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Design of Electronic Cooling System

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ABSTRACT

The ability of electronic devices to dissipate heat remains of great challenge in electronics. Many researchers are working on innovative ways to provide cooling solution or reuse this heat. Pin fin is widely used in numerous applications to dissipate the heat.Electronic component can be cooled using natural convection.Heatpipes are used effectively to remove the heat due to recent advances in heat pipe have proved, it is one of the major contender for heat removal. The flexibility is different sizes has become major advantage of using heat pipe as a heat exchanger.

*In current project work, the '**electronic cooling solution**' is provided for a '**LED flashlight**' that emits 75W. We have proposed a combination of extended surface as '**fins**' along with '**heat pipe**'. The experimental work is carried out to dissipate heat and also enhance the performance of heat pipe heat exchanger in electronic cooling application. Due to space constraints, the use of fins in combination with heat pipes gives better cooling effect. A basic strategy to evaluate an exchanger's performance is through the study of '**dimensionless numbers**'. The impact of dimensionless numbers is used to evaluate heat transfer coefficient.*

I.INTRODUCTION

1.1 Heat Exchanger

Heat exchanger has becomean inherent part of the mechanical systems such as power plants, process industries and heat recovery units, and plays a very significant role. The performance evaluation of any thermal systems is broadly depends on the effectiveness of heat exchangers. This leads to continuous improvement on efficient and reliable designs in the overall system performance. Fig. shows the application of heat exchanger used in cooler[1].

Fig 1- Heat exchanger

The heat transfer takes place in three fundamental modes such as, conduction, convection and radiation.

1.2 Heat Transfer Mechanism

The fundamental modes of heat transfer are:

a) Conduction
b) Convection
c) Radiation

1.3 Component of Heat Exchanger

The main components used in heat exchanger are listed below:

i.Tubes
ii.Channel partition plates
iii.Shell baffles
iv.Tie rods
v.Shell barrel and channel barrel
vi.Nozzles
vii.Flanges
viii.Tube sheets

1.4 Performance of Heat Exchanger

The performance of heat exchanger is greatly affected by the use of above components and its material properties.

Heat exchangers are employed in the process industries as well as in electronics as a means of providing heat transfer between two streams of fluid across a medium. The heat exchanger ensures the conservation of heat energy. To optimize and improve heat exchanger performance, the operator must operate the exchanger within its designed and specified limits. Also, the operator must identify those operating parameters that can affect heat exchanger performance. The key operating parameters to monitor include feed material, high degree of fouling, poor maintenance culture, climatic effects, etc.

To ensure a long service life, process personnel should have anunderstanding of material properties and their corresponding effects at varying conditions. Further, process personnel should take special care in the operation and maintenance of the heat exchanger.

The performance of heat exchanger can be improved by using heat pipes. The performance of the heat pipe heat exchanger is based on tube material, wick structure and working fluid. The effect of all these things is studied according to temperature range. They have high thermal conductivity. They can easily be implemented as heat exchangers in refrigerators and other types of heat transfer devices. Heat pipe has heat transfer coefficient 10^3–10^5 W/m^2 K and thermal resistance is 0.01–0.03 K/W.

1.5 Electronic Cooling

Electronic devices produce heat as a by-product of normal operation. As the power of these systems increases and the space allotted to them diminishes, heat flux or density (heat per unit area, W/m^2) goes up to a large extent. When electrical current flows through a semiconductor or a passive device, a portion of the power is dissipated as heat energy. Besides the damage that excess heat can cause, it increases the movement of free electrons within a semiconductor, causing an increase in signal noise. Moreover, the junction temperature of a semiconductor device should always be kept below the maximum safe operating temperature specified by the manufacturer, as excessive heating adversely affects the performance, life and reliability of the device.

The present work is motivated by the need of effective passive cooling for LED flashlight used in cameras. The cooling of the flashlight is done with help of heat pipes and extended surfaces fins.Heatpipes are widely used in electronic cooling because heat pipes are ideal heat transport. Heat pipes are very good heat spreader from hot spot like a CPU to a big surface like an enclosure of side wall.

