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Design and Thermal Analysis of Heat Sink for Light Emitting Diode of Street Light

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Abstract: **Light-Emitting Diode (LED) street lamps swear heavily on prospering thermal management, that powerfully affects the optical extraction and also the reliability/durability of the LED lamp. Light Emitting Diode (LEDs) are currently wide employed in several fields together with traffic lights, vehicle backlights and liquid show (LCD) displays thanks to their long life, sensible illumination potency and low energy consumption. At present, LEDs are more and more commutation the standard lighting and are getting used normally illumination cherish the road lamp. For the dynamic LED street lamps, sensible light-weight extraction is that the most vital factor, however low junction temperature of the LED modules is additionally vital for achieving an extended period of time and a high optical potency. Actually, there are several reports concerning early failures of street lamps, known as dead lamps that are thought to be a barrier within the public and administration acceptance of LED street lamps. Thus temperature estimation is often a vital issue for LED development. During this paper we have a tendency to review completely different previous work of thermal analysis on LED and conjointly discuss concerning drawbacks and deserves of previous analysis.**

Keywords: Light Emitting Diode, CATIA, Heat Sink, LCD

I. INTRODUCTION

Light emitting diode (LED) differs from standard lightweight sources; it provides an instantaneous transfer of voltage into lightweight. Though there are several lighting technologies, Light-Emitting Diode has been expected as Associate in nursing ‘ultimate lamp’ for the longer term. [1]

Theoretically, Light-Emitting Diode has several distinctive blessings admire high potency, smart dependable, long life, variable color and low power consumption. Recently, Light-Emitting Diode has begun to play a crucial role in several fields, so Light-Emitting Diode product are currently getting used in several fields together with traffic lights, vehicle headlights and tail lamps, LCD displays and street lamps and then on [2]. Light-Emitting Diode is anticipated to be utilized in general lighting that consumes regarding V-day of the overall energy round the world. It’s believed those high-energy light - emitting diodes are going to be the dominant lighting technology by 2025 [3].

High-power LEDs operation will manufacture for high Luminas; however they additionally generate important heat at an equivalent time. It’s been rumored that the optical output of the Light-Emitting Diode is sharply degraded with the rise in junction temperature [4] as a result of the warmth considerably influences the dependable and sturdiness of the Light-Emitting Diode [5].

Therefore effective thermal style and reliable thermal characterization of Light-Emitting Diode system are some key factors in style issues. For top dependable, it's vital that most specific in operation junction temperatures don't seem to be exceeded. So far, Light-Emitting Diode street lamps are typically composed of the many high-energy Light-Emitting Diode modules. With higher chip densities, thermal management of the Light-Emitting Diode lamp proposes an enormous challenge to the road lamp style and producing. There’s a requirement to outline the junction-to-ambient and junction-to-case thermal resistances for multi-chip modules during a lot of rigorous manner and supply data to predict junction temperatures beneath discretionary powering of individual chips.

Light-Emitting Diodes (LEDs) are tangency devices created from semiconductor materials, cherish gallium compound (GaAs), gallium compound phosphate (GaAsP), or gallium phosphate (GaP). semiconducting material and germanium are unsuitable to be used in LEDs as a result of these junctions turn out heat with no considerable infrared (IR) or visible radiation. The junction in LEDs is forward biased.

When electrons cross the junction from the n-type to the p-type material, the electron-hole recombination method produces photons in an exceedingly method referred to as electroluminescence.

An exposed semiconductor surface will then emit light-weight.

Wavelength size is said to the energy gap of the fabric. Materials with larger energy gaps turn out shorter wavelengths [6]. 2 primary approaches will be accustomed acquire white light from LEDs. The primary methodology is to mix light from red, green, and blue LEDs. White light fashioned during this manner will be “tuned” to seem heat or cool by adjusting the amounts of every colorize the combo. The second methodology uses a blue Light-Emitting Diode with a phosphor coating. The coating emits a yellow light once the blue light from the Light-Emitting Diode shines thereon. The combo of the yellow light with the blue light forms a white light. Unskillfully in phosphor conversion is one reason that a white Light-Emitting Diode is a smaller amount economical than a colored Light-Emitting Diode. Some light energy is lost within the conversion to yellow [7]. Light-Emitting Diode epitaxial layers emit heat centered on little areas.

When a Light-Emitting Diode lamp with varied diodes is switched on, the temperature of the lamp will increase quickly because the Light-Emitting Diodes or LED modules among emit heat. If the warmth isn't well dissipated, it's going to cause flicker and degrade the illumination quality of the Light-Emitting Diode lamp. It’s going to conjointly shorten the service lifetime of the lamp. Thermal management and management are thus major problems in solid-state lighting merchandise. Below numerous solutions are planned,

II. LITERATURE REVIEW

Wilcoxon and Cornelius et al. [4] delineated the thermal management approach for a light engine and given the results of their finite-element model. The practical blueness of the model was well-tried by the experimental knowledge and was wont to assess varied style aspects of the sunshine engine to grasp their effects on the general thermal resistance. The results of their finite-element model indicated that the junction temperature of the LEDs during this lightweight engine would be near to their most values in a very high-temperature atmosphere. However, through the utilization of exotic materials appreciate diamond/aluminum composites, Light-Emitting Diode temperatures may be considerably reduced below the values obtained during this testing.

