A Result Paper on Thermal Performance of Heat Pipe By Using Nanofluid

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***Abstract*—The effect of nanofluid on the heat transfer has investigated. The thermal performance of heat pipe for nanofluid was tested experimentally. The experimental set up which contains heat pipe, heater, control panel, temperature indicator, motor, measuring flask etc. has been prepared. The water based Al_2O_3 nanofluid has used. The five different concentrations 0.1%, 0.3%, 0.5%, 0.7% and 0.9% of water based Al_2O_3 nanofluid have used in the heat pipe for five different heat inputs 50W, 100W, 150W, 200W and 250W. The heat transfer in the heat pipe for different concentrations of water based Al_2O_3 nanofluid for different heat input has been calculated. The heat transfer rate has increased in the heat pipe when Al_2O_3 nanofluid was used and it has lowered when pure water was used. For 0.3%, 0.5% and 0.7% concentration of Al_2O_3, heat transfer has increased and for 0.9% concentration it has lowered to some extent in heat pipe. The nanofluid helps to increase heat transfer rate and thermal performance of heat pipe.**

***Keywords*— Nanofluid, Stability, Heat pipe, Thermal performance**

I. INTRODUCTION

The heat transfer has a very important factor in thermal engineering. The main focus has to increase heat transfer rate through minimum area with optimum cost. One of the most common heat transfer device has heat pipe. The main consideration in designing heat pipe has to select appropriate heat transfer fluid. A new emerging branch nanotechnology has found its application in heat transfer field. Nanofluid is the mixture of base fluid and nanoparticles. The nanoparticles are freely suspended in base fluid. It has found that Nanofluids have better thermal conductivity than its base fluid. In the present work water based Al_2O_3 nanofluid has been used. The different concentrations of Al_2O_3 nanofluid has prepared in the ultrasonic vibrator. The 500 mm long heat pipe has been taken for the present work and it has tested for five concentrations 0.1%, 0.3%, 0.5%. 0.7% and 0.9% of water based Al_2O_3 nanofluid. The temperatures of various sections of heat pipe have recorded for different concentrations of Al_2O_3 nanofluid at different heat inputs. Based on observations made during the experiments, the heat transfer by the heat pipe at each concentration of Al_2O_3 nanofluid has been calculated for different heat input. The various results have plotted graphically.

II. PREPARATION OF NANOFLUID

Preparation of nanofluids is the first foot-step to the experimental studies The two step method is used for preparing nanofluid. In the two step method firstly nanoparticles are manufactured by physical, chemical, mechanical or any other means and then nanoparticles are mixed in the base fluid The alumina (Al_2O_3) nanoparticles used in the present work which are mixed in base fluid water with the help of ultrasonic vibrator. The mixture water and Al_2O_3 is prepared in the Powersonic-405 ultrasonic vibrator. The different concentrations of Al_2O_3-water nanofluid are prepared.

For preparing nanofluid of 0.1% volume concentration, 100 ml base fluide water is taken. In this water Al_2O_3 nanoparticles of weight 0.3504 gm are added. This mixture is prepared in seamless stainless steel tank. Then this tank is placed in Power Sonic-405 device. The power is switched on and the temperature of 300C and time duration of 60 min. has set on the device. In this device the ultrasonic sound waves from transducer element make low and high pressure states in the solution repeatedly. Due to which microscopic bubbles are formed and these bubbles are imploded as per pressure status. The ultrasonic energy emitted this time mixes the most contaminant without any damage. After 60 min. the power is switched off and Al_2O_3 - water nanofluid is taken out. This nanofluid has good stability. Similarly the different concentrations of Al_2O_3 - water nanofluid have prepared. The amount of Al_2O_3 nanoparticles required for preparation of each concentration of nanofluids has calculated using the law of mixture formula.

III. EXPERIMENTAL PROCEDURE

The heat pipe is charged with 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 two evenly spaced thermocouples at an equal distance from the evaporator.

