ENHANCEMENT OF HEAT TRANSFER FOR ELECTRONIC DEVICES USING HEAT PIPES WITH NANO FLUIDS

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Abstract: Heat pipes are one of the most effective procedures to transport thermal energy from one point to another, mostly used for cooling on a combination of conduction and convective heat transfer. A typical heat pipe consists of an evaporator attached to the heat source and the opposite end (a condenser) attached to the heat sink. The middle section (the adiabatic section) is insulated. In this paper, the design, fabrication and testing of heat pipe for transferring a heat load of 31.3 W is discussed. In this heat pipe, it consists of silver oxide as nano-fluids and mild steel wire mesh with cotton for making wick. Nano-fluids are prepared by the electrochemical synthesis method by selecting the appropriate temperature, voltage, and current. The overall length of the heat pipe is 100 mm, and the temperature difference in the heat pipe is 30°C. The temperature difference in each section, i.e., the evaporator, adiabatic, and condenser sections of the heat pipe, are shown in the graph, and the results are discussed.

***Key Words*: Nano fluid, Heat pipe, adiabatic, nano particles, Electrochemical, Silver Oxide.**

1. INTRODUCTION

The demand for faster and smaller micro-electronic systems continues to increase, and consequently, the amount of heat produced per volume increases. Therefore, the need for novel, efficient cooling devices is vast. Heat pipes are effective passive heat spreaders that can be used to solve this problem. Due to the combined convection and phase transition, high heat exchange efficiency can be achieved. Heat pipes are promising devices to remove thermal energy and keep the integrated circuits at the proper working temperature. The advantage of the heat pipe is that it uses phase change phenomena to remove thermal energy since the heat transfer coefficient of the phase change is normally 10 to 1000 times larger than typical heat transfer methods such as heat conduction, forced vapor or liquid convection.

Other applications of electronic cooling have included rectifiers, thyristors, transistors, traveling wave collectors, audio and RF amplifiers, and high density-semiconductor packages.

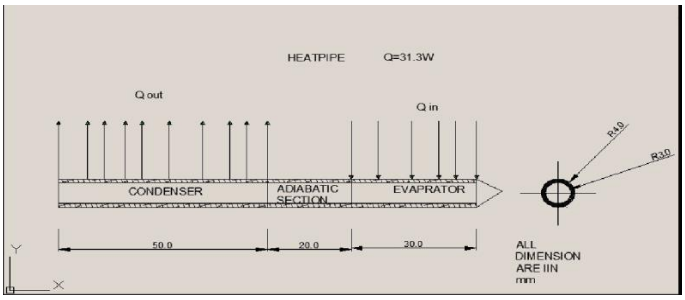

Fig -1: 2D view of wick type heat pipe

Fig -2: Image of wick type heat pipe with thermo couple and aluminium fin fitted in evaporator section

2. Literature Review

A.Naveen (2018) et al studied a TiO_2 nano fluid heat pipe designed for diameter and length of 31 mm and 500 mm respectively. It was tested by a container. The heat pipe was made of wick, copper, and stainless steel. The maximum heat load was 100W and the temperature was 373K in the maximum range. Swati Verma (2017) et al studied Silver (Ag) nano particles based on the combination and concentration of base fluid, and their thermo-physical properties. From these combinations, the size of nano particles was 1 to 5% by volume, and the temperature at 270^{0}C was selected and compared with benzene (C_6H_6) as base fluid. L. Karikalan (2022) et al Investigated shell and tube heat exchanger heat transfer rate with different volume of carbon nanotube nanofluid. The result of thermal conductivity, specific heat, and viscosity was compared with theoretical value. Abu Raihan Ibna Ali (2020) et al. reviewed the nano particles and their heat transfer applications and concluded that nano fluids had excellent thermal conductivity. B. Kirubadurai (2014) et al Investigated particles sizes, shapes and concentrations percent in the nano fluids. He concluded that the concentrations of nano fluid will vary up to a critical level and the thermal conductivity of fluid increased by physical properties of nano particles present in the nano fluids. Mohammed Saad Kamel (2016) et al reported the enhancement of heat transfer using nano fluids as one of the passive heat transfer techniques in several heat transfer applications. It is considered to have great potential for heat transfer enhancement and is highly suited to application in heat transfer processes like microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, and in boiler flue gas temperature reduction. This review covers the enhancement of heat transfer by using nanofluids and potential applications of nanofluids. Saif Ullah Khalid (2020) et al reviewed the performance improvement of heat pipe, with different types of nano fluids, grooves, wicks and the orientation of heat pipe. Better heat transfer heat pipe design is optimized only by economical and feasible methods.