Kim et al. [5] investigated the thermal management system for associate degree semiconductor diode light in a very rear projection TV.

Their results showed that decreasing thermal resistance between LEDs and substrate was the foremost effective thanks to dissipate heat, and also the applicable limit of thermal resistance existed for varied heat-dissipating conditions of LEDs. They additionally steered that the warmth transport system uses red, inexperienced and blue Light-Emitting Diode lights to confirm product quality.

Liu et al. [6–8] studied a microjet array cooling system for thermal management of a high-powered LED lighting supply. Experimental and numerical investigations were conducted. AN infrared measuring device was wont to

Measure the on-line temperature, and thermocouples evaluated the cooling performance of the planned system. The experimental and numerical results explained that the micro jet-based cooling system has smart cooling performance.

Petroski et al. [9] developed associate LED-based spot module sink in an exceedingly free convective cooling system. A cylindrical tube, longitudinal fin sink was wont to solve the orientation downside of LEDs.

Chen et al. [10] gave silicon-based electricity (TE) device for cooling dynamical LEDs. The take a look at results showed that their TE device may effectively cut back the operational temperature of dynamical LEDs.

Acikalin et al. [11] used electricity fans to chill LEDs. Their results showed that the fans may cut back the warmth supply temperature by the maximum amount as 37.48^{o}C. Electricity fans are shown to be a viable answer for the thermal management of electronic parts and LEDs.

X. Luo, T. Cheng, W. Xiong, Z. Gan and S. Liu et al. [12] experimented thermal analysis of an 80 W LED street lamp was presented. Sixteen thermocouples were used to measure the temperature points at the aluminum base and fins. The experiments demonstrated that the temperatures near the chip were nearly the same; no obvious temperature difference existed in this area. A numerical model was also proposed based on the experiment. The numerical results were compared with the experimental results to ensure the feasibility of the numerical model. The numerical results of the thermal resistance analysis showed that at an environment temperature of 458C, the maximum junction temperature of the LED chips on the present 80 W LED street lamp would be equal to the critical temperature 1208^{O}C, which leads to poor reliability and lower life and optical efficiency of the LED street lamp.

Shung-Wen Kang, Kun-Cheng Chien and Wei-Chung Lin et al. [13] proposed to replace traditional street lamps with an LED street lamp containing a multilayered substrate structure for heat dissipation. Used simulation software to analyze the heat distribution for the proposed model. The simulation showed that our model would be effective at dissipating heat in the LED lamp. We tested temperature changes at 120 and 180 W of inputted power. The LED heat sink slug’s average temperature remained in safe ranges. Less than 5 ^{o}C difference existed between actual and simulated results. The average thermal resistance values were 0.24 ^{o}C/W at 120 W and 0.22 ^{o}C/W at 180W. The data showed that a multilayered substrate structure is not only able to improve LED efficiency but also to solve the heat dissipation issue in LED lamps.

Lai et al. [14] proposed an indoor LED lighting prototype that used pressed-flat grooved heat pipes as heat transfer channels to conduct heat emitted by LEDs to heat-sink fins. Single layered heat dissipation module in the above design cannot provide a reliable solution in high power LED streetlamps.

Kim and Shin et al. [15] mentioned transient thermal measurements of high-octane GaN-based LEDs with multi-chip styles. The structure perform theory was applied to see the thermal resistance of Light-Emitting Diode packages.

The overall thermal resistance of multi-chip packages was found to decrease with the amount of chips thanks to parallel cooling. However, the impact of the chip range on the thermal resistance of the package powerfully depends on the magnitude relation of partial thermal resistance of chip which of slug below the chip.

Lall et al. [16] performed some experiments for non-uniform powering of a multiple-chip module mounted on a vertical board in natural convection. the common chip temperature thanks to multiple sources at intervals the module was thought of because the reference temperature for evaluating the junction temperature rise of a specific chip. This approach offered a additional refined methodology for analysis of no uniformly battery-powered multi-chip modules compared to previous strategies.

Im et al. [17] developed a replacement approach to see the junction temperatures of the system in packaging (SIP) and therefore the temperature distinction from the common temperature was calculated by linear superposition. The 'hot spot factor', that might replicate the impact of chip size and hot spot on the chip, was new planned. Victimization this approach, one will calculate device junction temperatures merely and accurately.

Zahn et al. [18] mentioned however a central composite style of experiments may be applied to produce a additional correct thermal characterization of a multi-chip module package. The tip product was a series of linear or polynomial equations that would be used by the client to calculate individual device junction temperatures over a good variation of convection cooling environments and multiple device power dissipations.

III. OBJECTIVES

There are following objective are to be expected from the present work

1. The primary object of the present work to increase heat transfer rate from existing LED Frame which is the heat source.
2. To predict the heat transfer rate from existing design in LED frame experimentally
3. To evaluate the heat transfer rate in Proposed heat sink for LED Frame.
4. To evaluate the heat transfer rate with new design of heat sink.
5. To optimize the heat sink design from the basis of heat transfer rate.
6. To maximize the heat transfer rate from the LED heat sink.

