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COOLING OF LED BULB BY USING DIFFRANT ARRAY OF FINS

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ABSTRACT

The demand for high light output LED systems lead to significant heat generation rates, so that higher heat fluxes result in elevated junction temperatures on LED chips in SSL lighting systems. Moreover, the changes on the junction temperature strongly impact the reliability, lifetime, light output and quality of the light. Because of their implicity, reliability, low cost and silent operation, passive air-cooling systems are preferred in LED lamps. Thus, the optimization of the heat sink in an LED system is crucial..A-line LED lamps are investigated and a number of FOMs are proposed based on the performance, size and weight. There for we are studied with various shape of fin array such as Rectangular, Square, Circular, Spine and Plus Sign Shape fin. On comparison, plus sign fin array gives the greatest heat transfer than that of other extensions having the different shape of fin array with same height and base area finned surface .The efficiency of fin with plus sign fin greater as compare to other patter of fin. The temperature of a plus sign fin is minimum i.e. 47.476 ^{0}c

Key Words: ***Array, Convective Heat, LED Bulb, Temperature, Heat Flux***

I. INTRODUCTION

The latest solid-state lighting through light-emitting diodes (LEDs) has witnessed an inevitable trend to produce white light illumination. As one of the potential substitutes of traditional incandescence or fluorescent lamp, LEDs have the distinctive advantages in providing high quality luminescence efficiency, energy saving, and service life.

For LEDs of higher luminous intensity, a higher injection current ([20 mA) or multi-chip packaging is often necessary in illumination applications.

Since the performance and the lifetime of LEDs strongly rely on its temperature, the allowable maximum junction temperature, which is always regarded as significant performance indicator of the thermal and lighting design, was usually specified as 125 _C . Meanwhile, LED chip was limited thermally for light output, reliability, and phosphor conversion efficiency, and optically transparent epoxy or silicone based materials would change color if the temperature limits were exceeded. Therefore, removal of the large amount of the heat generated in LEDs remains a big challenge facing current LED designers and thermal management engineers.

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A 65W incandescent bulb produces about 1,000 lumens, which can presently be achieved with a 26W CFL lamp or a 12–15W LED array. The use of solid-state lighting requires arrays because a single LED is incapable of producing that much light output. High power LEDs, defined as those that consume at least 1 W, are the type of LEDs being considered for general illumination.

The recent lighting trend has been the changeover from incandescent bulbs to CFLs, since this transition increases efficiency by five times and lifetime by up to ten times. Lately, there has been little improvement in efficiency for all light sources except LEDs, as shown in Figure. Typical LEDs have an efficiency of around 75 lumens/watt, although prototypes are already capable of up to 150 lumens/watt. Because solid-state lighting is on course to be the source type with the best luminous efficiency, there is substantial motivation for using them in general lighting applications.

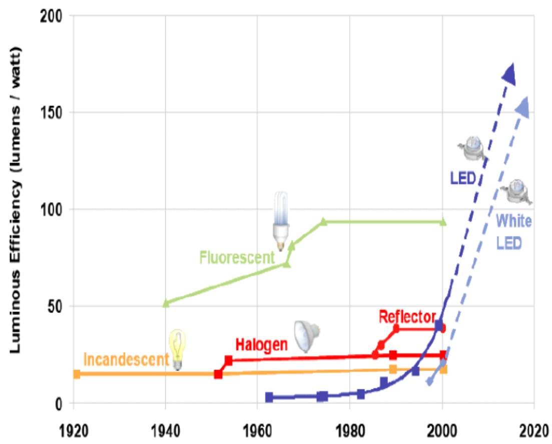

Figure . Luminous efficiency timeline for general illumination sources

As shown in the above Fig1.1 it is cleared that luminous efficiency is greater than incandescent lamp and fluorescent lamps, only if the LEDs are provided with the better thermal management.

II. LITERATURE REVIEW

Y. Sing Chan and S. W. Ricky Lee [1] in the paper “Spacing optimization of high power LED arrays for solid state lighting” discussed the an analytical approach to determine the optimum pitch by utilizing a thermal resistance network, under the assumption of constant luminous efficiency. This work allows an LED array design which is mounted on a printed circuit board (PCB) attached with a heat sink subject to the natural convection and being validated by finite element (FE) models, the current approach can be shown as an effective method for determination of optimal component spacing in an LED array assembly for SSL.

