Comparison Of Thermal Analysis Of Heat pipe With Silver End At Evaporator Section

T. Mahidhar Reddy, N. Lavanya, R. Manohar Babu

Abstract: Heat pipe is one of the heat transfering devices that transfers heat by following principles of both thermal conductivity & phase transition so that heat can transfer efficiently between two bodies. Heat pipe is a passive heat transfer heat exchange device which is utilized to expel heat from the heat source. The performance and effectiveness of the heat pipe rely on different factors likely working fluid, diameter, wick structure, wick mesh size etc. Here in this project we conducted the experimental work on comparison of copper cylindrical heat pipe and copper cylindrical heat pipe with silver pipe (i.e.combined copper and silver) at one end i.e at its evaporator section using TiO2 (Titanium dioxide) as a working fluid. As silver is more heat conductive than copper, so thermal resistance of is less and it is placed at different angles of 0°,60°, 30°, and 90° with the horizontal. Comparison of thermal performance of two heat pipes is analyzed where the Evaporator thermal resistance at 60° angle for copper with silver heat pipe at a load of 10W is 0.4K/W, total thermal resistance is 1.7K/W and for only copper pipe is 0.6K/W, 2.0K/W respectively.

Index Terms: Heat pipe, Nano fluid, Thermal resistance, Heat load,evaporator section,wick material.

1. INTRODUCTION

Heat pipe is two stage heat transfer gadget which is utilized for cooling of electronic components. Heat pipe gives a more effective thermal performance than fins and other heat transfered devices. The performance and productivity of a heat pipe depend upon various factors like porosity, type of wick, permeability, filling ratio e.t.c. It mainly depends on operating conditions like, heat input and orientation. By now a days nanofluids have been used in heat pipe technology which is utilized as the working fluid in different proportions and sizes to upgrade the thermal performance of the heat pipe. Working pressure and Nanoparticles mass concentration affect the thermal efficiency of the heat pipe.

Some tests have been conducted, Among them Hung conducted experiment on heat pipe. He used (Al2O3/water) NanoFluid as a working fluid rather than water, due to this heat transfer coefficient(at evaporation) by one time and most extreme heat flux to 35% were increased .Venkatachalapathy, GKumaresan, and L.G. Asirvatham[5] conducted experiments on heat pipe. They used wick material, sintered wick and CuO nanoparticles. They observed that temperature difference in surface temperature and temperature of vapour at center of heat pipe is 500oC. At 1.000 wt.% of nanofluid(CuO) with distilled water at 45° angle with horizontal, heat transfer coefficient and thermal conductivity enhanced by 30% and 64% respectively, thermal resistance decreased to 66%, thermal efficiency enhanced by 25% when compared with heat pipe with horizontal tilt angle.

G. Kumaresan, S. Venkatachalapathy [6] were conducted experiments on heat pipe to enhance thermal performance by using nanofluids. They showed that at 60° tilt angle, wick heat pipe reached a maximum value of thermal performance. At 90° tilt angle, thermosyphon heat pipe reached a maximum value of thermal performance. Due to nanoparticles size and its volume proportions, the maximum change occur in temperature distribution.Sina Razvarz, Mostafa Keshavarz and Moraveji [7] were conducted an experimental work on heat pipe. They used Al2O3 nanofluid as working fluid. They noticed that charging of the nano fluid to the heat pipe fundamentally increases the heat transfer than decreases the heat resistance. They finally showed, low temperature observed in the curve zone in thermosyphone heat pipe and this temperature diminishes from the evaporator to the curve zone and after that increments.Yang et al. [8] conducted an experimental work on heat pipe(horizontal micro-grooved) to analyze the heat transfer performance. He used CuO nanoparticles between 0.5 to 2.0 wt.% and diameter of 50nm and in this experiment he used different operating pressures between 7 to 20 kPa. In this experimental work he showed that at 1 wt.% mass proportion and 7.45 kPa operating pressure gives better thermal performance. Critical heat flux and evaporator heat transfer coefficient are increased by 30% and 46% respectively, compared with heat pipe which is using DI water.

