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HEAT REJECTION APPLICATION BY USING HEAT PIPE

Siddharth Suman
Asst. Prof. Department of Mechanical Engineering
Dr. D. Y. Patil college of Engineering and Innovation, varale, pune, INDIA
siddharthsumansingh@gmail.com

Ratnakant Bandgar
BE Department of Mechanical Engineering
Dr. D. Y. Patil college of Engineering and Innovation, varale, pune, INDIA

Dhanaraj Malage
BE Department of Mechanical Engineering
Dr. D. Y. Patil college of Engineering and Innovation, varale, pune, INDIA

Pravin Guja
BE Department of Mechanical Engineering
Dr. D. Y. Patil college of Engineering and Innovation, varale, pune, INDIA

Akshay Katkar
BE Department of Mechanical Engineering
Dr. D. Y. Patil college of Engineering and Innovation, varale, pune, INDIA

ABSTRACT— The paper deals with heat pipe and cooling of central processing unit (CPU).Heat pipe is self operating device which is capable of transferring large amount of heat with minimum temperature difference between the hot end (evaporator) and cold end (condenser).The heat pipe can be regarded as good way for cooling electronics equipment. It can transfer heat from one point to another point. In computer, the use of heat pipe makes it possible to create less noise and effective system for cooling of computer.

Keywords- Heat pipe, nanofluids, Central processing unit.

I. INTRODUCTION

Today's rapid IT development like internet PC is capable of processing tremendous data at higher speed. This shows higher heat density and increased heat dissipation, making CPU temperature increase and causing the shortened life, distorted and failure of CPU. The performance level of electronics system such as computers are increasing rapidly while keeping the temperature of heat sources under control has been a challenge so, heat pipe can be a great option for cooling the central processing unit (CPU).[1]

A het pipe is essentially a passive heat transfer device over relative large distances with an extremely high effective moving part that can quickly transfer heat from one point to another point. [2]

A. Heat pipe

The word heat pipe as the name suggested, is a device having thermal conductivity to transfer heat rapidly from evaporation and condensation of a fluid in a sealed system .Heat pipe can be considered as a super thermal conductor that transfer heat by the evaporation and condensation of a working fluid. [3]

i. Types of Heat Pipe

a. Cylindrical heat pipe: Cylindrical heat pipe with closed ends is a common and conventional type of heat pipe. It requires circulation of working fluid and a wick to return the liquid. It consists of three sections, evaporator, adiabatic, and condenser. El-Genk and Lianmin [5] reported on the experimental investigation of the transient response of cylindrical copper heat pipe with water as working fluid. Results showed that the temperature of the vapour was uniform along the heat pipe whereas the wall temperature drop was very small (maximum variation less than 5 K) between the evaporator section and the condenser section. The steady-state value of the vapour temperature was increased when the heat input was increased or the cooling water flow rate was decreased. Said and Akash[6] experimentally studied the performance of cylindrical heat pipe using two types of heat pipes with and without wick, and water as the working fluid. They studied the impact of various inclined angles, such as 30°, 60°, and 90°, with the horizontal on the performance of heat pipe. Results displayed that the performance of heat pipe with wick was better than the heat pipe without wick. The overall heat transfer coefficient was the best at the angle of 90°.[4]

b. Flat heat pipe: Wang and Vafai [7] presented an experimental investigation on the thermal performance of asymmetric flat plate heat pipe. The flat heat pipe has four sections with one evaporation section in the middle and three condenser sections. The heat transfer coefficient and the temperature distribution were achieved. The results indicated that the temperature was uniform along the wall surfaces of the heat pipe, and the porous wick of the evaporator section had significant effect on the thermal resistance. The heat transfer coefficient was found to be 12.4 W/m2°C at the range of input heat flux 425–1780 W/m2. Thermal performance of a flat heat pipe thermal spreader was analysed by Carbajal. et al. [8] they carried out quasi-three-dimensional numerical analysis in order to determine the field variable distributions and the effects of parametric variations in the flat heat pipe system. Investigations showed that flat heat pipe operating as a thermal spreader resulted in more uniform temperature distribution at the condenser side when compared to a solid aluminium plate having similar boundary conditions and heat input [4].

