EFFECT OF INCLINATION ANGLE IN PERFORMANCE EVALUATION OF HEAT PIPE WITH ZINC OXIDE NANOFUID

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ABSTRACT
This experiment is all about to investigate the thermal performance by experimentation on Heat pipe. ZnO/water nanofluid has been prepared and sonified with ultrasonicator. Sample of nanofluid concentration has been prepared in the range of 0.25, 0.50, 0.75, 1.0, 1.25, 1.50, 2.0 (in volume %). Thermal resistance and Thermal performance of hp has been find out at different inclination angle which is starting from 0°, 15°, 30°, 45°, 60°, 75°, 90° at power input 50 W, with the application of ZnO nanofluid and DI water as functioning fluid one by one and the outcomes results with both the fluid has been compared.

Keywords: Inclination angle, Nanofluids, Nanoparticles, Thermal efficiency, Thermal resistance.


1. INTRODUCTION
From the couple of years the research has been achieved a milestone in electronics industry by manufacturing the gadgets and laptops more compact, handy and speedy but behind this the temperature of these electronics devices increases because of the availability of limited space in these devices. Therefore in order to minimize the operating temperature of these electronic devices heat pipe is introduced in these devices. Heat pipe is one of those equipments which help us to circulate the heat energy from high temperature to low temperature as a results efficiency of system in which heat pipe is placed has been increased. In order to make heat pipe more efficient the nanofluids used as operating fluid and these nanofluids act as catalyst and enhance the thermal efficiency of hp. Huge researches with various nanofluids have been done so far, some of the researches are:
Mehrali et al. [1] performed the experiment at different inclinations with different power input and found that thermodynamic performance enhanced at 90° inclination and 120 W power input in the presence of nitrogen doped graphene working fluid.

Liu et al. [2] performed the experiment in the presence of Cu, CuO and SiO\textsubscript{2} nanofluids. While performing the experiment some of the factors have been taken like size of the nanoparticles, type of nanoparticles and concentration of nanoparticles and also operating pressure. This experiment revealed this Cu, CuO nanoparticles increases the thermodynamic efficiency of hp while in case of SiC the thermodynamic performance of hp decreases. This entire phenomenon has been takes place whether the thermodynamic performance increases or decreases this is due to the formation of thin layer in the hp due to the presence of different type of nanoparticles.

Gunnasegaran et al. [3] performed the research on hp with the application of SiO\textsubscript{2}/H\textsubscript{2}O nanofluids as the functioning fluids in order to increase the thermal performance of hp. The research has been performed within the input power range 20 W-100 W. This research also shows the liquid and vapors lines which show the fluid flow patterns. The nanofluids used 3.0% by volume. The researchers also compared the result with fem simulation methods. The researchers revealed that average decrease in the thermal resistance is 28%-44% from heat input 20 W to 100 W as compared with pure water.

Noie et al. [4] examined the thermal properties of closed hp by using the Al\textsubscript{2}O\textsubscript{3}/water based nanofluids as the operating fluids in volume concentration of 1-3%. the study revealed that thermal performance has been increased up to 14.7% when nanofluids is used instead of pure water at different power input.

Kamyar et al. [5] examined the research on hp with the applications of two different nanofluids i.e. Al\textsubscript{2}O\textsubscript{3} and TiSiO\textsubscript{4} as the operating fluids at different operating conditions. The researchers revealed that research can be takes place at different nanofluids/water based in variety of volume concentration i.e. 0.01%, 0.02%, 0.05%, 0.075% also the operating load are 40 W, 70 W, 120 W, 180 W, 210 W. The researchers revealed that there is decrement in the thermal resistance of hp by 65% and 57% when Al\textsubscript{2}O\textsubscript{3} is used by 0.05% by volume and same case in TiSiO\textsubscript{4} is used 0.075% by volume. This research also revealed there is increase in the heat transfer coefficient results decrease in temperature wall of evaporator.

Senthilkumar et al. [6] examined the thermal properties on hp with use of copper-water nanofluids as working fluids. Researchers performed the research at different angle. The research revealed that optimum work obtained at an angle of 45° and 70 W power input.

Menlik et al. [7] carried out the research with the help of MgO/water nanofluid as the operating fluid at different operating conditions. The researchers revealed that thermal performance of hp has been increased by 26% at power input 200 W.