Now a day because of the ever-increasing density of dissipated power, thermaland electro-thermal modeling of electronic systems has become an indispensablestage of their design and analysis.As electronic devices run, they consume electric power, this power needs to be dissipated or otherwise heat will be accumulated and device's temperature may exceed to dangerous levels.If system is not properly designed and controlled, high rates of heat generation result in high operating temperatures for electronic component. This jeopardizes its safety and reliability. Consider the simplest electronic component, the resistance, as the electric current pass through it heat is generated by Equation given below:

$$P = I^2 * R \qquad (1)$$

Where;

P = Represents both the electric power and heat dissipated in W

I = Electric current in A

R = Electric resistance in Ω

In electronic cooling, natural or free convection occurs due to the change in density of the fluid caused by heating process. In a gravity field, the fluid, which has a lower density, is lighter and therefore rises, creating a movement in the fluid which is called convection. This movement permits the fluid to pick up heat and carry it away. The natural convection is the common method used in electronics cooling; there is a large class of equipment that lends itself to natural convection .This category includes stand-alone packages such as modems and small computers having an array of printed circuit boards (PCB) mounted within an enclosure. The general equation to define the convective heat transfer either forced or free is given by the Newton's law of cooling:

$$q = hA\,(Ts - T\infty) \qquad (2)$$

Based on heat transfer effectiveness, the existing cooling modes can be classified into four general categories which are:

a. Natural convection
b. Forced convection by air cooling
c. Forced convection by liquid cooling
d. Liquid evaporation.

In current project work, we use natural convection for electronic cooling of LED flashlight, because natural convection is the effective method for cooling of the electronic component.

II.NEED OF ELECTRONIC COOLING

Electronic equipment has made its way into every aspect of modern life, from toys to high-power computers. As the electronic devices run, they generateheat, this heat needs to be dissipated or it will cause damage to device. Hence to prevent device from damaging while working, there is a need for electronic cooling.

In case of LED flashlight there is huge amount heat energy generated which results in temperature rise that causes overheating. In earlier days this heat is dissipated with the help of radial fins. The rate of heat dissipation by the radial fins is very poor and the resistance occurred is very large; so there is need of designing a system which will overcome the above problems.

Conventionally, radial fins were used but to improve heat transfer rate, there is a need to change fins or orientation of fins. Use of radial fins resulted in high resistance and low heat transfer. Hence to avoid this overheating, fan were used to bring down its temperature. As it is application from film industry, we need to avoid noise produced by fans. Due to all issues faced by conventional setup, we modified the system with axial fins.

Generally, in electronic appliances, cooling is provided by forced convection which generates more noise. Thus to reduce this unwanted sound produced by fans, we use natural convection phenomenon which helps in optimal running of the system.

III. PROBLEM STATEMENT

Design and manufacturing of electronic cooling system to dissipate heat generated by LED flashlight with the help of extended fins and heat pipes.

Fig 2- Flashlight

IV. OBJECTIVES

a. To dissipate 75W of heat generated by heat source with the help of number of fins and heat pipes

b. To find out optimum fin spacing and fin efficiency

c. To find heat transfer coefficient

d. To find out spreading resistance and heat pipe resistance

V. LITERATURE SURVEY

5.1 Performance & Thermal Analysis of Heat Sink with Fins

Heat sinks are devices that enhance heat dissipation from a hot surface, usually the case of a heat generating component, toe cooler ambient, usually air.Heat sink is a passive heat exchanger that cools a device by dissipating heat into the surrounding medium.

The heat sink is a very important component in cooling design. It increases the component surface area significantly while usually increasing the heat transfer coefficient as well. Thus, the total resistance from the component junction to the surroundings is reduced significantly, which in turn reduces the junction temperature within a device.The primary purpose of a heat sink is to maintain the device temperature below the maximum allowable temperature.

Heat sinks are the commonly used devices for enhancing heat transfer in electronic components. In this work, a new concept for cooling the electronic components using the Aluminum alloy heat sink is proposed.

Practical heat sinks for electronic devices must have a temperature higher than the surroundings to transfer heat by convection, radiation, and conduction. The power supplies of electronics are not 100% efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat sink is included in the design to disperse heat to improve efficient energy use.

Heat transfer taken in natural air and aluminum 6063 as a fin material. To study of thermal performance of different fin and get the value of thermal resistance,we required some dimensionless numbers such as Grashof number, Rayleigh's number, Prandlt number each dimensionless number signifies something.

5.2 Electronic evaporative cooling

With the development of human civilization, electronic equipmentsets, such as computers, radios and electricvehicles, intrude all respects of our daily lives. Some particular electronicequipment sets with smaller size have to deal with a largeheat flux. Most of them need to work in relatively stable conditionswith a small temperature fluctuation range. When the temperature exceeds to certain values, the performance of the componentsgoes down sharply, eventually stopping the device fromworking. Therefore, the cooling performance of electronic componentsis always an interesting topic for researchers. However, traditional cooling systems can no longer satisfy the requirements for the cooling performance of electronic components because oftheir limited cooling capability. Nowadays, two-phase evaporative cooling systems are widely applied in the electronic cooling field, e.g. cooling of radio, computers, or chips.