c. Micro heat pipe: Micro-heat pipes differ from conventional heat pipes in the way that they replace wick design with the sharp-angled corners, which play an important role in providing capillary pressure for driving the liquid phase. Hung and Seng [9] studied the effects of geometric design on thermal performance of star-groove micro-heat pipes. Three different types of cross-sectional shapes of micro-heat pipes such as square star (4 corners), hexagonal star (6 corners), and octagonal star (8 corners) grooves with corner width w, were considered. Properly, the corner apex angle 2θ was varied from 20° to 60°. At steady-state system, one-dimensional mathematical model was developed to yield the heat and fluid flow characteristics of the micro-heat pipe. Results shows that the geometrical design of the star groove micro-heat pipes provides a better insight on the effects of various geometrical parameters, such as cross-sectional area, total length, cross-sectional shape, number of corners, and acuteness of the corner apex angle.[4]

d. Oscillating heat pipe: Oscillating (pulsating) heat pipe (OHP) is one of the promising cooling devices in modern application that can transport heat in quick response in any orientation, where the oscillating circumstance offer an enhanced heat transfer mechanism. The unique feature of OHPs, related with conventional heat pipes, is that there is no wick structure to return the condensate to the heating section; thus, there is no counter current flow between the liquid and vapour.[10] The fluctuation of pressure waves drives the self-exciting oscillation inside the heat pipe, and the oscillator accelerates end-to-end heat transfer.[11] The pressure change in volume expansion and contraction during phase change initiates and sustains the thermally excited oscillating motion of liquid plugs and vapour bubbles between evaporator and condenser[12], this is because both phases of liquid and vapour flow has the same direction. The thermally driven oscillating flow inside the capillary tube successfully produces some free surfaces that significantly enhance the evaporating and the condensing heat transfer.

ii. Advantages of heat pipe

a. Maintenance free
b. Last a very long time
c. Are environmentally safe
d. May reduce or eliminate the need for reheat
e. Requires no mechanical or electrical input
f. Efficient space

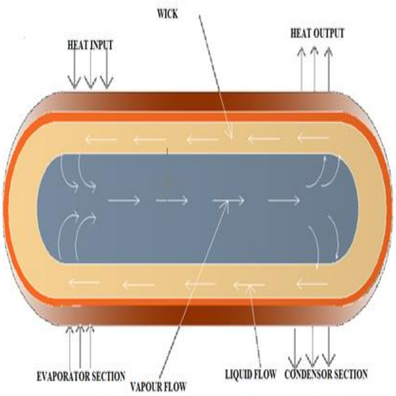

Fig.1, Heat Pipe

B. Working fluid

A first consideration in the identification of a Suitable working fluid is the operating vapors temperature range. Within the almost temperature band, several possible working fluids may exist, and a variety of characteristics must be examined in order to determine the most acceptable of these fluids for the application considered. The prime requirements are:

i. Compatibility with wick and wall materials
ii. Good thermal stability
iii. Wet ability of wick and wall materials
iv. Vapour pressure not too high or low over the operating temperature range
v. High latent heat
vi. High thermal conductivity
vii. Low liquid and vapour viscosities
viii. High surface tension
ix. Acceptable freezing or pour point.

The selection of the working fluid must also be based on thermodynamic considerations which are concerned with the various limitations to heat flow occurring within the heat pipe line, viscous, sonic, capillary, entrainment and nucleate boiling levels. In heat pipe design, a high value of surface tension is preferable in order to enable the heat pipe to operate against gravity and to generate a high capillary driving force. [13]. In addition to high surface the heat pipe is evacuated and then charged with the working fluid prior to being sealed, the internal pressure is set by the vapour pressure of the fluid. As the heat input to the evaporator, liquid in the Wick design is vaporized, creating a pressure gradient in the vapour core. Such pressure gradient forces the vapour to flow along the pipe to the cooling section where it condenses releasing its latent heat of evaporation, which is rejected to the surrounding by a heat sink. The liquid then returns to the evaporator section through the pores in the wick structure by the action of capillary pressure produced by the small pores of the wick structure. As a result, heat is sucked at one end of the heat pipe and rejected to the other. The working fluid serves as the heat transport method. The heat input section of the heat pipe is called evaporator, the cooling region is called condenser, and this is because the working fluid is being vaporized or condensed. In between the evaporator and condenser section, there may be an adiabatic section.

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Table No. 1: Fluids and Their temperature Range. [14]

Fluids	Temperature Ranges(•c)
Helium	-271---269
Nitrogen	-203---160
Ammonia	-78---100
Acetone	0---120
Methanol	10---130
Water	30---200
Mercury	250---650
Sodium	600---1200
Silver	1800---2300

C. Operation of Heat Pipe

The heat pipe operating principle is that a liquid is heated to its boiling point, vaporizes and gives of useful heat, condenses and return to heat source. The heat pipe is a closed and utilize in vacuum. The boiling point of a liquid is a function of surrounding pressure it, because of the strong vacuum (about 10-3 micron of Hg), the working fluid is virtually in a state of liquid-vapor equilibrium. Successfully, a slightly raise in temperature will cause it to boil and vaporize. .Inside the container liquid is under its own pressure, which enters the pores of the capillary material wetting all internal surfaces. Applying heat at any section along the surface of the heat pipe causes the liquid at that point to boil and enter a vapor state. When that occurred, the liquid picks up the latent heat of vaporization. The gases, which then has a higher pressure, moves inside the closed container to a colder location where it condenses

