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Design and Thermal Analysis of LED Lamp Cooling by using Optimization of Circular Fins

Deepak Bhonde[1*] Purushottam kumar sahu[1] Yogesh Dodia[2]
1.Department of Mechanical Engineering, CDGI, Indore (M.P.), India
2.Department of Mechanical Engineering LNCT, Indore (M.P.), India

Abstract
The selection of particular fin configuration in LED Lamp for heat transfer application depend on the weight and manufacturing technique consideration as well as the thermal characteristics it exhibits, Circular Fins are one of the most popular choice for enhancing the heat transfer rate to Minimize an junction temperature by minimizing the total thermal resistance of system. For actively cooled systems, this may essentially be achieved by simultaneously engineering the conduction through the heat sink and creating a well-designed flow pattern of Heat over suitable convective surface area. Finite element method (FEM) was used to compute the maximum temperature at junction of LED. An extensive study was carried out using ANSYS, a powerful platform for Heat flow through Led Heat sink. Results obtained were presented in a series of temperature along the length of fins.
Keywords: ANSYS, Circular Fins, FEM, Junction Temperature, Thermal Resistance.

INTRODUCTION

Light emitting diodes (LEDs) are solid state (P-N junction semi conductor) devices that convert electrical energy directly into light by a process called electroluminescence. LED is a solid-state technology. 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 (20mA) or multi-chip packaging is often necessary in illumination applications . However, only less than 20% of injection energy was converted to light, while the remained was transferred into heat. 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 150^0C . 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.

Present Lightening Systems facing the same problem as mentioned above i. e. they want to optimize their thermal system design of 50 Watt LED so that they can improve quality of their LEDs by cost wise as well as design wise.

METHODOLOGY

Figure 1 showed the schematic diagram of a conventional LED package structure. The LED die was packaged with silicon or epoxy encapsulant. Phosphors were added into encapsulant to convert wavelength range from blue to yellow in order to get white light. Since silicon or epoxy encapsulant has low thermal conductivity, the heat flow path can be ignored. The temperature of the LED junction (Tj) can be expressed as $T_j = T_a + (R_{ja} \times P_d)$

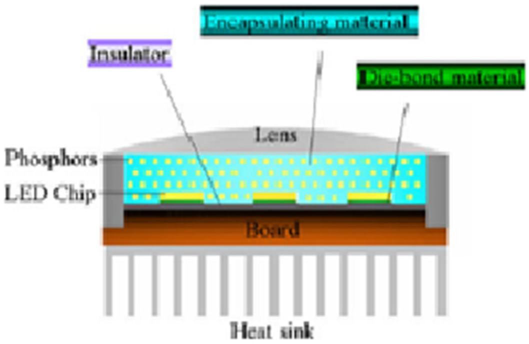


Fig. 1 Schematic diagram of a conventional LED package structure

Thermal management of LEDs is extremely critical and understanding it is essential when designing and developing LED systems. To prolong their lifetime and improve their performance, LEDs must be kept cool under all drive and operating conditions. The fundamentals of heat transfer and a full understanding of the heat path and thermal stack is needed to properly design an LED system. Thermal simulations and testing should be used to optimize and measure the performance of each LED system.

By utilizing thermal resistance networks, such as that of Figure 2, the most important factors in the thermal conductance of a system may be pinpointed. This research analyzed the impact of the heat sink and shroud geometries on the total system resistance, although the active cooling model that was used only included resistances from convection and within the heat sink. Radiation is typically responsible for less than 5% of heat transfer in forced convection and was assumed negligible for this study. The resistances from thermal interfaces and within the LED constitute research fields beyond the scope of this work.

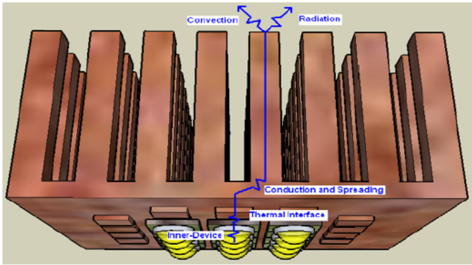


Fig. 2 Simplified thermal pathway of an array of down-lighting LEDs attached to a heat sink.

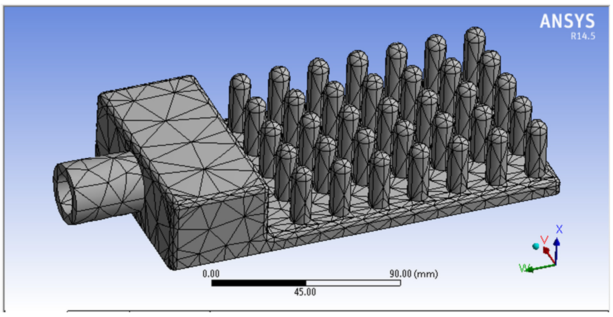
In the light of the above, the present work deals with,

i) Developing a FEM methodology using ANSYS for the coupled-field analysis of circular fins by minimizing the total system's thermal resistance.

ii) Studying the variation in junction temperature of the fin by varying number of nodes and carrying out a convergence study.