2 HEAT PIPE TECHNOLOGY

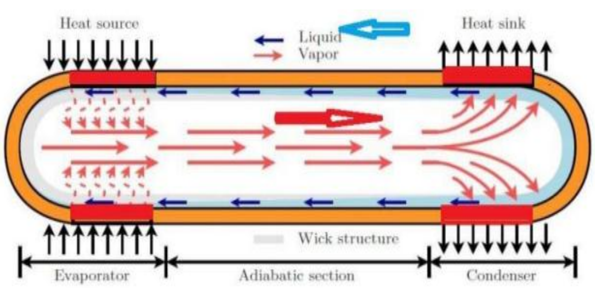

***Fig. 1**. Heatpipe*

Heat pipe comprises of three significant areas: an adiabatic segment, an evaporator segment and an condenser segment. When heat(power) input is provided in the evaporator section it vaporizes the working fluid, which is in equilibrium(according to zeroth law of thermodynamics) with its own vapour. This produces a pressure difference between two segments(i.e evaporator section and condenser section), which moves the vapour through the adiabatic segment. At the condenser segment, heat is expelled by condensation i.e. by providing low temperature water through outlet surface or

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by giving low temperature water through outlet surface or by providing fins it finally dispersed through an outer heat sink. The capillary impact of the wick structure will constrain the progression of the fluid from the condenser to evaporator segment.

3 EXPERIMENTAL SETUP

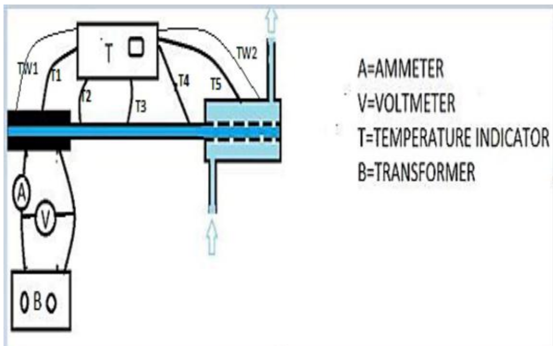

Fig. 2. *Schematic Diagram Of The Experimental Apparatus°*

Main components of the experimental setup are Voltmeter, Ammeter, Auto transformer, Temperature indicator, Heat pipe, Water tank and Water pump. In heat pipe wick material is a copper mesh with 200 mesh/inch, and working fluid is water with 0.2%wt Tio2 nanoparticles with size 10 nm.T1, T2, T3, T4 and T5 are the temperatures of working fluid at 1, 2, 3, 4 and 5 points of two heat pipes.
Temperatures of heat pipe at different points on heat pipe are measured by thermocouples
Tw1=Evaporator wall temperature.
Tw2=Condenser wall temperature.

Fig. 3. *Tio2 Nanoparticles*

Fig. 4. *Copper Mesh*

TABLE 1: Dimensions Of Heatpipes

S.No	Section	Outer diameter mm	Inner diameter mm	Area mm^2	Length mm
1	condenser	11.7	12.7	126	100
2	evaporator	11.7	12.7	126	100
3	adiabatic	11.7	12.7	126	300
4	evaporator (silver)	12.7	13.7	147	100

mm- millimeter

FIG. 5. *COMPLETE COPPER PIPE AND (COMPOSITE PIPE)COPPER WITH SILVER (AT EVAPORATOR SECTION) HEAT PIPE*

4 EXPERIMENTAL PROCEDURE

The power supply is turned on, it is adjusted by using a transformer to increase the power. The test is conducted for 30 min to reach a steady state. Note down temperature values at different points on heat pipe. The heat pipe temperature is measured by using Type-k thermocouples. Similar process repeated at different heat inputs like 10w, 20w, 30w, 40w and 50w respectively. All thermocouples(Type-K) are attached to a digital temperature indicator. Thermocouples (with the vulnerability lower than 0.1 °C) are distributed along the outside surface of the heat pipe segment as shown fig2. one thermocouple is connected to the focal point of the evaporator area, three thermocouples are joined to the adiabatic segment and one thermocouple is appended to the condenser segment. Nickel chrome wire heater (maximum 90 W) is used as a heat source in the heating section. Thus, heat(power) load (Q) and temperature differences (ΔT) were measured. The thermal resistance(R) of the heat pipe is determined by the following equation:

$$R = \frac{\Delta T}{Q} \left(\frac{K}{W}\right)$$

Following graphs represents comparison of temperature distribution of heat pipes.

