A Review on Natural Convection Cooling of Vertical Cylinder with Inclined Fins

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Abstract : Due to recent development in the semiconductor technology, heat dissipation through external heat surface finds an extensive scope for many researchers today. The natural heat convection heat sink proves to be great solution for heat dissipation through external surfaces (fins). The passive cooling of any surface is found to be more preferable than active cooling. A lot of research in natural convections through external surfaces is conducted experimentally and being verified numerically and analytically using various software. The research is being conducted to investigate the effect of various parameters such as fin length, fin height, fin numbers, their spacing, orientation, shape and sizes and the effect of these parameters on the overall performance of the proposed systems. The given paper aims to review the various research being conducted on inclined extended surface on the various.

IndexTerms **-Extended surfaces, heat dissipation, and natural convection cooling.**

I. INTRODUCTION

With the rapid development in electronic devices in the recent years, a lot of research is being put on the development of semi-conductor technology. The heat generation from electronic devices is considerably increased with continuous increasing demand for high performance and size reduction. The heat generation density (heat flux) from silicon microprocessors has reached 100 W/cm^2 and is approaching that of the surface of the sun. The high heat generation from these electronic devices raises the junction temperature which affects the overall performance and durability of it. The temperature of this devices must be maintain within desired limit as the rate of thermal failure increases and life of the devices decreases exponentially with increases in junction temperature. This leads to an increasing demand of the thermal management of these devices for increasing their performance and durability. The various cooling techniques have been suggested; among them the natural convective heat sinks prove to be best due to their low cost, simplicity and reliability. The natural convective heat sinks are extensively used for moderate heat flux applications like telecommunication modules, displays, home appliances, industrial heat exchangers, LED's.[1]

Martynenko and Khramtsov and Raithby and Hollands have conducted many research on heat transfer through extended surface using natural convection. The conducted works highly motivate the fact that the heat transfer from extended surface increases considerable that leads to high heat dissipation. Many researchers conducted the theoretical and experimental studies on the heat dissipation through vertical cylinders with extended surfaces. Also, extensive research on the various geometric parameters like fin length fin height, fin thickness, fin shape, fin spacing, fin number, etc. has been conducted and verified experimentally and validated using numerical and analytical techniques.[1,2]

II. TERMINOLOGY OF HEAT SINK

The terminology of heat sink is shown in fig no.1,

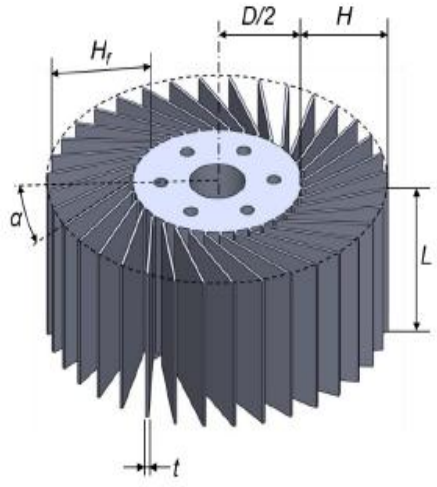

Fig. 1 Heat sink terminology [1]

Where
D = Diameter of cylinder
H = Radial height of fins
Hf = Actual height of fins
L = Length of fins
α = Angle of inclination
t = Thickness of fin