Thus, the gas gives up the latent heat of vaporization and transfer heat from the input to the output end of the heat pipe the performance of heat pipe is affected by gravity. Optimum performance is obtained when the pipe is vertical with the condenser region directly above the evaporator. In this location gravity aids the pumping action in the wick. However, heat pipe can operate in any location and are bidirectional. If a heat pipe doesn't take advantage of the gravitational forces, a high power rating is required [15].

A typical heat pipe consists of three main region, which includes an evaporator section, an adiabatic region, and condenser region. Heat added at the evaporator region vaporizes the working fluid, which is in equilibrium with its on vapour. This creates pressure difference between evaporator region and condenser region, which drives the vapour through the adiabatic region. At the condenser region heat is separated by condensation and is ultimately dissipated through an external heat sink. The capillary effect of the wick structure will force the flow of liquid from condenser to evaporator section. The heat is transferred as latent heat energy by evaporating the working fluid in the evaporator (hot side) and condensing the vapour in the condenser (cold side), the circulation is completed by the forces, such as capillary force, gravitational force, electrostatic force directly acting on the liquid flow.[16]

D. Wick:

The wick structure is the most important component of a heat pipe. It is responsible for the return of liquid from the condenser section to the evaporator region by the capillary property, even against the direction of gravity. Thus, the presence of wick makes the heat pipes utilize in all orientations. The grooved wick, sintered wick, and screen mesh wick are the most important types of wick studied abundantly. [4]

These wick types are widely used in the electronics industries are:

a. Metal sintered powder Wick: This type of the wick has a small pore size, resulting in low wick Permeability, leading to the generation of high capillary forces for antigravity applications. The heat pipe that carries this type of wick gives small variation in temperature between evaporator and condenser region. This minimizes the thermal resistance and increases the effective thermal conductivity of the heat pipe.

b. Grooved wick: This type of wick generates a small capillary driving force, but is appropriate or sufficient for low power heat pipes, which operates horizontally or with the direction of gravity. Zhang and Faghri [17] simulated the condensation on a capillary grooved design. They analysed the impacts of surface tension, contact angle, temperature drop, and fin thickness using the volume of fluid (VOF) model. Results show that the contact angels and heat transfer coefficients decreased when temperature difference increased.

c. Screen mesh wick: Used in many of the products, and they have demonstrated useful characteristics with respect to power transport and orientation sensitivity. Wong and Kao [18] presented visualization of the evaporation/boiling process and thermal measurements of horizontal transparent heat pipes. Presented the picture and thermal resistance measurement for the sintered mesh–wick evaporator in flat plate heat pipes. The wick thickness was between 0.26 and 0.80 mm with various combinations of 100 and 200 mesh screens. Results indicated that the increasing heat load tend to decrease the resistance of the evaporation until partial dry out occurred.

II. CAD MODELLING

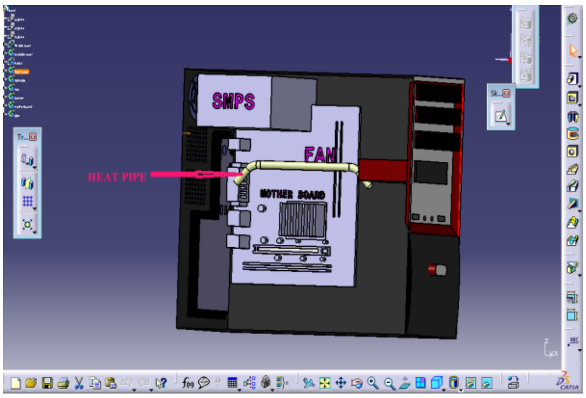

Fig.2, CAD Model of CPU Heat Pipe.

In above CAD model it shows the model of CPU and heat pipe.In this model heat pipe arrengment shows that which removes heat from the system.The heat pipe is replaced by the fan which is mounted on the moterboard.This model is created from the CATIA V5.

III. CONCLUSION

Heat pipe is a thermal super conductor under certain heat transfer condition they can transfer the heat energy 100 times more than available best conductive materials, because of negligible temperature gradient exist in heat pipe.

The heat pipe has compact, light weight, reversible in operation and high thermal flux handling capacity makes heat pipe to use new modern period and in more broad variety applications to overcome critical heat dissipation problem.

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