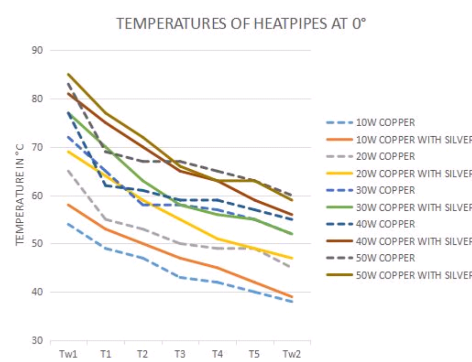

Fig. 6. *Temperation Distribution Of Heatpipes At 0° And Different Heat loads*

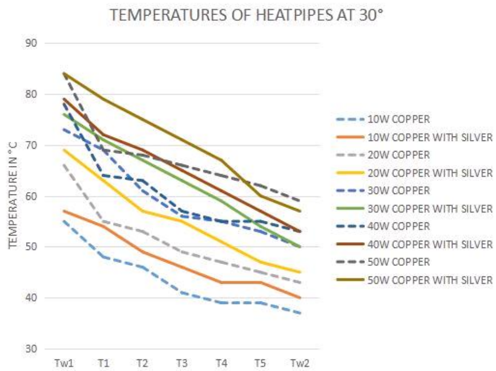

Fig. 7. *Temperation Distribution Of Heatpipes At 30° And Different Heat loads*

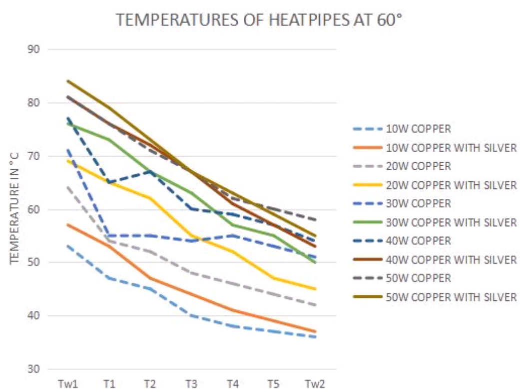

Fig. 8. *Temperation Distribution Of Heatpipes At 60° And Different Heat loads*

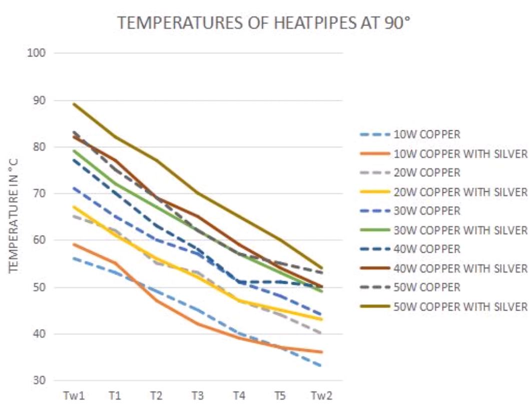

Fig. 9. *Temperation Distribution Of Heatpipes At 90° And Different Heat loads*

4 RESULTS AND SAMPLE CALCULATIONS

4.1 Thermal Resistance

$$R = \frac{Tw1 - Tw2}{Q(W)}$$

Where Tw1=evaporator wall temperature. Tw2=condenser wall temperature. Q=heat input. R=Thermal resistance. Sample calculations for R at Q=10w and 0 degrees,
For copper heat pipe,R=1.6°C/w.
Similarly for copper with silver heat pipe, R=1.9 °C/w.
Similarly, at different heat inputs and angles thermal resistance noted as follows graphs Below graphs represents no difference between both Heatpipe but copper heat pipe with cylindrical heat pipe better results at 60 degree angle.