IV. METHODOLOGY

4.1. Parts of LED assembly

Figure 1: LED assembly

Figure 2: Core part of LED assembly

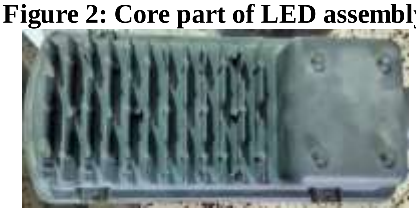

Figure 3: Fins of LED assembly

Figure 4: Control System of LED assembly

4.2. Thermal analysis

Thermal analysis determines the temperature distribution and associated thermal quantities in a system or component. With the help of thermal analysis various thermal quantities like the temperature distributions, the amount of heat lost or gained, Thermal gradients and Thermal fluxes. Thermal analysis play an important role in the design of many engineering applications including internal combustion engines, turbines, heat exchangers, piping systems, and electronic components etc. In many cases thermal analysis is used to analysis or calculates thermal stresses.

4.3. Types of thermal analysis

Steady state thermal analysis determines the temperature distribution and other thermal quantities under steady state loading conditions. A steady state loading condition is a situation where heat storage effects varying over a period of time can be ignored.

Transient thermal analysis determines the temperature distribution and other thermal quantities under conditions that vary over a period of time. There are three different types of heat transfer: conduction, convection, and radiation. A temperature difference must exist for heat transfer to occur. Heat is always transferred in the direction of decreasing temperature. Temperature is a scalar, but heat flux is a vector quantity.

4.4. CAD geometry

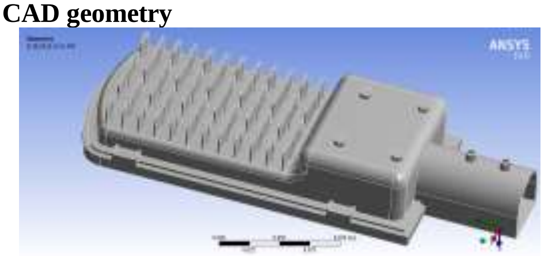

Figure 5: Geometry of Actual LED Frame

In the present work The CAD geometry of LED heat sink is created with the help of CATIA software then imported in ANSYS workbench for further analysis. A three dimensional view of north bridge heat sink is shown in figure No. 6.

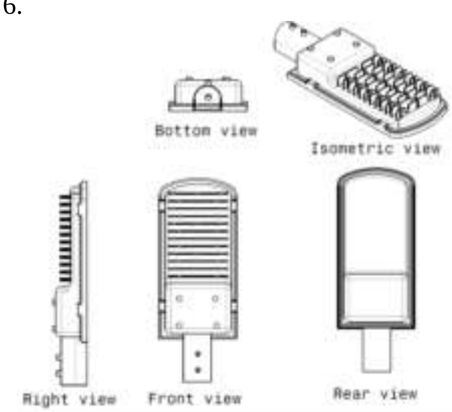

Figure 6: 3D view of LED

4.5. MESHING

Meshing is a critical operation in FEA. In this operation, the CAD geometry is divided into large numbers of small pieces. The small pieces are called mesh. The analysis accuracy and duration depends on the mesh size and orientations. With the increase in mesh size, the finite element analysis speed increase but the accuracy decrease.

After completing the CAD geometry of LED heat sink is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. The total Node is generated is 237199 & Total No. of Elements is 236092, it is clear from the mesh geometry the node numbers and element numbers are almost six in digit which show that the mesh is very fine because the result accuracy depends on the mesh quality.

Figure 7: Meshing of CAD file

For any kind of analysis material property are the main things which must be defined before moving further analysis. There are thousands of materials available in the ANSYS environment and if required library is not available in ANSYS directory the new material directory can be created as per requirement. For the present work aluminum used as a material of Northbridge heat sink. The material properties of the present case are as: Density: 2770 kg m^3, Coefficient of Thermal Expansion: 2.3e-005 C^{-1}, Specific Heat: 875 J kg^{-1} C^{-1}.

4.6. Boundary condition

1. The maximum temperature generated on inside face of the LED heat sink as predicted during the experimental reading.
2. Since this LED heat sink is used for street lighting situated in open space that is why there is normal air flow hence it is assumed that in this open space the normal air temperature available and its convective coefficient value is lies between 0-25 W/m^2. For the present work the value of convective coefficient is taken as 18W/m^2.
3. The value of conductive coefficient of the material is taken as 235 W/m°C.
4. The maximum temperature recorded during the experimental reading was 138.19 °C.
5. The Mechanical APDL solver is used for present analysis.

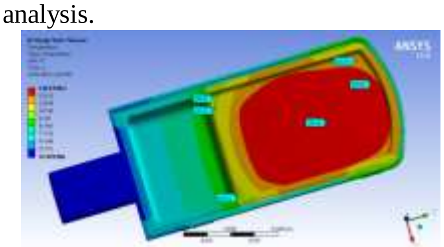

Figure 8: Heat distribution on LED

The steady state thermal analysis result indicates the temperature distribution of actual LED heat sink the maximum temperature is 138.19°C and minimum temperature is 47.49 °C. Hear two images are shown the temperature distribution over the actual LED heat sink one of the image show temperature distribution inside the LED frame and other image show the temperature distribution over the back side of the LED frame.

