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Review on the Effect of Geometrical Parameter on Heat Transfer Performance for LED

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***Abstract* - LED lamp use increases day by day. In LED about 80% of energy is converted into heat. Excess heat causes a decrease in life as well as illumination efficiency. In this paper, we reviewed the different techniques used for the cooling of the LED. Generally, the passive method is preferred in the cooling of the LED. An experimental and numerical study was done by the researcher to obtain optimum arrangement for heat dissipation from the heat sink of the LED. Qie shen discussed the effect of orientation of fin on a rate of heat transfer. Hao wegang studied the effect of fin length fin height synergy angle on thermal resistance. Yicang Huang carried out a numerical simulation of the different arrangements of heat sinks like conventional and OPF and PPF. The spiral profile is the best in heat dissipation is discussed by P Ranjith**.
***Keywords:* LED, Heat Sink, Orientation**

I. INTRODUCTION

Nowadays, conventional light source is replaced by an LED lamp for energy saving purposes. The LED light has compact in size and more energy efficient. It is an environment-friendly source. The life of LED chips and illumination is affected by junction temperature. The radiant efficiency of the high-power LED will decrease with an increase in junction temperature and the luminous efficiency of LED increased with the decrease in Junction Temperature. Around 20 to 30% of energy is converted into light and remaining is converted into heat. The Heat is a waste product in Led working So it may be dissipated quickly. This heat will hamper on the life of LED as well as the illumination of the LED. The various techniques are available for waste heat dissipation from LED like active and passive. The passive technique is cost-efficient, and it will require less space, so it is widely used. The extended surface is the most reliable and cost-efficient passive technique. Generally, a rectangular fin array is used in LED.

II. REVIEW OF PAPERS

Thermal management of the LED is nowadays more important, so Various researcher works on the optimization of the heat sink of the LED. Fin length, number of fin, shape or profile of fin, the material of fin, fin spacing, the thickness of the base plate, height of fin, width of the fin are the important parameters that need to optimize for higher heat transfer rate. The few of them reviewed below.

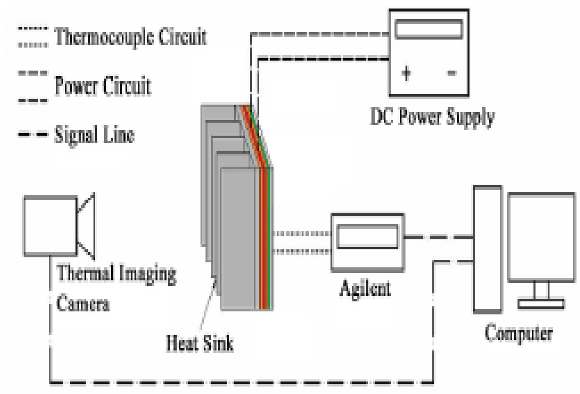
Qie Shen *et al* [2] carried out experimental as well as numerical study for understanding orientation effect on fluid flow and heat transfer for rectangular fin array under natural convection. Heat sink made up of aluminium alloy 5083 and setup consist revolving frame to achieve the desired orientation. The size of the baseboard is 123mm*157mm and aluminium base thickness is kept 10mm also fin height and fin thickness kept 50mm and 2mm, respectively.

They kept the steel plate in between the two copper plates to simulate the LED generating heat. The heating layer is covered by PCB &PMMA Lampshade over which silicone grease is spread. They carried out the test for 12, 24, and 35 W heat power. The experimental setup, as well as a revolving arrangement of the heat sink shown in the fig.no.1. numerical analysis is carried out for 8 orientations.

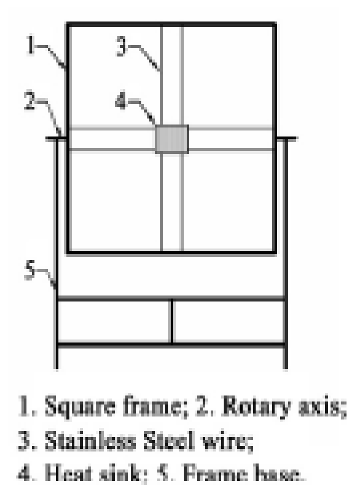
The experimental and numerical result is compared in this paper, they observe slightly more variation between predicted and observed excess temperature. For 7& 11 number of fins observed less variation in thermal performance from 0^0 to135^0. For 270^0 orientation around 40% of excess temperature rise is observed. Inflow analysis they observed, 315^0 orientation for 16 numbers of the fin has better heat dissipation performance and 180^0, 225^0, 270^0 have poor heat transfer.