5.3 Literature summary-

a. Methods of electronic cooling and its importance

b. Types of heat pipes with construction and working principle along with design criteria is given.

c. Working fluid selection based on operating temperature and application of heat pipe is an important step in performance optimization of heat pipe heat exchanger.

d. Study of thermal resistance network, convective heat transfer analysis and pressure drop analysis is also done.

e. Study of spreading resistance and its impact on electronic cooling of components and different methods for reducing spreading resistance

f. Electronic cooling is effective transfer of heat from electronic devices to the ambient using heat sinks or other cooling technologies.

VI.DESIGN OF ELECTRONIC COOLING SYSTEM

To start a domestic working model for the project work there is a need to design it so that it can meet all the requirements.

6.1 Design Basis:

According to given problem statement, we have rate of heat transfer as 75watt. Heat source which is producing 80°C temperature which is to be maintained 60°C and ambient temperature is 25°C. To dissipate 75W heat we used heat sink made of aluminium with natural cooling.

To understand the principle of a heat sink, consider Fourier's law of heat conduction. Fourier's law of heat conduction, simplified to a one-dimensional form in the x-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction, qk {\displaystyle q_{k}}is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred:

$$q_k = -kA\frac{dT}{dx} \qquad (3)$$

where

k is the thermal conductivity of the fin materialAluminium: 120 to 240 W/(m·K)

6.2 Design primary heat sink

Gr= Grashof's number

Ra= Rayleigh's number

Pr= Prandlt number

$\beta=\frac{1}{T}$= Thermal expansion of coefficient

T=Surface Temperature

T_{∞}=Air Temperature

L= Characteristic Length

ϑ= Kinematic viscosity

For $30^{0}c$ and 1atm pressure

k=0.02735 $\beta = \frac{1}{323}$

Pr=0.7228 $\vartheta = 1.798 * 10^{-5}$

$$Ra = Gr * Pr$$

$$Gr = \frac{g\beta(T - T_{\infty})\,L}{\square^2}$$

$$Ra = \frac{g\beta(T - T_{\infty})\,Lc^3}{\square^2} * Pr$$

$$Ra = \frac{9.81 * 1(60 - 40) * 0.162^3}{323 * (1.799 * 10^{-5})^2} * 0.7228$$

$$Ra = 6.95 * 10^5$$

t=Thickness of fins

6.3 Design of secondary heat sink

For $30^{0}c$ and 1atm pressure

k=0.02735 $\beta = \frac{1}{323}$

Pr=0.7228 $\vartheta = 1.798 * 10^{-5}$

Lc=0.05m

$$Ra = \frac{g\beta(T - T_{\infty})\,Lc^3}{\square^2} * Pr$$

$$Gr = \frac{g\beta(T - T_{\infty})L}{\square^2}$$

$$Ra = \frac{9.81 * 1(60 - 40) * 0.05^3}{323 * (1.799 * 10^{-5})^2} * 0.7228$$

$$=169.763*10^3$$

VII. FUTURE SCOPE

We can use more heat pipes for more effective heat transfer if there is a space constraint.

Heat removed from the electronic component can convert into another form of energy.

We can use peltier module and thermoelectric generator to convert thermal energy into electrical energy.

REFERENCES

Books:

[1] A. F. Mills and B. R. I. L, R. D. Irwin, "Basic Heat and mass transfer", 1995

[2] M. A. Taylor, "Plate-Fin Heat Exchangers: Guide to Their Specification and Use", Harwell Laboratory Oxon, UK, amendment to 1st ed., 1989..

[3] E. H. C. K Loh and I. A. D. J Chou Enertron, "Comparative study of heat pipes performances in different orientations", 2010.

[4] Y. A. Cengel," Heat and Mass Transfer", 4th ed., Tata Mac Grow-Hill, Delhi.

[5] B.H.C.F.R., Velraj. R. V. Seenraj, "Heat transfer enhancement in latent heat storage system", sol. Energy 65, Vol. 3.

[6] D. reay and P. Kew, "Heat pipes,Theory,Design and applications", Edition 5.

Journals:

[7] Lee, S., Song, S., Au, V., and Moran, K., Construction/ Spreading Resistance Model for Electronic Packaging, Proceedings of *ASME/JSME Engineering Conference, Vol. 4,* 1995.

[8] M. Patriknemec, A. A. "Thermal performance measurement of heat pipe," University of ilina, Department of power engineering, Univerzitn, 2011.