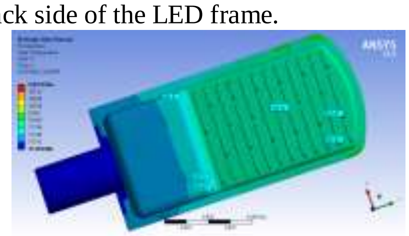

Figure 9: Temperature Distribution over the LED frame

The below result (Figure 10) designate Total heat flux generated on the actual LED frame heat sink maximum heat flux generated is 6.2629e5 W/m^2 and minimum heat flux generated is 3.642e-11 W/m^2.

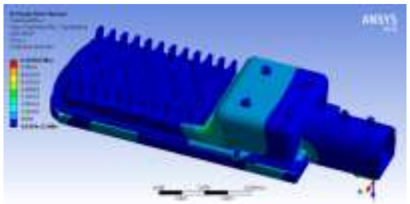

Figure 10: Total Heat flux

The below result (Figure 11) indicates directional heat flux generated on the actual LED frame heat sink maximum heat flux generated is 4.1734.5 W/m^2 and minimum heat flux generated is -3.9871e5 W/m^2.

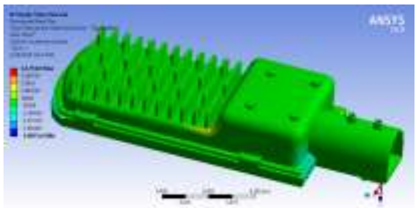

Figure 11: Directional Heat Flux

V. RESULTS

5.1. Proposed Design

The CAD geometry of proposed design LED heat sink is created with the help of CATIA software then imported in ANSYS workbench for further analysis.

Figure 12: CAD Geometry of LED Frame for proposed design

Figure 13: Meshing

After completing the CAD geometry of LED heat sink is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. The total Node is generated is 249621 & Total No. of Elements is 248492. it is clear from the mesh geometry the node numbers and element numbers are almost six in digit which show that the mesh is very fine because the result accuracy depends on the mesh quality.

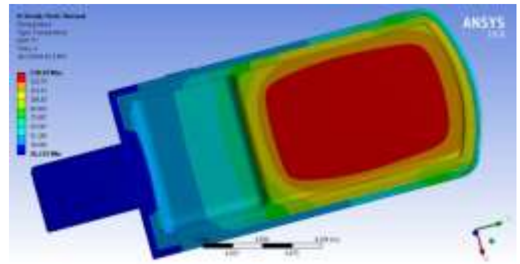

Figure 13: Temperature distribution of proposed design over the entire LED frame (a)

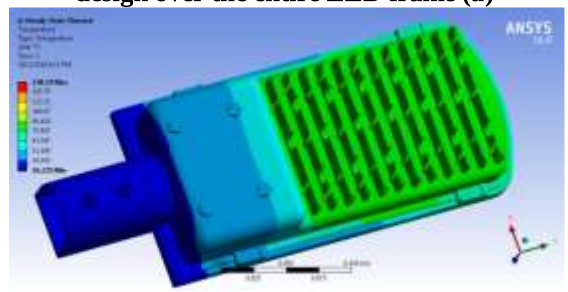

Figure 14: Temperature distribution of proposed design over the entire LED frame (b)

The steady state thermal analysis result of proposed design indicates the temperature distribution of actual LED heat sink the maximum temperature is 138.19ºC and minimum temperature is 26.225 ºC. the color couture of temperature distribution over the entire LED frame shown in figure No. hear two images are shown the temperature distribution over the actual LED heat sink one of the image show temperature distribution inside the LED frame and other image show the temperature distribution over the back side of the LED frame. Result revel that there is no change of temperature distribution over the LED frame during the steady state thermal analysis and transient thermal analysis, in both case lower temperatures are almost same.

The below result (Figure 15) designate Total heat flux generated on the actual LED frame heat sink maximum heat flux generated is 2.6231e5 W/m^2 and minimum heat flux generated is 4.1881e-12 W/m^2.

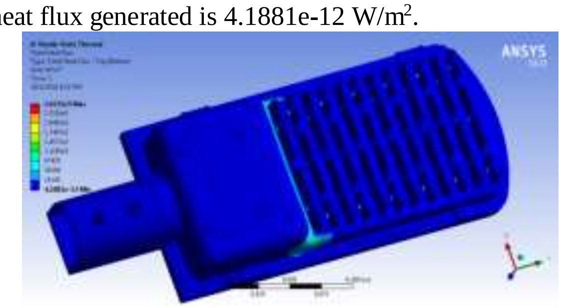

Figure 15: Total Heat flux of proposed design

The below result (Figure 16) indicates directional heat flux generated on the actual LED frame heat sink maximum heat flux generated is 2.0826e5 W/m^2 and minimum heat flux generated is -2.2373e5 W/m^2.

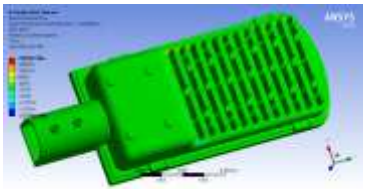

Figure 16: Directional Heat flux of proposed design

The static and transient thermal analysis ware conducted using ANSYS workbench based on finite volume methodology the effects of different important geometrical parameters on the steady state and transient natural convective heat transfer rate from both actual and proposed design of heat sink.