Moraveji et al. [8] performed the research with the application of Aluminium /water nanofluids on sintered wick hp. The investigation is takes place at 90° angle between evaporator and condenser. Also the size of the nanoparticles has been taken is 35 nm. The investigation is takes place at different concentration of working fluid i.e.(1%-3%) by weight. The study revealed that there is the decrement in thermal resistance and wall temperature difference and in the end thermodynamic behavior of hp increases as compared to pure water.
2. METHODOLOGY
The power is coming to the evaporator portion from the heater can be controlled by controller switch. Water jacket was there at the condenser portion. Stable cooling bath is used which control the temperature of cooling water. Thermocouples are present at all the three sections of heat pipe i.e. evaporator, adiabatic and Condenser portion in order to record temperature these thermocouples are connected with data control system. At first the heat pipe is evacuated with the help of vacuum pump. Then after, inlet valve of heat pipe is put on and filling takes place. Stabilizer is used during filling the heat pipe in order to decrease the variation in vacuum heat pipe apparatus. After that reservoir valve put off. In order to decrease the heat losses glass wool is mounted over the apparatus (as shown in Fig.1). Now put the power switch on and this experiment is starting from heat input 50 W. Now temperature has been increases which can be recorded from digital screen. After giving the load we have to wait for 20-25 minutes so that stable reading has been obtained. After getting the stable data on the digital screen switch off the power and record the data which is available on the digital screen. Now switch on the valve of the bath tub and water is free to enter via condenser portion in order to cool the heat pipe. In this way the process continue with the different input power. Thermal performance and Resistance of heat pipe has been investigated at different inclinations with application of water and ZnO nanofluid at different concentrations.

Figure 1 Experimental setup
3. RESULTS AND DISCUSSIONS

Thermal resistance across the hp has been figure out with the use of water and ZnO nanofluid one by one. Thermal resistance has been finding out by using the formulas given below:

\[ R = \frac{\left( T_e + T_c \right)}{Q} \]

\[ T_e = \frac{(T_1 + T_2)}{2} \quad \text{and} \quad T_c = \frac{(T_3 + T_4)}{2} \]  

(a)

\( T_1 \& T_2 \) are interface temperatures of evaporator, \( T_3 \& T_4 \) are interface temperatures of condenser, \( R \) is Thermal Resistance and \( Q \) is power supplied.

This Experiment is performed with Variation in inclination angle i.e. from \( 0^\circ, 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ \) and \( 90^\circ \) at constant heat load is 50 W (as shown in Fig.2). Also the concentration of nanofluid has been ranges from 0.25\%, 0.50\%, 0.75\%, 1.00\%, 1.25\%, 1.50\%, 2.00\%. As From the Experimental results the reduction in thermal resistance of heat pipe takes place by 42.15\% when ZnO nanofluid is used instead of DI water. From the results we can say that the resistance declines maximum at \( 45^\circ \) inclination with 0.75\% nanofluid concentration by volume. Hence here we get the optimum angle and optimum concentration of nanofluid.

![Figure 2](image)

**Figure 2** Effect of Variation in Inclination Angle on Thermal Resistance

Now, the thermal efficiency across the hp has been figure out with the use of DI water and ZnO nanofluid one by one. The Experiment is performed with Variation in inclination i.e. from \( 0^\circ, 15^\circ, 30^\circ, 45^\circ, 60^\circ, 75^\circ \) and \( 90^\circ \), with constant heat load 50 W. Also the concentration of nanofluid has been ranges from 0.25\%, 0.50\%, 0.75\%, 1.00\%, 1.25\%, 1.50\%, 2.00\% . Thermal efficiency can be figure out by using the formulae:

\[ \eta = \frac{(\Delta T)}{(VI)} \]  

(b)

\( \eta \) is thermal efficiency; \( \Delta T \) is temperature difference b/w evaporator & condenser, 

\( VI \) is input power.

From the results the thermal efficiency found maximum at \( 45^\circ \) inclination with 0.75\% nanofluid concentration by volume (as shown in Fig.3). The enhance in thermal efficiency of heat pipe takes place by 35.20\% when ZnO nanofluid is used instead of DI water. Following are the reasons due to which thermal efficiency enhanced are describe below:
Effect of Inclination Angle In Performance Evaluation of Heat Pipe With Zinc Oxide Nanofluid

- Increased in the values of thermo physical properties mainly heat conduction capacity result as increase in thermal performance of hp.
- If the touching angle between nanofluid and inner surface of hp is decreased then heat transfer force and surface wettability increases.
- Nanoparticles film deposition in different section of hp played very important role in order to increase the rate of heat transfer. Deposition is takes plays in various sections of hp like evaporator, adiabatic sections and condenser sections however the deposition of nanoparticles is more effective when it takes place in evaporator section.
- Another point is that if we increase the mass concentration which is quantity of nanofluids then the two properties have been increases i.e. Thermal conduction and Viscosity. Increase in thermal conductivity is very good for increase in efficiency of hp but increase in Viscosity is not good for efficiency of heat pipe. As Viscosity of hp increases then also flow resistance increases and hence thermal efficiency decreases. Therefore when we perform the experiment we always find out the optimum concentration point where we get very good thermal efficiency.

![Figure 3](image-url)  
**Figure 3** Effect of Variation in Inclination Angle on Thermal efficiency

4. CONCLUSION

This research explained the Thermal performance of hp using ZnO/water as the functioning fluid. Optimum point has been found which is 0.75% concentration of nanofluid and 45° inclination angle also it can be concluded that zinc nanoparticles enhance the heat conduction capability of nanofluid and hence thermal performance of hp has been increases drastically in compared with DI water and discover a new trend for nanofluid applications in electronic devices so that their cooling rate increases and they perform in a effective way.

REFRENCES


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