6.4. Variation of Thermal Resistances (R) With HeatInput

Figures show the variations of thermal resistances that occur at different fill ratios for the three different working fluids at different heat input. These graphs are used for comparison of thermal resistances at different fill ratios of different working fluids. The variations of thermal resistances with different heat inputs for dry run and wet run (for 30%, 50% and 100%) are shown inbelow.

a. Effectiveness of the heat pipe is indirectly brought in terms of thermalresistance

$$Q = V \times I = 10 \times 0.2 = 20\ \mathrm{W}$$

$$R = \frac{T_e - T_c}{Q}\ {}^{\circ}\frac{C}{W}$$

$$R = \frac{45.5 - 34}{2} = 5.75\ {}^{\circ}\frac{C}{W}$$

b. The overall heat transfer co-efficient is givenby

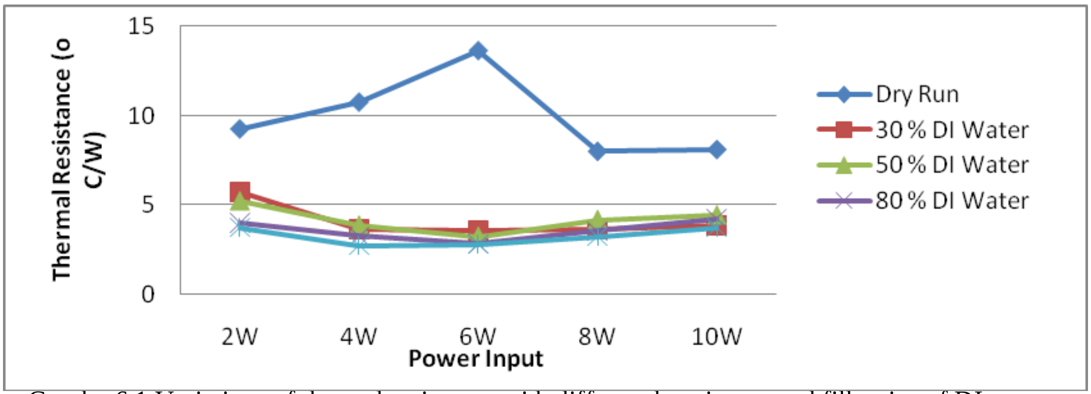
$$h = \frac{Q}{A(T_e - T_c)}$$

$$h = \frac{2}{\frac{\Pi}{4}D^2(T_e - T_c)} = \frac{2}{\frac{\Pi}{4}(0.025)^2(45.5 - 34)}$$

$$= 354.95\ \frac{W}{m^2\ {}^{o}C}$$

Power Input	**2W**	**4W**	**6W**	**8W**	**10W**
Thermal Resistances (R)					
Dry Run	9.25	10.75	13.625	8	8.1
35 % DI Water	5.75	3.65	3.58	3.625	3.9
55 % DI Water	5.25	3.875	3.25	4.187	4.45
85 % DI Water	4	3.25	2.83	3.56	4.25
100 % DI Water	3.75	2.75	2.83	3.25	3.75

Table: 6.1 Thermal resistances along Heat Pipe with DI water at different fill ratios