5.2. ASSUMPTIONS

The following assumptions are made to model the air flow and heat transfer in a continuous finned heat sink.

- Steady state laminar flow of air is considered
- Symmetric flow and identical heat transfer throughout the heat sink
- Isothermal boundary condition is applied for the base and fins.
- Air entrance from the side is Negligible on the heat sink means the fresh air inflow and outflow from the open sides of the outmost fins wall is small compared to the air flow entering from the bottom of the fins array

5.3. Thermal conductivity

It is the degree to which a specified material conducts electricity, calculated as the ratio of the current density in the material to the electric field which causes the flow of current. The rate at which heat passes through a specified material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance.

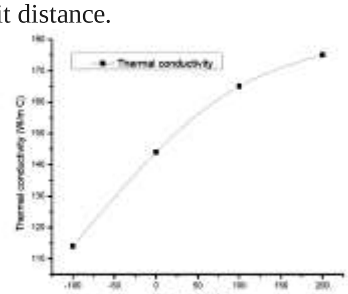

Figure 17: Thermal conductivity of LED heat sink

Table 1: Thermal conductivity of LED heat sink Table

Temperature [^oC]	Thermal conductivity [W/m^oC]
-100	114
0	144
100	165
200	175

Data source: ANSYS Library 2016

Table 2: Temperature Distribution over Actual LED frames heat sink for steady state thermal analysis:

Static Thermal Analysis		
Temperature [^oC]	Total Heat Flux [W/m^2]	Directional Heat Flux [W/m^2]
47.494	8.86E-12	-4.81E+05
57.571	1.29E+05	-3.20E+05
67.648	2.58E+05	-1.59E+05
77.726	3.87E+05	1.32E+03
87.803	5.16E+05	1.62E+05
97.88	6.45E+05	3.23E+05
107.96	7.74E+05	4.83E+05
118.04	9.03E+05	6.44E+05
128.11	1.03E+05	8.04E+05
138.19	1.16E+05	9.65E+05

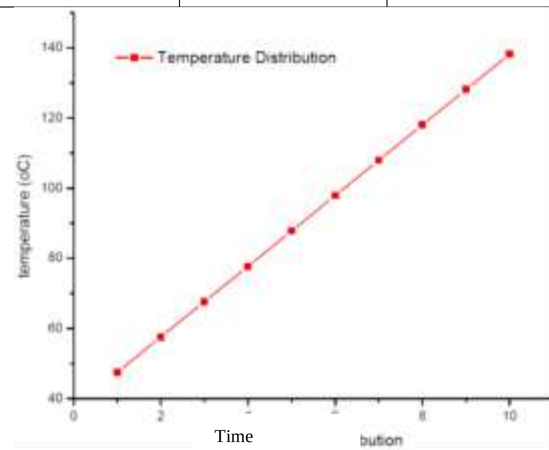

Figure 18: Temperature distribution over the actual LED Heat sink

The result of steady state thermal analysis of LED frame heat sink indicates the temperature distribution over the entire heat sink, the maximum temperature is 138.19ºC for actual and proposed design but the minimum temperature of actual heat sink is 47.494 ºC, The tabulated result of actual design are shown in table 1 & 2 and comparative result in the form of graph shown in figure 19.

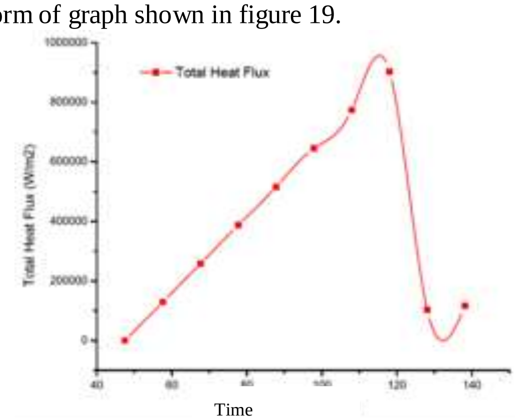

Figure 19: Total heat flux for actual heat sink

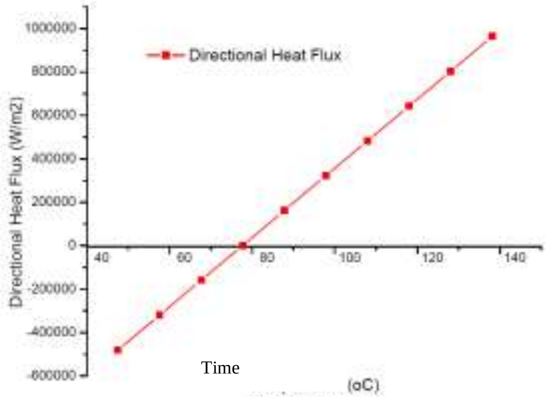

Figure 20: Directional heat flux for actual heat sink

Total heat flux and Directional Heat Flux during the steady state Thermal Analysis

The result of Total heat flux generated on the LED heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 16.2629e5 W/m^2 and minimum heat flux generated is 3.642e-11 W/m^2. but for proposed design of heat sink the total heat flux are different then actual design the maximum value of total heat flux are 2.6231e5 W/m^2 and minimum heat flux generated is 4.1881e-12 W/m^2 The comparative result of total and directional heat flux in tabulated form shown in table 3 and the graphical representation in figure 21.