FINITE ELEMENT ANALYSIS

- The finite element analysis was based on the following common assumption: Steady-state heat flow,
- The material are homogeneous and isotropic,
- There is no heat source,
- The convection heat transfer co-efficient is same all over the surface, The temperature of the surrounding fluid is uniform,
- The thermal conductivity of the material is constant.



Statistics	
Nodes	17834
Elements	8844
Mesh Metric	None

Fig. 3 Circular Coarse mesh

Details of "Analysis Settings"

Step Controls	
Number Of Steps	48.
Current Step Number	1.
Step End Time	600. s
Auto Time Stepping	On
Define By	Time
Initial Time Step	600. s
Minimum Time Step	60. s
Maximum Time Step	600. s
Time Integration	On

Fig. 4 Boundary conditions

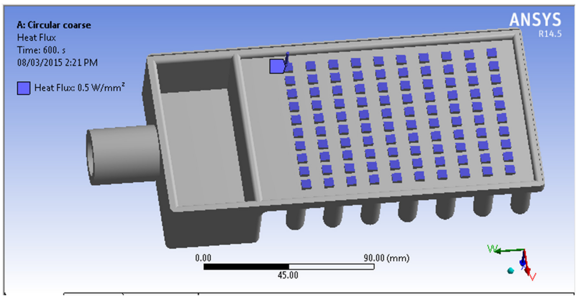


Fig. 5 Heat Flux

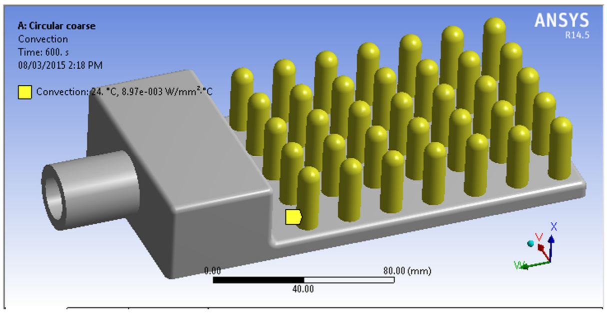
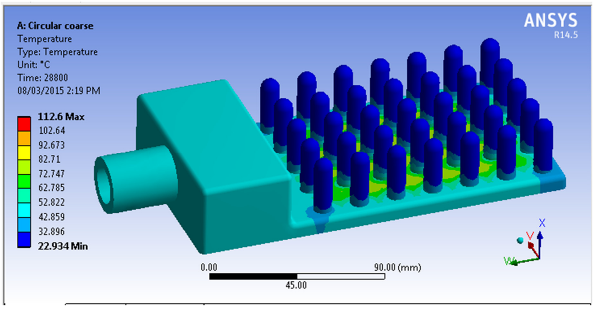


Fig. 6 Convection

Result 1



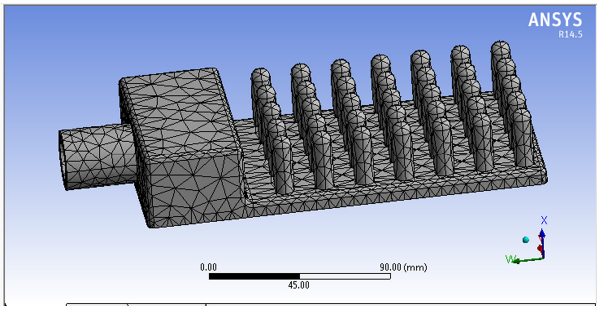
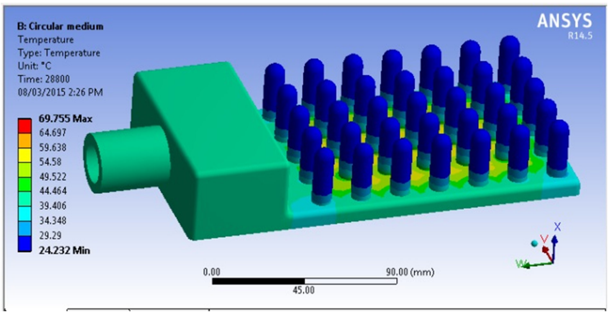
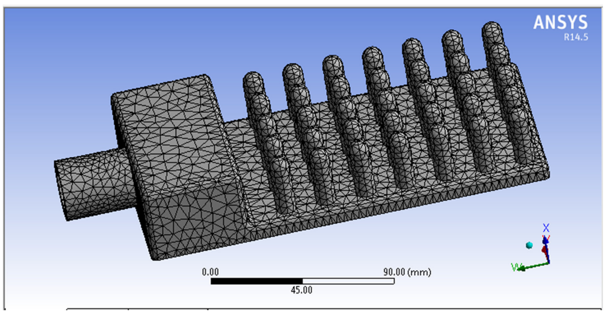