In this paper, they made the following conclusion

1. Denser fin array is more sensitive to orientation
2. Orientation effect factor based on heat dissipation for 135^0, 225^0, 315^0 are 99%, 76%, 91% respectively.



(a)



(b)

Fig.1 Schematic Sketch of the Experimental setup. (a) Measurement and Data Acquisition System. (b) Schematic Diagram of the Revolvable Frame

Haowegang *et al* [4] was done the thermal analysis of LED heat sink array under natural convection Aluminum heat sink array is taken as shown in figure no.2. Numerical simulations were done on fluent software. The effect of conduction, convection, radiation is considered numerical result is validated experimentally, for the validation temperature difference between experimental and numerical taken into consideration. They got less variation in the experimental and numerical results with a correlation coefficient of 0.985. In experimental analysis heat input of 1W tow maintain by varying input voltage. Heat sink for experimentation has no. of fin=56, L=W=42mm H=31mm.

They also predict the effect of the number of the fin, height of fin, synergy angle, and radiance on thermal resistance and heat transfer coefficient. As the number of fin increases the thermal resistance and average heat transfer coefficient decreases as shown in fig 4. They also observed that with increases in height of fin heat dissipation increases but thermal resistance decreases as shown in fig.5 According to the synergy principle they conclude that the synergy angle plays an important role in thermal properties of the LED array heat sink shown in fig.6. Heat transfer performance is strengthened by reducing the synergy angle.

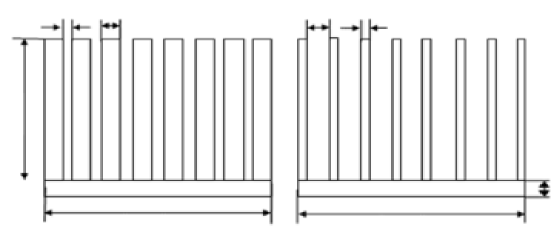


Fig.2 Schematic array heat sink [4]

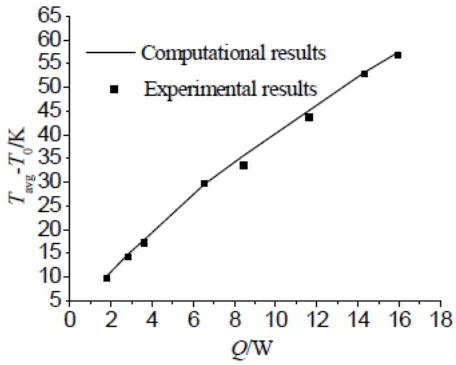


Fig.3 Comparisons of the Calculated Results with Experimental Results [4]

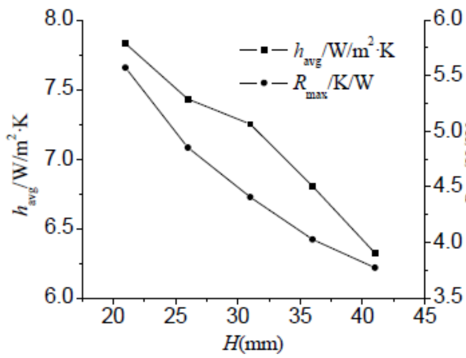


Fig.5 Influence off in Height (h) on Thermal Resistance (rmax) and Heat Transfer (h avg) [4]

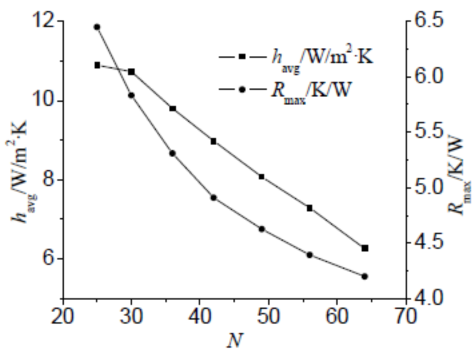


Fig.4 Influence of the Number of Fins (n) on thermal Resistance (rmax) and Heat Transfer (h avg). [4]