Table 3: Temperature Distribution over LED frame heat sink for Transient thermal analysis

Temperature Distribution	
Minimum Temperature [ºC]	**Maximum Temperature [ºC]**
28	124.81
33.778	123.8
39.437	121.98
43.031	119.01
44.233	115.46
47.257	111.91
47.424	108.75
47.414	113.7
47.404	125.95
47.394	138.19

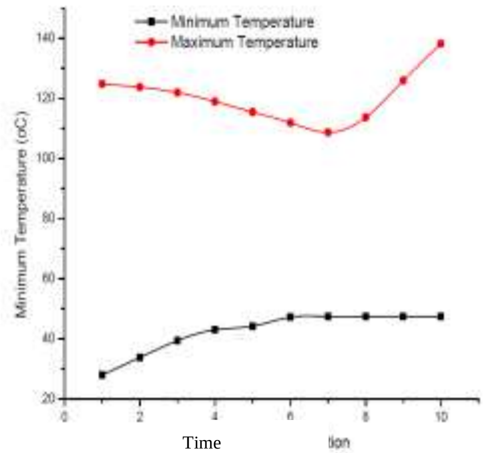

Figure 21: Temperature distribution over the actual LEF Heat sink

The result of transient thermal analysis of LED frame heat sink indicates the temperature distribution over the entire heat sink, the maximum temperature is 138.19ºC and the minimum temperature of actual heat sink is 47.394 ºC. The tabulated result of actual and proposed design are shown in table 4 and comparative result in the form of graph shown in figure

Table 4: Total heat flux during the Transient Thermal Analysis

Total Heat Flux			
Minimum Temperature [ºC]	**Minimum Total Heat Flux [W/m²]**	**Maximum Temperature [ºC]**	**Maximum Total Heat Flux [W/m²]**
28	3.39E-12	124.81	4.46E+06
33.778	1.18E-11	123.8	2.13E+06
39.437	5.70E-12	121.98	1.42E+06
43.031	7.22E-12	119.01	1.44E+06
44.233	1.92E-12	115.46	1.38E+06
47.257	1.88E-11	111.91	1.27E+06
47.424	1.44E-11	108.75	1.14E+06
47.414	5.84E-12	113.7	1.01E+06
47.404	1.68E-11	125.95	1.20E+06
47.394	8.86E-12	138.19	1.46E+06

The result of Total heat flux generated on the LED heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 1.4604e5 W/m^2 and minimum heat flux generated is 8.8594e-12 W/m^2. The comparative result of temperature and total heat flux in tabulated form shown in table 5 and the graphical representation in figure 22.

Table 5: Directional heat flux during the Transient Thermal Analysis:

Minimum Temperature [°C]	Minimum Directional Heat Flux [W/m²]	Maximum Temperature [°C]	Maximum Directional Heat Flux [W/m²]
28	-3.93E+06	124.81	3.73E+06
33.778	-1.83E+06	123.8	1.70E+06
39.437	-1.11E+06	121.98	1.04E+06
43.031	-6.08E+05	119.01	9.66E+05
44.233	-4.44E+05	115.46	8.69E+05
47.257	-3.99E+05	111.91	7.77E+05
47.424	-5.10E+05	108.75	7.00E+05
47.414	-7.61E+05	113.7	8.82E+05
47.404	-9.93E+05	125.95	1.15E+06
47.394	-1.21E+06	138.19	1.39E+06

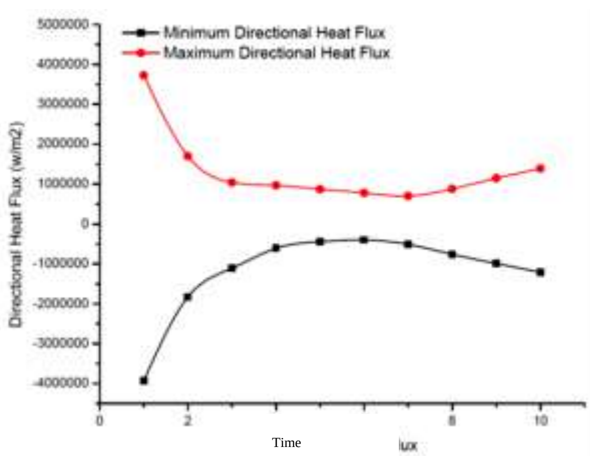

Figure 22: Directional heat flux for actual heat sink

Temperature Distribution over Proposed Design of LED frames heat sink for steady state thermal analysis:

The result of steady state thermal analysis of LED frame heat sink indicates the temperature distribution over the entire heat sink, the maximum temperature is 138.19°C for actual and proposed design but the minimum temperature of actual heat sink is 26.225 °C, The tabulated result of actual design are shown in table 6 and comparative result in the form of graph shown in figure 24.