Christensen et al. [2] combined a 3-Dimensional Finite element model and thermal resistor network model to calculate the impact of a compact high power LED array density, and active versus passive cooling methods on device operation. It was suggested that active cooling such as, forced air convection, flat heat pipe and liquid cooling would be better to maintain high power LEDs under the maximum temperature limit. But practically the above methods are not possible to incorporate, it would be better to innovate conventional fin design.

Abdul Aziz and F. Khani [3] used the homotopy analysis method (HAM) to develop an analytical solution for the thermal performance of rectangular and various types of convex parabolic fins. They concluded that results produced by HAM i.e. convex parabolic fins have the better heat dissipation than rectangular type fin are more accurate than direct numerical solutions.

Chau et al. [4] investigated and proposed the cooling enhancement design of LED heat sources through an electro-hydrodynamic (EHD) approach, in which the forced convection of air is achieved by the ion wind due to gas discharge phenomenon. With this type of design, the sink temperature can be maintained in the range of 20-300C from the peak value of 650C without using any external cooling.

Ma et al. [5] proposed vibrating fin for thermal management of an LED device. These vibrating fins, which are coated with thin copper and composed of piezoelectric material, can vibrate and conduct heat from the finned base using piezoelectric effect, but the cost of these types of LEDs, are so high and hence not easily accepted by the customer. So not suitable for commercial purpose.

S.A. Nada [6] studied the effects of fin length and fin spacing for both orientations at a wide range of Rayleigh number. It has been found that insertion of fins with any fin array geometries increases the rate of heat transfer. Quantitative comparisons of heat transfer rate and surface effectiveness for both enclosure orientations have been reported. Optimization of fin-array geometries for maximum Nusselt number and finned surface effectiveness has been conducted. Also correlations were predicted and were compared with the present and previous experimental data and good agreement was found by S.A. Nada.

Kim et al, 2013 [7], investigated natural convection from vertical cylinders with longitudinal plate fins proposed correlation for estimating Nu.

Lee et al, 2014 [8], heat sink of LED lighting was optimized with respect to its fin-height profile. Optimization was conducted to simultaneously minimize the thermal resistance and Mass. The cooling performance of the optimized design (pin–fin array with the tallest fins in the outer region) showed an improvement of more than 45%.

B. Ramdas Pradip et. al. [9] had studied the many industries are utilizing thermal systems wherein overheating can damage the system components and lead to failure of the system. In order to overcome this problem, thermal systems with effective emitters such as ribs, fins, baffles etc. are desirable. The need to increase the thermal performance of the systems, thereby affecting energy, material and cost savings has led to development and use of many techniques termed as “Heat transfer Augmentation”. This technique is also termed as “Heat transfer Enhancement” or “Intensification”. Augmentation techniques increase convective heat transfer by reducing the thermal resistance in a heat exchanger. Many heat augmentation techniques has been reviewed, these are (a) surface roughness, (b) plate baffle and wave baffle, (c) perforated baffle, (d) inclined baffle, (e) porous baffle, (f) corrugated channel, (g) twisted tape inserts, (h) discontinuous Crossed Ribs and Grooves. Most of these enhancement techniques are based on the baffle arrangement. Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop.

III. RESULT AND DISCUSSION

3.1 Mathematical

Calculation are taken for a plus sign fin for finding a temp.