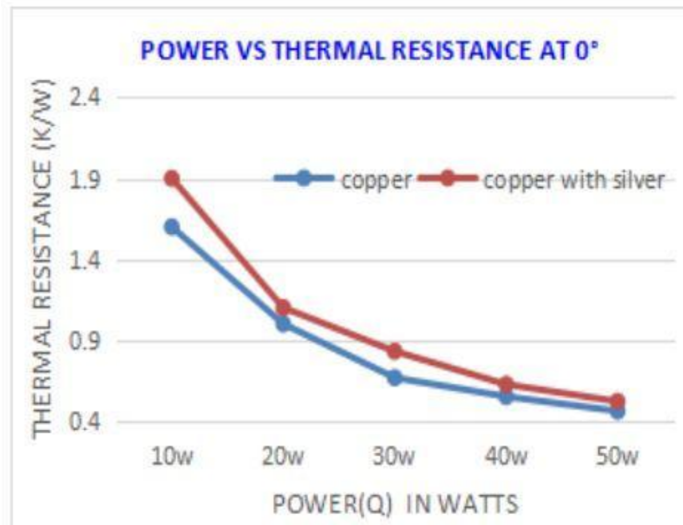

Fig. 10. *Comparison Of Total Thermal Resistance At Different Heat loads At 0°*

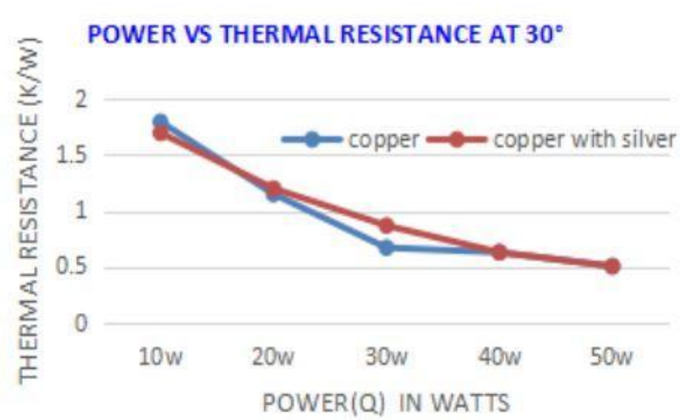

Fig. 11. *Comparison Of Total Thermal Resistance At Different Heat loads At 30°*

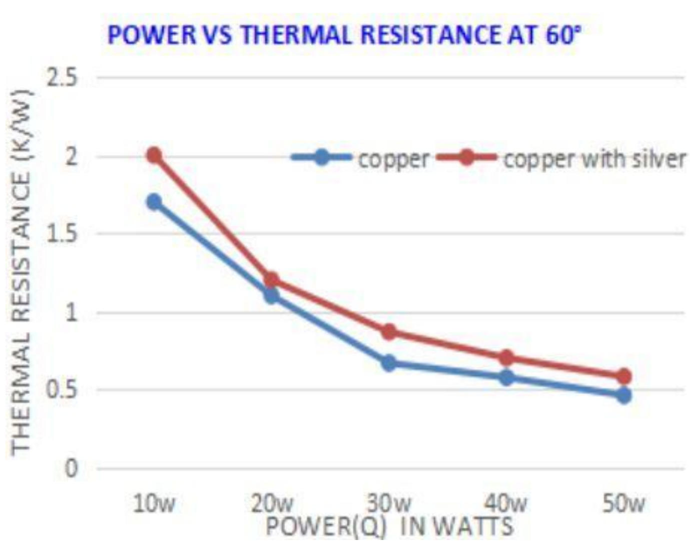

Fig. 12. *Comparison Of Total Thermal Resistance At Different Heat loads At 60°*

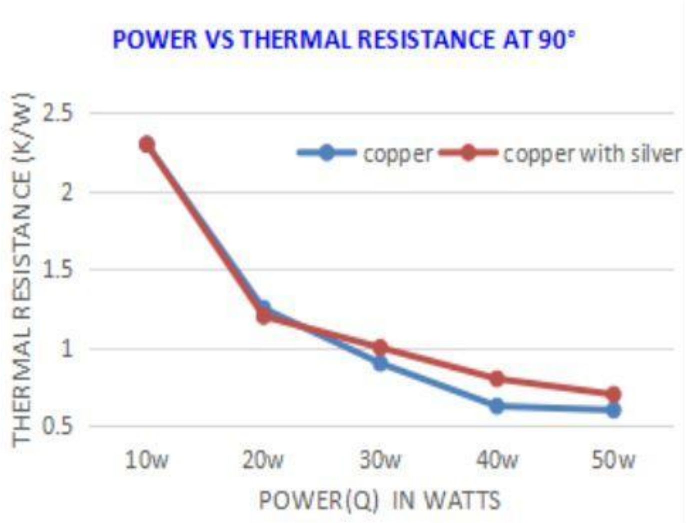

Fig. 13. *Comparison Of Total Thermal Resistance At Different Heat loads At 90°*

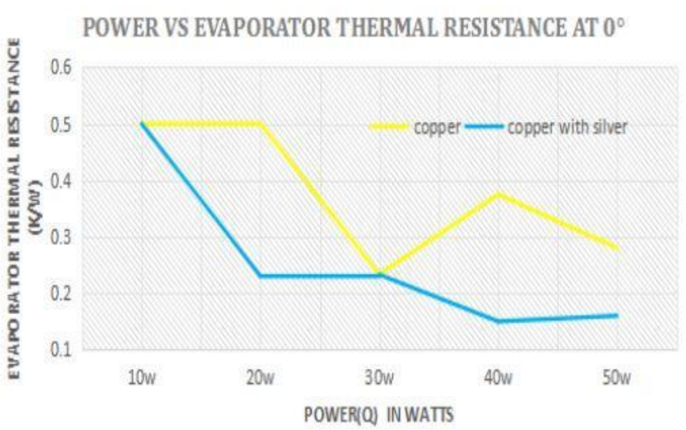

Fig. 14. *Evaporator Thermal Resistance Of Heat pipes At 0°*

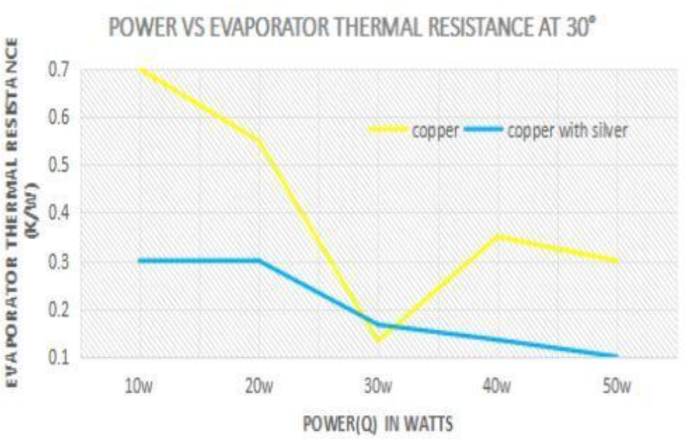

Fig. 15. *Evaporator Thermal Resistance Of Heat pipes At 30°*

4.2 Evaporator Thermal Resistance

$$\mathrm{Re} = \frac{Tw1 - T1}{Q}(k/w)$$

Where Tw1=evaporator wall temperature, T1= temperature at point 1 on heat pipe, Q=heat input, R=Thermal resistance. Heat transfer takes place from high temp low temp, If Tw1 >T1 then heat transfer from Tw1 to T1. Hence it indicates that the copper pipe wall has a good thermal conductivity. Silver has more Tw1 than copper. Sample calculations for R at Q=10w and 0 degrees,