3. Experimental Set up

The experimental set up is based on

- Evaporator Tube
- Condenser Tube
- Stainless Steel Mesh
- Porous Wick
- Reservoir Tank
- Fan
- Heating Source with Control Unit
- Working Fluid

3.1. DESIGN OF WICK -TYPE HEAT PIPE

Heat pipe is made of copper tube and has three distinct sections namely the evaporator section, the adiabatic section and the condenser section. The lengths of each section are 30, 20, and 50 mm, respectively. An aluminum fin is fitted in the condenser section to increase the heat transfer rate. The heat load transfer capacity from the source to the sink is 31.3 W. Mild steel wire mesh with cotton is used as a wick. The effective length of the heat pipe is 100mm, which is closed on both ends with a copper cap of length 5mm each. The wick is drenched with silver oxide nano-fluid. The heat intake from the heat source by the evaporator section is transferred through the wet wick and taken in the form of vapour to the adiabatic section, it is condensed in the where condenser section by the SMPS fan (Evaporator).
The condensed silver oxide nano-fluid goes to the evaporator section due to wicking by capillarity action. This process is repeated for the exchange of heat from heat source to the sink.

The wick type heat pipe is tested using temperature measuring unit. The experiment setup consists of
(i) Silver beaker with hot water of temperature 80^{o}C
(ii) Temperature measuring unit
(iii) Stand for holding heat pipe
(iv) SMPS fan
The Prepared Heat pipe with silver oxide Nano fluid is tested by using heat source of immersion water heater with temperature 60, 70,80^{o}C. The temperature at different section of heat pipe is measured by using thermocouple (K -type).

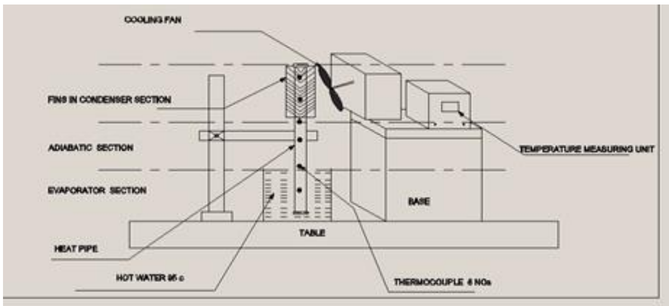

Fig -3: Experimental setup

4. TESTING

There are three sections based on eevaporator, adiabatic and Condenser section, on the experiment setup. In each section temperature was measured with two thermo couples at two different places. The Temperature sensed by the thermocouple was measured from the Temperature control unit.The Evaporator section (30mm) is immersed in the hot water (Heat source) . In the condensor section (50mm) , We fix the aluminium fin of 35mm width. The finned condensor section was cooled by SMPS fan. The results are analysed with different temperature range and tabulated.

Fig -4: Image of experimental setup

5. RESULTS AND DISCUSSION

The tested Temperature range are 60,70, 80°C . The Temperature Distribution along the heat pipe at the different sections is measured. The overall Temperature difference (drop) is 30° and heat source input is 31.3W.