- Input Power: 50W
- Atm. Temprature:22 ^{0}C
- Height of fin: 30 mm
- Cross section area of fin:117 mm^2
- Total no. fin:59
- Surface area of fin:0.0012 m^2
- Convective coefficient h : 25 W/m^{2}k

The amount of heat generated by each fin: = 50/59

=0.8474 W

The temp. Generated at each fin: 0.8474=25*.0.0012*(Ts-22)

Ts=50.24 ^{0}c

The temperature generated at plus fin array is 50.24 ^{0}c.similarly the temperature generated at circular, rectangular, spline, square fin array led bulb are as follow

Sr. No.	Name of array	Area of fin(m^2)	Surface temp.(^{0}c)
1	Rectangular	0.0084	56.01
2	Square	0.0012	69.61
3	Circular	0.000942	83.63

4	Spline	.001324	65.134

Table 3.1.1 List of Temperature and Area of Fin

3.2 Simulation

ANSYS Work bench can be thought of as a software platform or framework where you perform your analysis activities. In other words, workbench allows you to organize all your related analysis files and databases under same frame work. Among other things, this means that you can use the same material property set for all analyses. as well as CATIA drawing software is also used for drawing the model.

Circular 20 Spacing Fin:

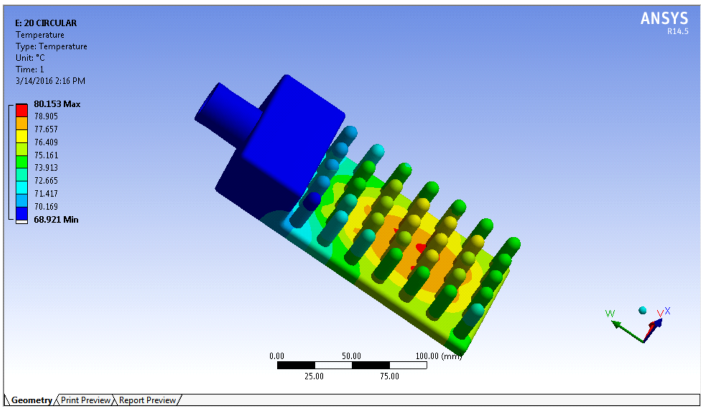

Fig. no. 3.2.1 As shown above, after successful run of simulation, found that the maximum temperature reach by base plate by using circular 20mm pin fins is near about 80^0C, and also by using designing software we know the exact weight of this circular 20mm pin finned base plate which is nothing but 0.63822Kgs.

Cross 20 Spacing:

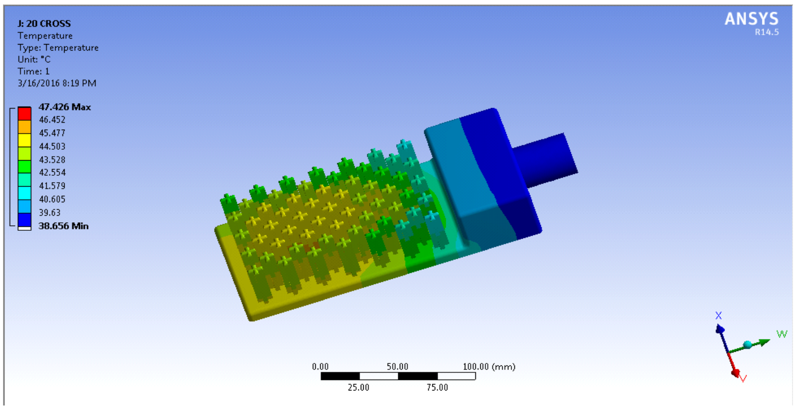

Fig. no.3.2.2 As shown above, after successful run of simulation, found that the maximum temperature reach by base plate by using cross 20mm plus sign fins is near about 47^{0}C, and also by using designing software we know the exact weight of this cross 20mm plus sign finned base plate which is nothing but .66961.Kgs.

Square 20 spacing:

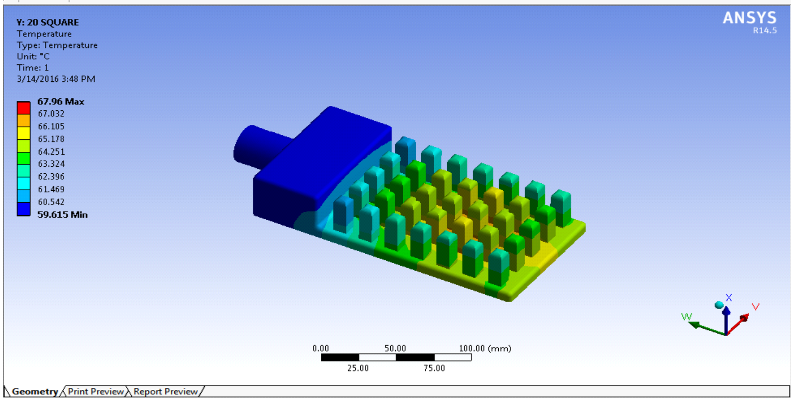

Fig. no. 3.2.3 As shown above, after successful run of simulation, found that the maximum temperature reach by base plate by using square 20mm square fins is near about 68^{0}C, and also by using designing software we know the exact weight of this square 20mmfinned base plate which is nothing but .70245Kgs.