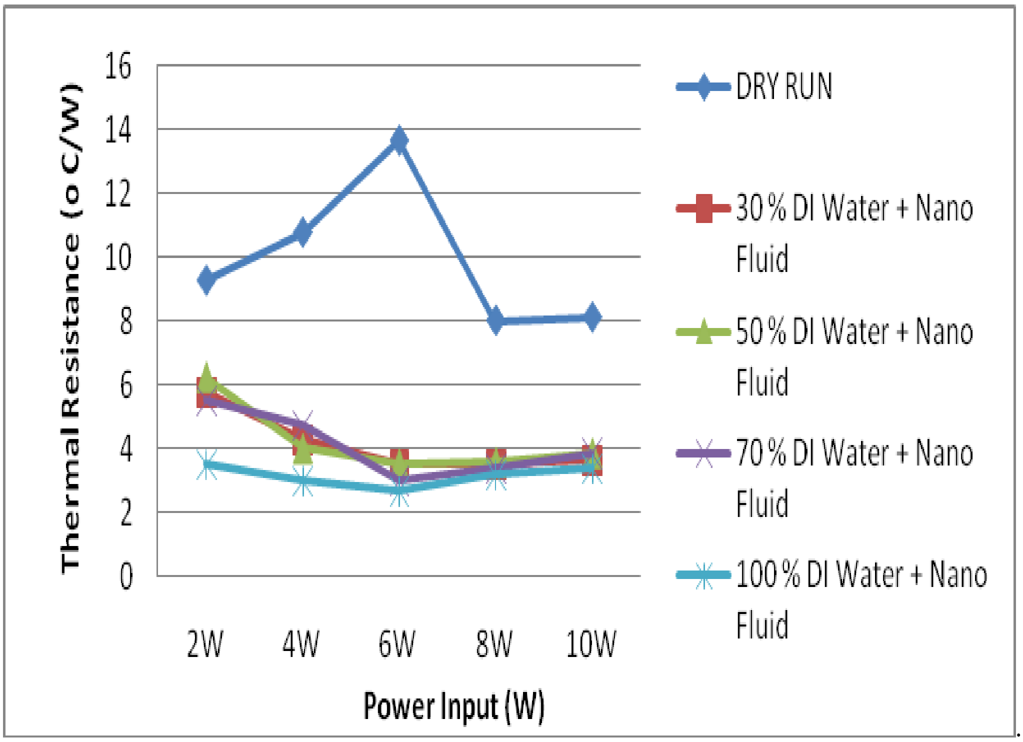
Graph : 6.1 Variations of thermal resistance with different heat inputs and fill ratios of DI water

6.5 Discussion On Table 6.1 And Graph6.1

The operating heat pipe with wet run has lesser overall thermal resistance when compared to dry run. For a 2W heat input capacity, the thermal resistance observed in the dry run was 9.25 °C/W and that in wet run was5.75°C/W.

Power Input	2W	4W	6W	8W	10W
Thermal Resistances (R)					
Dry Run	9.25	10.75	13.625	8	8.1
35 % DI Water + Nano fluid	5.75	4.25	3.5	3.5	3.6
55 % DI Water + Nano fluid	6.25	4	3.5	3.56	3.85
85 % DI Water + Nano fluid	5.5	4.75	3	3.37	3.85
100 % DI Water + Nano fluid	3.5	3	2.66	3.187	3.4

Table :6.2 Thermal resistances along Heat Pipe with DI water mixed with Nano fluid At different fill ratios



Graph:6.2 Variations of thermal resistance with different heat inputs for different fill ratio of DI water mixed with Nano fluid

6..6 Discussion on Table 6. 2 and Graph 6.2

In case of Nano fluid mixed with DI water, the temperature difference across evaporator and condenser continues to drop down with an increase in the fill ratio. With Nano fluid mixed with DI water as the working fluid, 100% fill ratio of evaporator volume shows the best result with minimum temperature difference across the evaporator andcondenser.

Graph. 6.3 Variations of thermal resistance with different heat inputs for different fill ratio and working fluids (Combine)

6.6 Discussion on Graph6.3

In general wet run shows the reduced thermal resistances for all levels of heat input and all types of working fluids. The dry run shows the largest values of thermal resistances and it is almost constant for varying heat loads. Acetone shows the minimum thermal resistances at all heat inputs for all fill ratios.

VII.CONCLUSIONS

1. Wet run shows an averaged constant temperatureslopes.
2. The operating heat pipe with wet run has lesser overall thermal resistance when compared to dryrun.
3. Performance of the nano fluid is better than the DIwater.
4. In case of Nano fluid mixed with DI water, the temperature difference across evaporator and condenser continues to drop down with an increase in the fillratio.
5. At 100% fill ratio of evaporator volume shows the bestresult.
6. Decrease in the cost as the iron oxide fluid is cheaper than other workingfluids.

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