The adiabatic section of the heat pipe is completely insulated with the asbestos material layer. The amount of heat loss from the evaporator and condenser surface is negligible.

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 and measured using a voltmeter and ammeter connected in parallel and series connections respectively.

In order to measure the average temperature of the evaporator, two thermocouples are distributed along the length of evaporator. Water jacket has been used at the condenser end to remove the heat from the pipe. The heat pipe has the ability to transfer the heat through the internal structure. As a result, a sudden rise in wall temperature occurs which could damage the heat pipe if the heat is not released at the condenser properly. Therefore, the cooling water is circulated first through the condenser jacket, before the heat is supplied to the evaporator.

The water flow rate measured using a measuring flask and stop watch placed at the outlet line to the jacket, the flow rate is kept constant to measure the average temperature of the condenser, three equally spaced thermocouples distributed along the length of condenser. The inlet and outlet temperatures of the cooling water are measured using two thermocouples.

The experiments are conducted using heat pipes which is manufactured as per mentioned dimensions. Firstly the heat pipes is filled with distilled water; secondly with 0.1 % aqueous solution of Al_2O_3 nanofluid, thirdly with aqueous solution of 0.3 % Al_2O_3 nanofluid and so on.

The power input to the heat pipe is gradually raised to the desired power level. The surface temperatures at different locations along the adiabatic section of heat pipe are simultaneously the evaporator wall temperatures, condenser wall temperatures, water inlet and outlet temperatures in the condenser zone 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.

The steady state condition is defined as a state in the variation of temperature is within 1^0C for 20 min. Then the power is increased to the next level and the heat pipe is tested for its performance.

Experimental procedure will be repeated for different heat inputs (50, 100, 150, 200 and 250W). The output heat transfer rate from the condenser is computed by applying an energy balance to the condenser flow.

IV. Results And Discussion

The different graphs are plotted to represent the results obtained for present system. The graphical representation is important to understand the system behavior for various input parameters and to draw conclusion from the system behavior. The graph represents nature of heat transfer through the heat pipe for conventional fluid water and for nanofluid.

The Fig. 1. shows graph between heat transfer and different concentrations of Al_2O_3 nanofluid at various heat inputs. The lowest heat transfer rate is observed for water than various concentrations of nanofluid for all heat inputs. For 0.1% concentration of Al_2O_3 the heat transfer rate is increased than water. From the graph it is noted that for 0.3%, 0.5% and 0.7% concentration of Al2O3 the heat transfer rate is maximum. Further for 0.9% concentration of Al_2O_3 the heat transfer rate is decreased near about heat transfer rate at o.1% concentration of Al_2O_3. The heat transfer rate of heat pipe is increases by addition of nanoparticles in the base fluid. But for higher concentration decrease in heat transfer rate is observed. This may happen due to agglomeration of nanoparticles in the base fluid or chocking of nanoparticles in the path of flow of nanofluid.

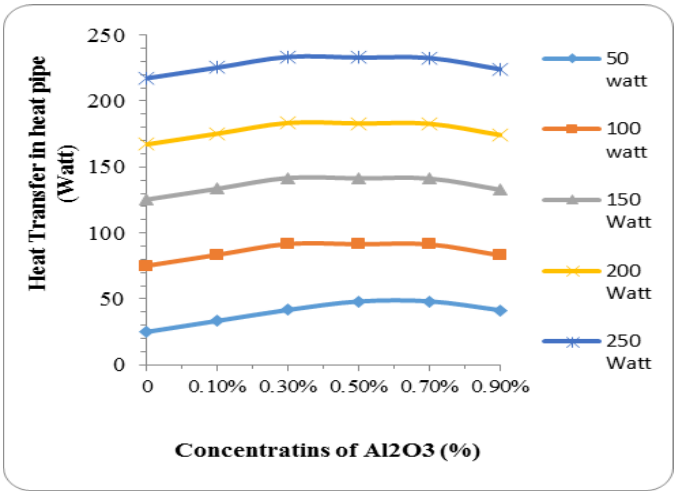

Fig. 1. Variation of heat tranafer in heat pipe with Al_2O_3 concentrations.