Table 6: Static Thermal Analysis

Temperature Distribution [°C]	Total Heat Flux [W/m²]	Directional Heat flux [W/m²]
26.225	4.19E-12	-2.24E+05
38.666	29145	-1.76E+05
51.106	58290	-1.28E+05
63.547	87435	-7.97E+04
75.987	1.17E+05	-3.17E+04
88.428	1.16E+05	1.63E+04
100.87	1.75E+05	6.43E+04
113.31	2.04E+05	1.12E+05
125.75	2.33E+05	1.60E+05
138.19	2.62E+05	2.08E+05

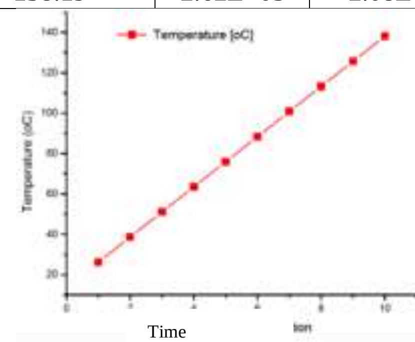

Figure 23: Temperature distribution of Proposed Design over the LEF Heat sink

Total Heat Flux over Proposed Design of LED frame heat sink for steady state thermal analysis:

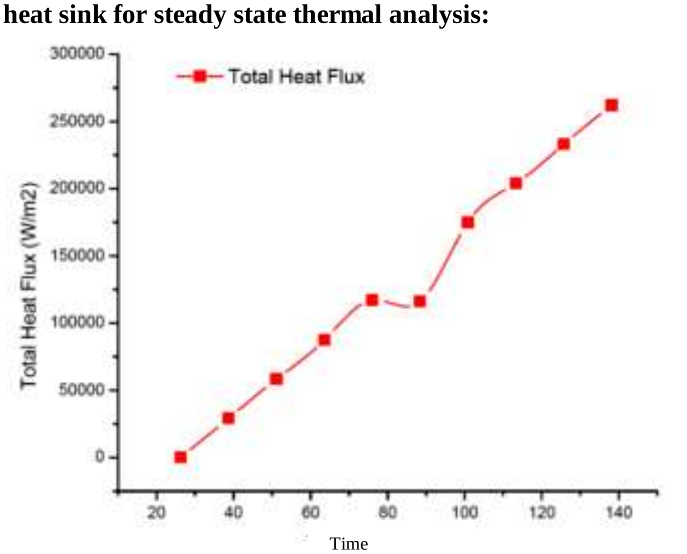

Figure 24: Total heat flux for Proposed Design heat sink

The result of directional heat flux generated on the LED heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 2.0826e5 W/m² and minimum heat flux generated is -2.2373e5 W/m². The comparative result of temperature and total heat flux in tabulated form shown in the graphical representation in figure 25

Directional Heat Flux over Proposed Design of LED frame heat sink for steady state thermal analysis:

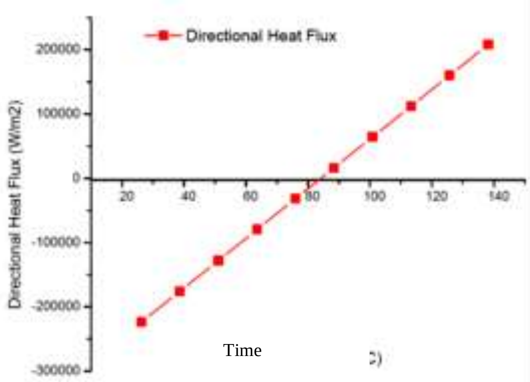

Figure 25: Directional Heat flex for proposed design

Table 7: Directional Heat Flex for proposed design

Minimum Temperature [°C]	Maximum Temperature [°C]
26.225	122.74
26.225	118.71
26.225	116.08
26.225	114.16
26.225	112.68
26.225	111.51
26.225	110.6
26.225	113.7
26.225	125.95
26.226	138.19

Temperature Distribution over Proposed Design of LED frames heat sink for transient thermal analysis:

The result of steady state thermal analysis of LED frame heat sink indicates the temperature distribution over the entire heat sink, the maximum temperature is 138.19°C for actual and proposed design but the minimum temperature of actual heat sink is 26.226 °C, The tabulated result of actual design are shown in table 8 and comparative result in the form of graph shown in figure 27

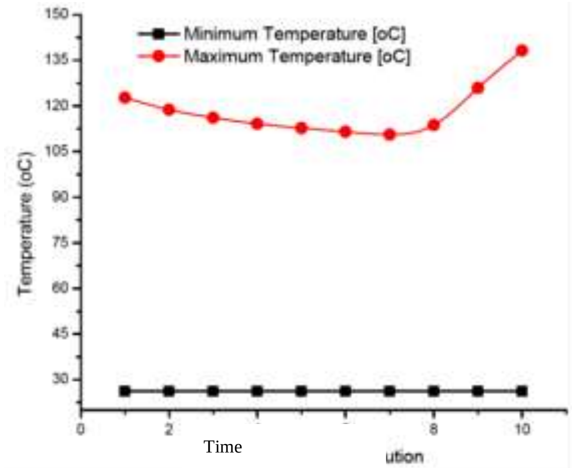

Figure 27: Heat distribution

The result of Total heat flux generated on the LED heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 6.0839e5 W/m^2 and minimum heat flux generated is 4.1881e-12 W/m^2. The comparative result of temperature and total heat flux in tabulated form shown in table and the graphical representation in figure

Table 8: Total Heat flux over Proposed Design of LED frame heat sink for transient thermal analysis:

Minimum Temperature [oC]	Minimum Total Heat Flux [W/m2]	Maximum Temperature [oC]	Maximum Total Heat Flux [W/m2]
26.225	1.53E-12	122.74	1.21E+06
26.225	1.08E-12	118.71	7.69E+05
26.225	5.41E-13	116.08	4.86E+05
26.225	1.89E-12	114.16	2.73E+05
26.225	1.55E-12	112.68	1.96E+05
26.225	4.00E-12	111.51	1.96E+05
26.225	2.01E-12	110.6	2.66E+05
26.225	1.24E-12	113.7	3.89E+05
26.225	3.45E-12	125.95	5.02E+05
26.226	4.19E-12	138.19	6.08E+05

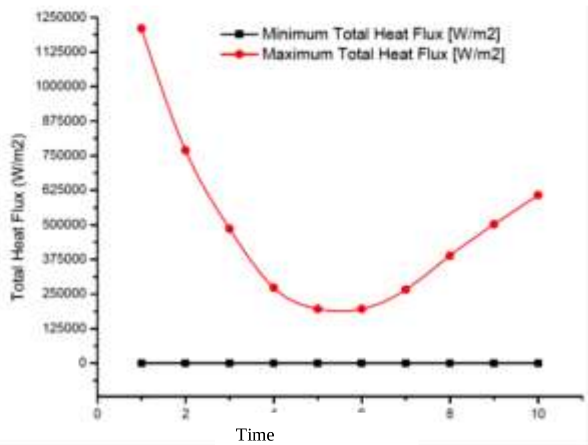

Figure 28: Total Heat flux over Proposed Design of LED frame heat sink

The result of directional heat flux generated on the LED heat sink are vary according to heat sink design the value of maximum heat flux generated for actual design is 4.9886e5 W/m^2 and minimum heat flux generated is -5.321e5 W/m^2. The comparative result of temperature and total heat flux in tabulated form shown in table and the graphical representation in figure

Table 9: Directional Heat flux over Proposed Design of LED frame heat sink for transient thermal analysis:

Minimum Temperature [^{o}C]	Minimum Directional Heat Flux [W/m^2]	Maximum Temperature [^{o}C]	Maximum Directional Heat Flux [W/m^2]
26.225	-1.11E+06	122.74	1.06E+06
26.225	-7.05E+05	118.71	6.68E+05
26.225	-4.43E+05	116.08	4.20E+05
26.225	-2.45E+05	114.16	2.33E+05
26.225	-1.36E+05	112.68	1.40E+05
26.225	-1.36E+05	111.51	1.40E+05
26.225	-2.32E+05	110.6	2.26E+05
26.225	-3.40E+05	113.7	3.24E+05
26.225	-4.39E+05	125.95	4.14E+05
26.226	-5.32E+05	138.19	4.99E+05

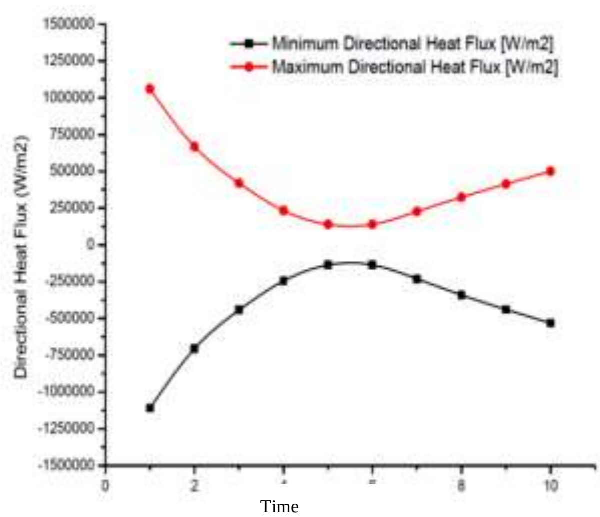

Figure 29: Directional Heat flux over Proposed Design of LED frame heat sink

VI. CONCLUSION

Experimental and analytical studies were performed in order to optimize geometrical fin parameters for natural convective heat transfer from Actual LED heat sink and proposed design of LED Frame Heat sink for geometrical and cost effective material optimization.

Carefully estimating thermal resistance is important for the long term reliability of any electronics components. Design engineers should always correlate the power consumption of the device with the maximum allowable Power dissipation of the package selected for that device using the provided thermal resistance parameters.

The following points have been identified in the form of conclusive statements which are as follows.

1. Proposed design of LED heat sink maximizes the total natural convective heat transfer as compared to actual heat sink of LED frame.
2. Since the maximum temperature developed on all types of heat sink design but the lower temperature is much below in proposed design of LED frame heat sink is attended.
3. In the present work two different geometry of LED frames are used for thermal analysis first one is actual heat sink and another one is proposed. Since actual heat sink is checked for steady state thermal analysis and transient thermal analysis from which proposed design of heat sink gives better heat convection from the heat of LED frame.

To summarize the proposed design of heat sink has better performance and heat dissipation from the heating zone in the LED frame. In the experimental investigation the maximum temperature indicating on bottom face of the LED frame heat sink which was about 138.19 ^{o}c that is why the present work more concentrate on it and also proposed new design for it.

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