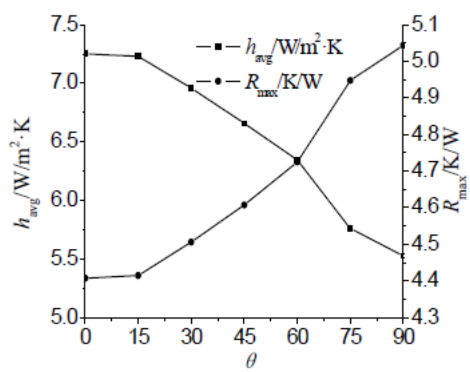


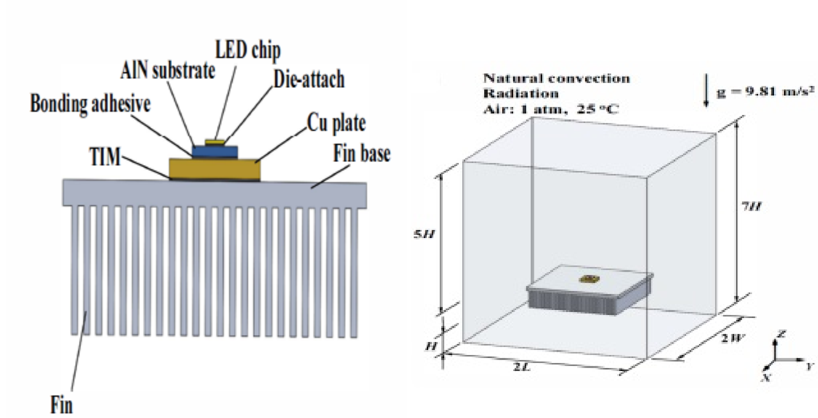
Fig.6 Influence of Synergy Angle (θ) on Thermal Resistance (rmax) and Heat Transfer (h avg). [4]

Yicang Huang *et al* [3] proposed new two new types of heat sink consisting of a combination of the pin fin, plate-fin and oblique for high power LED lamp cooling. Heat dissipation performance of newly designed fin arrays was compared with the convention model (plate-fin, pin fin, oblique fin) numerically. Figure no 7 shows the computational as well as a structural schematic of an LED module mounted on the heat sink. The height of the computational domain is taken as 5H above module and H below the LED module. The width and length of the computational domain chose as 2W and 2L. Heat transfer characteristics and computational time are considered for defining the scale of the computational domain. The model works under natural convection condition and ambient air pressure is set as 1atm pressure while the temperature of the air is 25^o C. Gravitational Acceleration and radiation effect is considered.

They have considered the various model having the fin base width 40mm, length 40mm, thickness 2mm, and height 10 mm. Plate-fin model with evenly spaced 24 plates, pin fin model with evenly space 300 pins, oblique fin model with 300 oblique fins and two models with the combination of these were studied with the same dimension as shown in fig.8 .in pin fin model each pin has a length of 2.4mm, a width of 0.8mm and height of 10mm and oblique fin has a length of 2.4mm, width 0.8mm and height of 10mm having a rectangular cross-section. The analysis of the model is done on ANSYS fluent15.0.

According to the result obtained by a numerical method they conclude that a new proposed model has a lower junction temperature by 6 °c to 10°C than conventional models. Then they optimized the proposed PPF (plate pin fin) and OPF (oblique plate-fin)by changing the number of plates. For PPF model number of plate-fin varies from 0,4,8,12,16,20,24 and for OPF model plate-fin number of plate-fin varies from 0,3,7,11,15,19,24.For PPF and OPF as an increase in the number of plate-fin junction temperature decreases firstly then it increases with an increase in the number of the plate shown in fig.9.

The PPF model having 8 plate-fin gives a better result which lower the junction temperature by 6.8 °C and 10.6 °C than those of the pin fin model. The OPF model with 7 plate-fins gives the better result which lowers the temperature of 9.4 °C and 12.2 °C than the oblique fin model.



(A) (B)

Fig.7 (A) Led Module on the FN Heat Sink, and (B) Computational Domain [3]

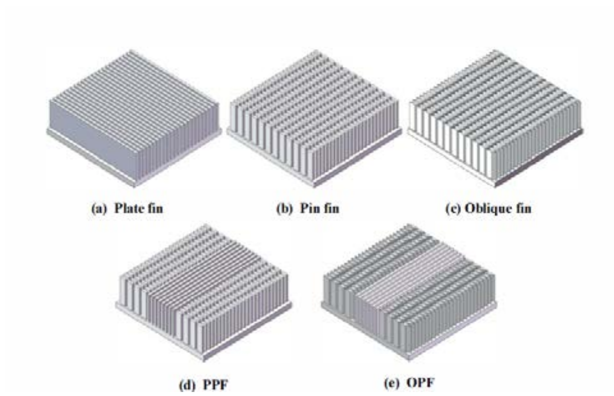


Fig.8 Geometries of three Conventional heat Sinks and two proposed heat Sinks. [3]