Fig.7 Circular Medium mesh

Result 2

Statistics	
Nodes	26453
Elements	13361
Mesh Metric	None

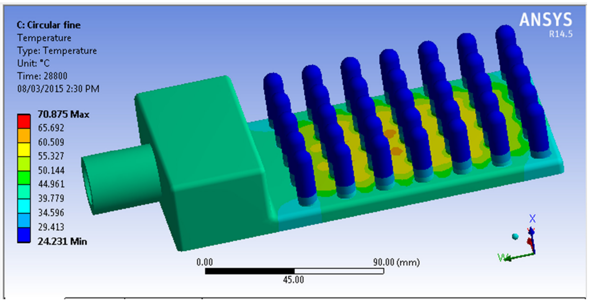


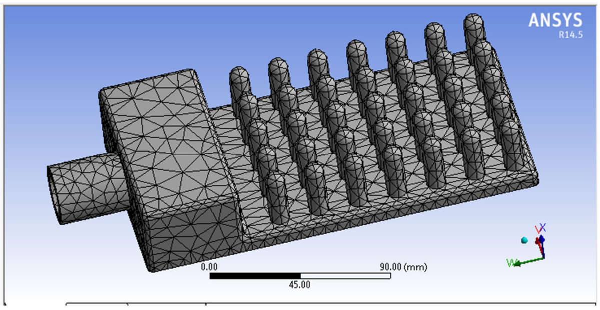


Statistics	
Nodes	61386
Elements	32670
Mesh Metric	None

Fig.8 Circular Fine mesh

Result 3

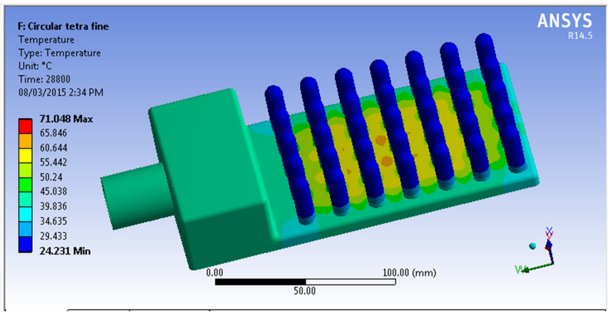


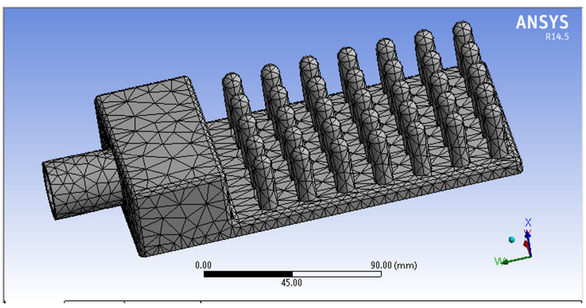


Statistics	
Nodes	70053
Elements	37529
Mesh Metric	None

Fig.9 Circular Tetra mesh

Result 4

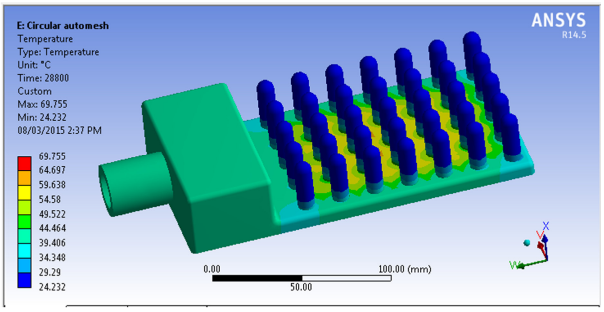


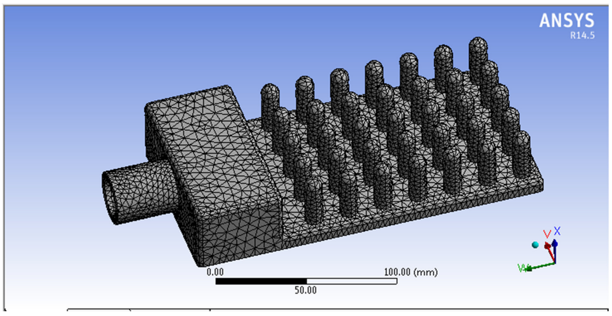


Statistics	
Nodes	26453
Elements	13361
Mesh Metric	None

Fig.10 Circular Auto mesh

Result 5

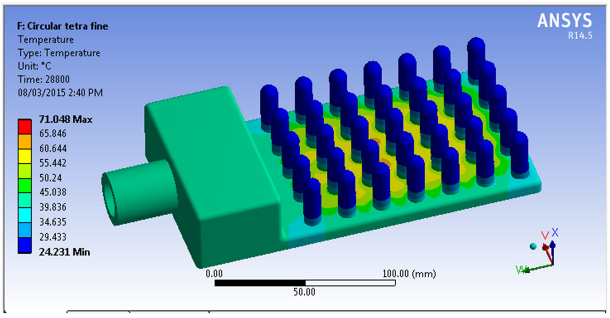




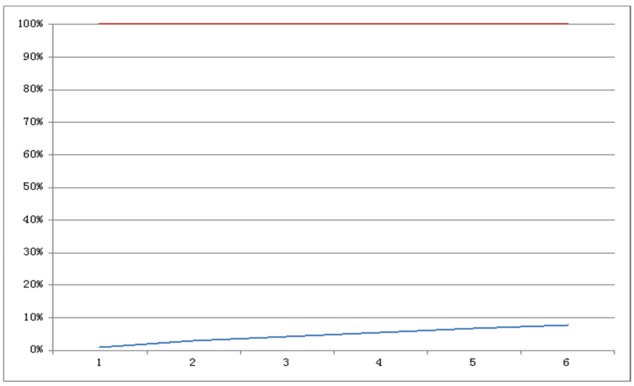
Statistics	
Nodes	70053
Elements	37529
Mesh Metric	None

Fig. 11 Circular Tetra Fine mesh

Result 6



Graph 1



Result Table 1

Sr. No	Type	Nodes	Elements	Temperature (^{0}C)
1	Coarse	17834	8844	112.6
2	Medium	26453	13361	69.76
3	Fine	61386	32670	70.87
4	Tetra	70053	37529	71.04
5	Auto mesh	26453	13361	69.74
6	Tetra Fine 3mm	70053	37529	71.048

CONCLUSION

Thermal management of LED is extremely critical and understanding it is essential when designing and developing LED systems. To prolong their lifetime and improve their performance, LED must be kept cool under all drive and operating conditions. The fundamentals of heat transfer and a full understanding of the heat path and thermal stack is needed to properly design an LED system. Thermal simulations and testing should be used to optimize and measure the performance of each LED system.

Technological developments in the area of high power LED light sources have enabled their utilization in general illumination applications. Along with this advancement comes the need for progressive thermal management strategies in order to ensure device performance and reliability.