Fig. 2. shows graph between evaporator surface temperature and different concentrations of Al_2O_3 at various heat inputs. It is obvious that as the input heat increases the surface temperature of evaporator increases. But here at same heat input, the evaporator surface temperature for different concentrations of Al_2O_3 is plotted. The increase and decrease in the evaporator surface temperature is observed for the different concentrations of Al_2O_3 nanofluid. For water and 0.1% concentration of Al_2O_3, considerable change in evaporator surface temperature is observed at all heat inputs. For 0.3%, 0.5% and 0.7% concentrations of Al_2O_3, the change in evaporator surface temperature is very less for all heat inputs. For 0.9% concentration of Al_2O_3 the surface temperature of evaporator is decreases than previous values except at 100 W heat input. This happes as the concentration of Al_2O_3 is high due to which the more heat may get absorbed by the Al_2O_3 nanoparticles so that the evaporator surface temperature is less as compared to previous concentrations of Al_2O_3 at same heat input. Though 0.9% concentration of Al_2O_3 absorbs more heat but from figure 5.1 it transfers less heat than previous concentrations of Al_2O_3. This phenomenan indicates stability problem of nanofluid.

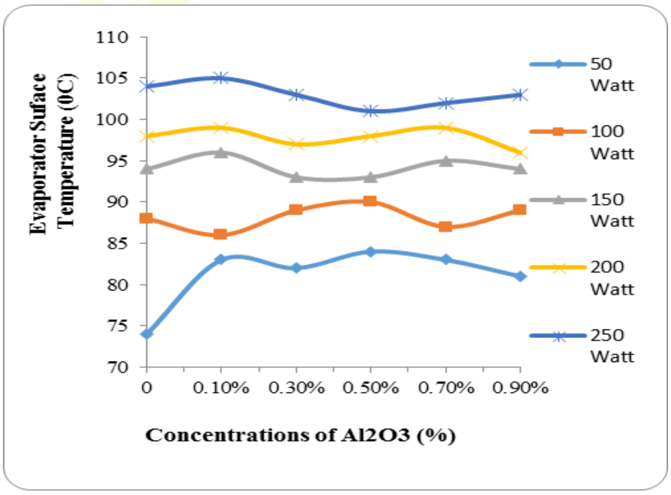

Fig. 2. Variation of evaporator surface temperature with Al_2O_3 concentrations.

Fig. 3. shows graph between condenser surface temperature and different concentrations of Al_2O_3 at various heat inputs. The condenser surface temperature decreases as the concentrations of Al_2O_3 increases upto 0.7% after this the condenser surface temperature increases except 50 W and 200 W heat input. This shows the behavior of heat transfer in the condenser section of heat pipe. The increase and decrease in condenser surface temperature is observed for different heat inputs and different concentrations of Al_2O_3. From the graph it is noted that 0.3% and 0.5% concentration of Al2O3 has lower condenser surface temperatures than 0.1%, 0.7% and 0.9% concentration of Al_2O_3 at all heat inputs. Hence 0.3% and 0.5% concentration of Al_2O_3 transfers more heat than other concentrations of Al_2O_3 at all heat inputs.