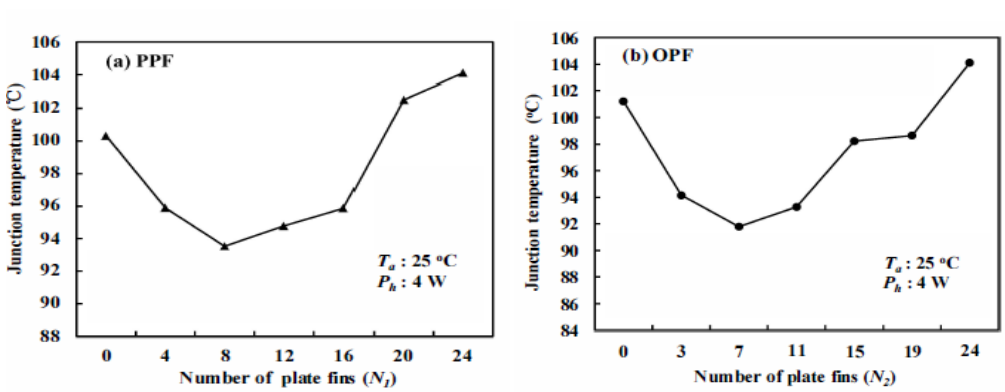


Fig.9 Comparison of junction temperatures of different PPF and OPF models [3]

It is observed that PPF8 lowers the thermal resistance by 9.00% and 13.4% than pin fin and plate-fin respectively. The OPF 7 model shows the lowest thermal resistance among all PPF and OPF models. At last, they conclude that OPF 7 and PPF8 is the model which shows the best thermal performance with a small mass of material. P Ranjith *et al* [1] investigate the three types of heat sink namely diagonal, cylindrical and spiral. they have experimented on 16 Watt LED for 100mA, 200mA, &300mA current and observed the variation of case temperature. Aluminium alloy IS 733.Grade:54300 has taken for the heat sink of the LED. Following the geometrical parameter considered for the study

1. The volume of heat sink =50*50*25mm
2. Fin thickness = 2mm
3. Fin height = 20mm
4. Fin spacing = 4 mm
5. Base plate thickness =5mm

Diagonal cylindrical and spiral profile of heat sink they have designed by keeping the above parameter fix. The figure is shown as follows

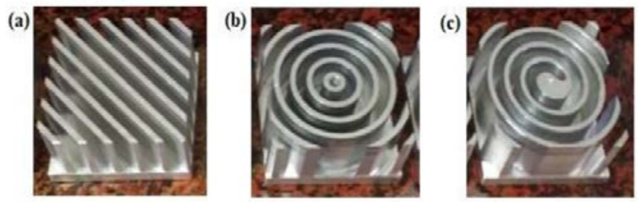


Fig.10 a) diagonal b) cylindrical c) spiral [1]

Following are the detail of these three profiles

TABLE 1 SPECIFICATION DETAILS OF THE DEVELOPED HEAT SINKS [1]

Profile of heat sink	**Fin length (mm)**	**Surface area (mm2)**	**Weight (gm)**
Diagonal	390	19100	79.6
Cylindrical	402	18205	79.2
Spiral	318	16220	78.1

In experimental work, they calculated junction temperature and thermal resistance of the heat sink. The experiment carried out for 60 min and recorded the case temperature every minute and light output by lux meter every 15 min. The experiment repeated three times and the average value is considered for cal calculations.

Following are the result; they have interpreted from the experiment.

1. Diagonal heat sink has highest junction temperature cylindrical and spiral
2. The diagonal heat sink offered more thermal resistance than cylindrical and spiral.
3. The spiral heat sink has the least junction temperature and thermal resistance for all current rating cylindrical has second and diagonal has the highest.
4. Weight for the spiral is less than cylindrical than diagonal

So spiral heat sink has the best solution for 16 watts LED among the three.

III. CONCLUSION

In this paper we review the four papers; it is observed that the geometrical parameters of fin play an important role in heat dissipation rate. There is an active and passive model is present for cooling. The passive technique most widely used for the cooling of LED lamps. Fin length, height, synergy angle, radiance inclination angle affects the heat performance parameter. Effect of Different profiles of heat sink mode like the spiral, diagonal and cylindrical on heat transfer for LED is studied. A comparison of conventional and combination of the conventional model is studied.

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