Minimizing an LED's junction temperature is done by minimizing the total system's thermal resistance. For actively cooled systems, this may essentially be achieved by simultaneously engineering the conduction through the heat sink and creating a well-designed flow pattern over suitable convective surface area.

REFERENCES

1. A multi-functional design approach and proposed figure of merits for solid state lighting systems by Muhammed Nasir Inan* and Mehmet Arik V Inan and Arik Journal of Solid State Lighting 2014, 1:8
2. Cooling of high power LEDs through ventilating ambient air to front surface of chip by Lu Ma • Yang Yang • Jing Liu Published online: 29 August 2012 by _ Springer-Verlag 2012
3. Enhanced Active Cooling Of High Power LED Light sources by utilizing shrouds and radial fins ,A Thesis Presented to The Academic Faculty by Mark Gleva in Georgia Institute of Technology in August, 2009
4. OPTIMUM DESIGN AND SELECTION OF HEAT SINK by 1Mukesh Kumar 2 Anil Kumar 3 Sandeep Kumar Asst.Prof. in Shivalik Institutes of Engg. & Tech.-Aliyaspur published paper in International Journal of Application or Innovation in Engineering & Management (IJAIEM)
5. You JP, He Y, Shi FG (2007) Thermal management of high power LEDs: impact of die attache materials. In: Proceedings of the IMPACT conference, Taipei, Taiwan, pp 239–242
6. Zukauskas A, Shur MS, Gaska R (2002) Introduction to solid state lighting. Wiley, New York, pp 21–29
7. Alvin C, Chu W, Cheng C, Teng J: Thermal Analysis of Extruded Aluminum Fin Heat Sink for LED Cooling Application
8. Chen KC, Su YK, Lin CL, Lu YH, Li WL, Chuang RW, Huang JQ, Chen SM (2008) Thermal management and novel package design of high power light-emitting diodes. In: Proceedings of 58th ECTC, Orlando, FL, pp 795–77
9. Cheng T, Luo XB, Huang SY, Gan ZY, Liu S (2008) Simulation on thermal characteristics of LED chips for design optimization.
10. Chen KC, Su YK, Lin CL, Lu YH, Li WL, Chuang RW, Huang JQ, Chen SM (2008) Thermal management and novel package design of high power light-emitting diodes. In: Proceedings of 58th ECTC, Orlando, FL, pp 795–797