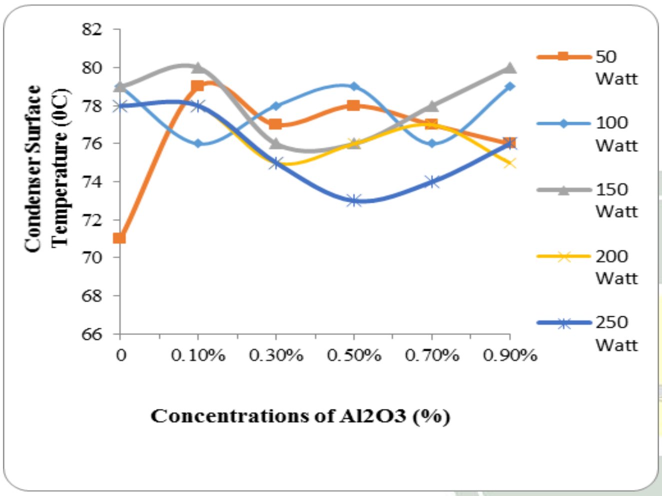

Fig. 3. Variation of condenser surface temperature with Al_2O_3 concentration.

The thermal efficiency of heat pipe is the ratio of heat transferred by the heat pipe to the heat supplied to heat pipe. The thermal efficiency of heat pipe for various concentrations of Al_2O_3 at different heat input is calculated and written in result table. The thermal efficiency for different concentrations of Al_2O_3 at different heat inputs is plotted graphically as shown in figure 4.4. The thermal efficiency for heat pipe is depends on amount on heat transferred by heat pipe. As the heat transfer is increases the thermal efficiency is also increases. Below graph shows variation of thermal efficiency with different concentrations of Al_2O_3 at various heat inputs. The thermal efficiency of heat pipe increases as the concentrations of Al_2O_3 increases upto 0.7% at all heat inputs and decreases at 0.9% concentration of Al_2O_3. The decrease in thermal efficiency indicates decrease in heat transfer. As discussed earlier at higher concentration of Al_2O_3 (0.9%) agglomeration of nanoparticles may occur which effects on heat transfer rate. Also chocking of nanoparticles in the wick of heat pipe May takes place due to which heat transfer rate decreases. Agglomeration of nanoparticles indicates poor stability.

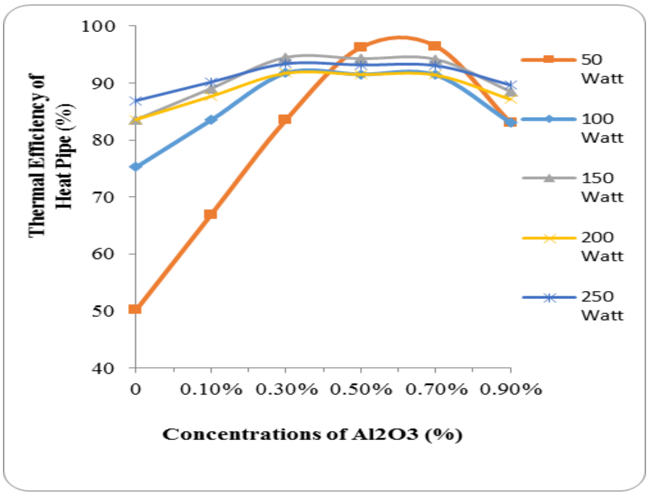

Fig. 4. Variation of thermal efficiency of heat pipe with concentrations of Al_2O_3.

CONCLUSION

After investigating the performance of heat pipe by using water based Al_2O_3 nanofluid, the increase in heat transfer rate in heat pipe has been observed as compared to conventional fluid.

- The enhancement in heat transfer rate has observed when water based Al_2O_3 nanofluid was used in the heat pipe. The maximum heat transfer observed at 0.3%, 0.5% and 0.7% concentration of Al_2O_3.
- Thermal efficiency of the heat pipe increases by 10% when water based Al_2O_3 nanofluid was used in the heat pipe.
- The maximum thermal efficiency and heat transfer were found at 0.3%, 0.5% and 0.7% concentration of Al_2O_3. Hence this concentration may be optimum for the present heat pipe.
- For higher concentration of water based Al_2O_3 nanofluid, it was observed that heat transfer rate decreases to some extent. This may happen due to stability of nanofluid. Hence stability of nanofluid plays important role in the heat transfer.

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