For copper heat pipe, Re=0.5k/w.

For copper heat pipe with cylindrical evaporator section, Re= 0.5k/w.

Similarly, at different heat inputs and angles thermal resistance noted as follows graphs.

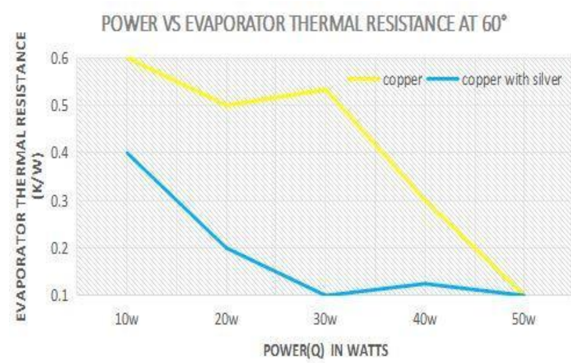

Fig. 16*. Evaporator Thermal Resistance Of Heat pipes At 60°*

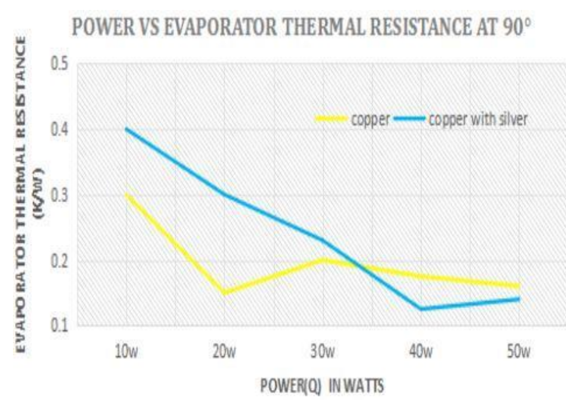

Fig. 17. *Evaporator Thermal Resistance Of Heat pipes At 90°*

Above graphs represents at high load thermal resistance, low for heat pipes.At 60 angle heat pipe has better thermal resistance than other angles.

5 CONCLUSION

Heat pipe at different angles of 0° ,60° , 30°, and 90° with the horizontal studied and compared copper heat pipe with copper heat pipe with a cylindrical evaporator silver pipe.Temperature distribution of both heat pipes measured. Wall evaporator temperature of copper Heatpipe is less than copper Heatpipe with cylindrical evaporator silver pipes.Evaporator thermal resistance, low at 60° for copper with silver heat pipes. Total thermal obstruction of both heatpipes approximately equivalent at various heat sources input and various points.

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