Spine 20 Spacing fin:

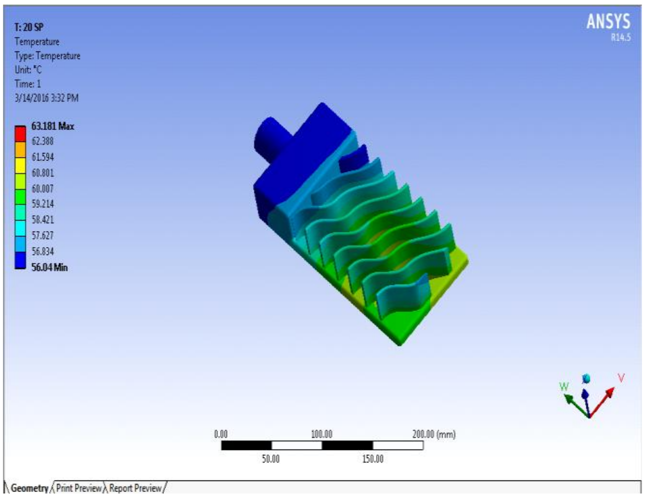

Fig. no.3.2.4 As shown above, after successful run of simulation, found that the maximum temperature reach by base plate by using pline fins is near about 64^{0}C, and also by using designing software we know the exact weight of this spline finned base plate which is nothing but .6065 Kgs.

Rectangular 20 Spacing Fin:

Fig. no. 3.2.5 As shown above, after successful run of simulation, found that the maximum temperature reach by base plate by using rectangular fins is near about 54^0C, and also by using designing software we know the exact weight of this rectangular finned base plate which is nothing but .79408Kgs.

3.2.6Ansys Simulation Result Table

Sr .No.	Arrays of fin with 20 spacing	No. Node	No. Element	weight (km.)	Max. temp. (^{0}c)	Min temp. (^{0}c)	Atm. Temp(^{0}c)
1	Circular	19676	10073	0.6382	80.153	68.921	22
2	Square	17650	8787	0.7024	67.96	59.615	22
3	Spine	21457	10998	0.6065	63.181	56.04	22
4	Rectangular	32186	17261	0.7940	53.821	47.902	22
5	Plus sign	69491	31006	0.6696	47.426	38.656	22

3.3Experimental

The best two resulted fin array led bulb are manufactured i.e. plus sign array fin and rectangular array fin. The material used for manufacturing is aluminum with thermal conductivity 210W/mk .Both lamp are switch on by supplying power battery of 12 V and 35000 amp. Take place for 3600 min duration and after that take a reading. The temp mentioned in testing room is 22 ^{0}c. the equipment used for measuring the temperature generated at heat sink is LED temperature measure gun.

Figure 3 .3 .1 . LED measure gun and lamp

The temperature of plus sign fin array is 48.69 ^{0}c

The temperature of plus sign fin array is 55.84 ^{0}c

IV. CONCLUSION

Experimental and ANSYS analysis is conducted over the company's existing conventional rectangular finned plate and proposed cross type finned plate in order to find out optimized solution for LED lamp in natural convection heat transfer. Steady state natural convection heat transfer for rectangular fin and cross fin is experimentally presented. ANSYS simulation is done on software ANSYS workbench version 14.5 Release. It is observed that by changing the geometry of conventional fin by proposed cross fin, convective heat transfer coefficient increases as well as the material required for fins is about 20% less over rectangular fin, hence the proposed fin is cost effective. Experimental, analytical and theoretical results are in good agreements.

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