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Performance in Heat Pipe with Variation of Thermal Resistance DI water Mixed with Nano Fluid

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ABSTRACT

In this paper the effort can be made for experimental investigation on the copper heat pipe. 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 mixed with DI water is used. The performance of copper heat pipe is tested and compared different working fluid; also the heat pipe is tested with different filling ratios. Overall the approached is made for improving the performance of heat pipe.

Keywords: Heat Pipe, Nano Fluid, Copper heat pipe.

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I. INTRODUCTION

The heat pipe is partially filled with a working fluid and then sealed. The working fluid mass is chosen so that the heat pipe contains both vapor and liquid over the operating temperature range. Below the operating temperature, the liquid is too cold and cannot vaporize into a gas. Above the operating temperature, all the liquid has turned to gas, and the environmental temperature is too high for any of the gas to condense. Whether too high or too low, thermal conduction is still possible through the walls of the heat pipe, but at a greatly reduced rate of thermal transfer. For the heat pipe to transfer heat, it must contain saturated liquid and its vapor (gas phase). The saturated liquid vaporizes and travels to the condenser, where it is cooled and turned back to a saturated liquid. In a standard heat pipe, the condensed liquid is returned to the evaporator using a wick structure exerting a capillary action on the liquid phase of the working fluid. Wick structures used in heat pipes include sintered metal powder, screen, and grooved wicks, which have a series of grooves parallel to the pipe axis. When the condenser is located above the evaporator in a gravitational field, gravity can return the liquid. In this case, the heat pipe is a thermosyphons. The heat pipe is a device that utilizes the evaporation heat transfer in the evaporator and condensation heat transfer in the condenser, in which the vapor flow from the evaporator to the condenser is caused by the vapor pressure difference and the liquid flow from the condenser to the evaporator is produced by the capillary force, gravitational force, electrostatic force, or other forces directly acting on it. The first heat-pipe concept can be traced to the Perkins tube. Based on the structure, a heat pipe typically consists of a sealed container charged with a working fluid. Heat pipes operate on a closed two-phase cycle and only pure liquid and vapor are present in the cycle. The working fluid remains at saturation conditions as long as the operating temperature is between the triple point and the critical state. a typical heat pipe consists of three sections: an evaporator or heat addition section, an adiabatic section, and a condenser or heat rejection section. When heat is added to the evaporator section of the heat pipe, the heat is transferred through the shell and reaches the liquid. When the liquid in the evaporator section receives enough thermal energy, the liquid vaporizes. The vapor carries the thermal energy through the adiabatic section to the condenser section, where the vapor is condensed into the liquid and releases the latent heat of vaporization. The condensate is pumped back from the condenser to the evaporator by the driving force acting on the liquid. For a heat pipe to be functional, the liquid in the evaporator must be sufficient to be vaporized. There are a number of limitations to affect the return of the working fluid.

II. EXPERIMENTAL PROCEDURE

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 nanofluid. 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 heat pipe, 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 output voltage from the variance.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.

III. RESULT

The variations of thermal resistances that occur at different fill ratios for the DI water with nano fluid. The variations of thermal resistances with different heat inputs for dry run and wet run (for 30%, 50% and 100%) are shown in Table 1. Variations of thermal resistance with different heat inputs for different fill ratio of DI water mixed with Nano fluid shown in Figure 1.

Power Input	2W	4W	6W	8W	10W
Thermal Resistances (R)					
Dry Run	9.2	10.75	13.625	8	8.1
35 % DI Water + Nanofluid	5.7	4.25	3.5	3.5	3.6
55 % DI Water + Nanofluid	6.2	4	3.5	3.56	3.85
85 % DI Water + Nanofluid	5.5	4.75	3	3.37	3.85
100 % DI Water + Nanofluid	3.5	3	2.66	3.187	3.4

Table: 1. Thermal resistances along Heat Pipe with DI water mixed with Nano fluid at different fill ratios

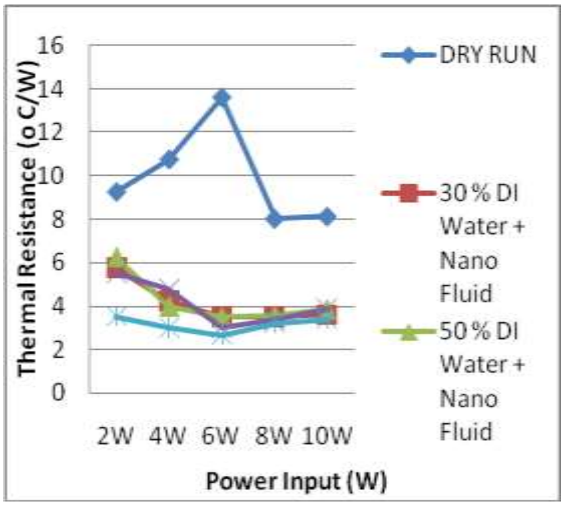

Figure: 1. Variations of thermal resistance with different heat inputs for different fill ratio of DI water mixed with Nano fluid

IV. CONCLUSION

It is 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 nano fluid mixed with DI water.

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