III. EXPERIMENTAL SETUP

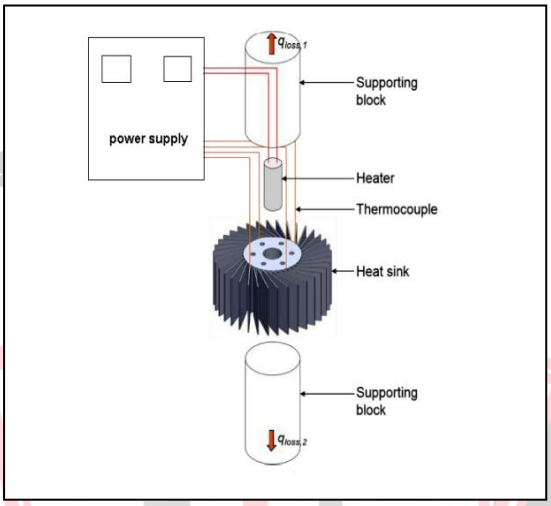

Fig. 2Heat sink assembly

Figure 2 shows the experimental setup of natural convection cooling of vertical cylinder with fins. It consist of heat sinks with various configuration of fins, cartridge heater as a heat source, control panel board to control the input parameter and display for showing data. Thermocouples are used to measure temperature of heat sink as well as ambient. The supporting blocks are provided to reduce heat loss in axial direction. It is made up of Teflon.

IV. REVIEW OF EXPERIMENTAL WORK

Jong Bum Lee [1] investigated experimentally the effect of natural convection from vertical cylinders with inclined plate fins for their use in cooling electronic equipment. Extensive experimental investigations are performed for various inclination angles, fin numbers, and base temperatures to study their effect. From the proposed work, a correlation for estimating the Nusselt number was found. The correlation is applicable when the Rayleigh number varies from 100,000–600,000 for the inclination angle of 30–90^0 and fin number are in the ranges from 9 to 36. It is also found that the optimal thermal resistance of the cylinder with inclined fins is 30% lower than that of the cylinder with radial plate fins. Thus, it is found that inclined fins have better performance over than radial plate fins.

MyoungwooLee [2] conducted experiment for natural convection from vertical cylinders with triangular fins with various fin numbers, fin heights, and base temperatures. From the experimental data, he propose a correlation for estimating the Nusselt number, which is applicable when the Rayleigh number ranges from 1000 to 120,000, ratio of the fin height to fin length ranges 0.2–0.6, and fin number from 9–72. The proposed correlation is found to have a good potential to use in early stages of heat sink design.

Hyun Jung Kim et al [3] experimentally investigated the effect of various fin numbers, fin heights, and base temperatures on natural convection from horizontal cylinders with longitudinal plate fins.
The experimental data was used to establish a correlation between various parameters in the range
Rayleigh number 300000–1000000; fin-height-to-cylinder-diameter ratio 1/6–1/2; and fin number 9–72. A contour map which describes the thermal resistance as a function of the fin number and fin thickness was also developed.

XiaobingLuo et al [4] experimentally investigated the performance of the microjet based cooling system for the thermal management of high-power light-emitting diodes (LEDs). He found that the use of microjet based cooling system for the flow

rate of micro pump is 9.7 ml/s, the maximum LED substrate temperature measured by the thermocouples will remain stable at about 36.7 ^{0}C.The preliminary test and numerical optimization results concluded the better performance of the optimized microjet cooling system in thermal management of a 220-W LED lamp. The temperature test demonstrates that the cooling system had good performance.

Bin Li et al [5] numerically and experimentally studied the heat transfer characteristics around a radial heat sink with a horizontal circular base, concentric ring, and rectangular fins subjected to natural convection A Finite Volume Method numerical model was used to analyze the temperature and natural convection heat transfer on the surfaces of the radial heat sink for a wide range of geometric parameters. The study aims to establish the relation between various parameters fin length spacing between fins and the Elenbaas number on the Nusselt number of the heat sink. In order to support the numerical results, experimental study was performed. The experimental result indicates that the present numerical model predicted the Nusselt number well within a maximum error of 4%. Thus the study establish a generalized correlation for predicting the Nusselt number as a function of the three afore mentioned nondimensional parameters. This correlation can be widely utilized for predicting the thermal performance of radial heat sinks with concentric rings subject to natural convection.