Case (i)
The heat source is 31.3 W and the hot water (source) temperature is 60°C.The temperature distribution along the evaporator sections are 60.59° C and the temperature distribution along adiabatic section are 49.48°C. The temperature distribution along condenser section is 38.35°C. Overall Temperature drop is 25°C.

Case (ii)
The heat source is 31.3W and the hot water (source) temperature is 70°C. The temperature distribution along the evaporator sections are 69.5, 65°C and the temperature distribution along adiabatic section are 64.7, 40°C. The temperature distribution along condenser section is 40, 35.4°C. Overall Temperature drop is 34.6°C.

Case (iii)
The heat source is 31.3W and the hot water (source) temperature is 80°C.The temperature distribution along the evaporator sections are 78.9, 78°C and the temperature distribution along adiabatic section are 78, 78°C .The temperature distribution along condenser section are 65, 45°C. Overall Temperature drop is 35°C.
From the testing of Heat pipe with Effective length of 100mm and constant heat source of 31.3 W in different Temperature range, the average difference in Temperature drop is 31.5°C.

Table -1: Temperature distribution

	EVAPORATOR		ADIABATIC		CONDENSER	
	DISTANCE (10 MM)	DISTANCE (20 mm)	DISTANCE (10 mm)	DISTANCE (10 mm)	DISTANCE (20 mm)	DISTANCE (30 mm)
TEMPERATURE IN °C	60	59	49	48	38	35
TEMPERATURE IN °C	70	69.5	65	64.7	40	35.4
TEMPERATURE IN °C	80	78.9	78	78	65	45

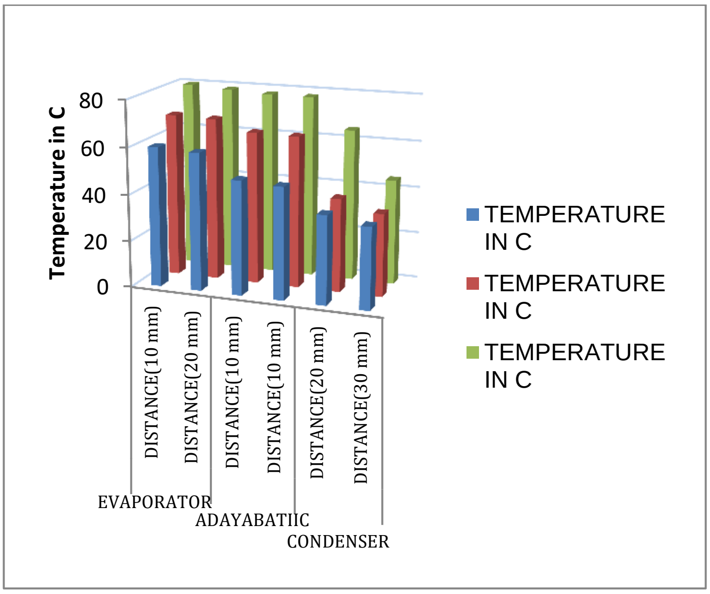

Chart -1: Temperature Distribution Chart

6. CONCLUSION

Experimental investigation of heat pipe preparation and Nano fluid preparation methods are studied and the wick type heat pipe with silver oxide Nano fluid tested successfully. In the condenser section, if the SMPS fan is not used the overall temperature drop is slightly decreased. To avoid the decrease in temperature drop we use fin with SMPS fan. The Experimental heat pipe was used to transport of heat load of 31.3W under ambient working conditions. Heat pipe with Effective length of

100mm and constant heat source of 31.3 W and average difference in Temperature drop is 31.5°C. So this heat pipe can be used in Electronic devices whose heat source 31.3 W or Temperature drop is in 31.5°C. The future development in this experiment pure silver as Nano fluid can be used instead of silver oxide Nano Fluid because of its high thermal conductivity.

In the heat pipe the wick structure can be changed to improve the capillarity action to increase the heat transfer rate.

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