ByoungHoonAn et al [6] proposed the empirical correlation for estimating the Nusselt number for natural convection from cylinders with vertically oriented plate fins. The suggested correlations is limited to the specified range as 100,000 <RaL< 600,000, 1/6 < H/D < 1/2, and 9 < N < 72. The presented correlations enabled a simple optimization and can be effectively used for the design of heat sinks in thermal design.

Bin Li et al [7]experimentally and numerically studied the effect of orientation for a radial heat sink with a circular base, concentric ring, and rectangular fins. The investigation was made study the effects of orientation angle with respect to gravity, various geometric parameters, Elenbaas number, on the Nusselt number. It was concluded that the influences of fin number and fins length on the orientation effect are significant, whereas the fin height and base height are slightly insignificant.
The horizontally oriented radial heat sinks had better thermal performance than vertically oriented radial heat sink due to the existence of the concentric ring preventing the natural convective upward flow. A closed-form correlation for predicting Nusselt number with heat sink design parameters was proposed.

Kuen Tae Park et al [8] investigated experimentally the natural convection from vertical cylinders with branched plate fins for various branch angles, fin numbers, and base temperatures. The experimental results proposed a correlation for estimating the Nusselt number applicable for the Rayleigh number, branch angle, and fin number in the range of 100,000–600,000, 10–40, and 9–36, respectively. The correlation was used to establish a contour map depicting the thermal resistance as a function of the fin number and fin thickness. The contour map also showed the fin number and fin thickness at which the thermal resistance was minimized. The comparison between the thermal resistances of cylinders with branched fins and conventional plate fins showed that the cylinders with branched fins exhibit thermal resistances up to 36% lower than those of cylinders with plate fins.

GyeongUk Kang et al[9] experimentally investigated the natural convection on vertical thin- and thick-cylinders for Rayleighnumbers from 1.4 x10^9 to 3.2 x10^{13}, the H/$D_O$from 0.6 to 140 at high Prandtl numbers. A sulfuric acid–copper sulfate electroplating system based on analogy concepts were employed for the measurements ofheat transfer rates. For vertical thin-cylinders, Nusselt numbers were in satisfactory agreements with theexisting correlation on vertical plates. It was found that the phenomenon occurred due to the flowinteractions, which promoted the development of momentum boundary layer and velocity fluctuations,leading to the enhancement of the Nusselt number. For vertical thick-cylinders, Nusselt numbers inlaminar flows were in satisfactory with the existing correlations which considerably decresed in turbulent flow with increase in Prandtl number. The Empirical relations for laminar and turbulent flows were derived from the phenomenon studied.

Fengming Wang et al [10] numerically and experimentally investigated the heat transfer characteristics for the natural convection over horizontal circular base, concentric ring, and rectangular fins. A Finite Volume based numerical model was analyzed to study the temperature and natural convection heat transfer co-efficient for a wide range of geometric Parameters. The numerical results was used to establish a generalized correlation for predicting the Nusselt number was developed as a function of the three aforementioned nondimensional parameters.This correlation can be widely utilized for predicting the thermal performance of radial heat sinkswith concentric rings subject to natural convection.

Leonardo Micheliet al [11] experimentally investigated the effect of the orientation of micro-finned heat sinks with different fin geometries and heat transfer coefficients and their orientation. The study concludes the effect of fin thickness on Nusselt number. The correlation of the effect of fin thickness on Nusselt number was analyzed and modified correlation was proposed.

CONCLUSIONS

In this paper review of Natural Convection Cooling of Vertical Cylinder with Fins has been carried out. It is observed that Passive cooling is always economical than active cooling hence fins are being very effective for natural convection cooling of vertical cylinder. It is also helpful to maintain the thermal performance of electronic component. The heat dissipation rate is

plays important role in performance of thermal component. The problem of heat dissipation rate is increases due to configurations of fins.

It is observed that the configuration of fins are reduces the thermal resistance of heat sinks. Heat dissipation rate is increases due to low resistance it will improves performance electronic component.

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