

## Investigation of the LEDs heat sinks

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**Abstract;** Junction temperature is an important parameter in thermal management of LEDs (Light emitting diodes) system. The junction temperature of three different types of LED is calculated numerically. Three dimension numerical simulation using ANSYS-Icepak 15 software package is presented for all cases. Appropriate heat sink is designed for each type of LED and investigates the effect of the fins height on the junction temperature. The increasing in electrical current utilized to driving the LEDs has concentrate high notice on the thermal management in the evolution of LED system. A felicitous design should have minimum thermal resistance between the heat sink base and the junction that depends on conduction heat transfer. The results showed the increase in a heat sink height 10% dissipate more heat transfer from the LEDs system at approximately 15%.

**Keywords:** LEDs, Heat sink, thermal management, junction temperature, ANSYS-Icepak 15.

### I. Introduction

There are many types of the Light-emitting -diodes (LEDs) superimpose from semiconductor materials, such as gallium phosphide (GaP), gallium arsenide phosphide (GaAsP) and gallium arsenide (GaAs). Germanium and silicon are inappropriate for utilized in LEDs because these junctions produce undesirable heat which is affected on lifetime of LEDs[1]. To dissipate this heat from LED system, we need to a better design of the heat sink. The temperature distribution on the heat sink depended on how heat dissipation from LEDs system into ambient air to keep the contact temperature (junction temperature) is low as possible. Heat transfer processes from LED system are the same in all practical cases, from (inside to outside) the heat source via the interface material, heat sink and into the ambient air[2].

There are many studies found in the literature surveys with regard to the thermal management of LED system. Raaid and colleagues[3] study the behavior of several types of LEDs light and design the heat sinks for each LED. They studied some parameters of the LEDs system and their effects on design of the heat sinks. They approximately estimated the cost of the each heat sink of the LEDs. Chi et al. [4] implemented the thermal analysis of high power LED Light and linked with heat sink including heat transfer due to radiation. They use a CFD numerical simulation together with some heat transfer correlations. Costa and Lopes[5] used a numerical study with regard to an amended heat sink for a light emitting diodes (LED) lamp working with natural convection conditions. Some parameters of the heat sink are taken in account such as length, height, and thickness in their study. Christensen and Graham [6], a three dimension numerical simulation is used for high power LED lamps with a heat sink, and their thermal resistance is used to find the different contributions of passive and active for the heat management in the of compact LED system. The main objective of this paper is to find the improved geometrical configuration of the heat sink to be used in LEDs light, given the critical (maximum) junction temperature of the LEDs.

### II. Analytical Solution

As we mentioned above, the main objective of this paper is to design the suitable heat sink for the LEDs system of the three different types of LED are Cree-XLamp(LED\_1), XPGWHT-L1(LED\_2) and XPEBWT(LED\_3). The target of the heat sink is to dissipate high junction temperature which causes the light output reduction by the three ways of heat transfer mechanisms as conduction, convection and radiation. As a result, when a junction temperature is increases, the light output of the LED decreases. Figure (1) shows the relative luminous flux versus junction temperature from the Cree-XLamp XB-D LED data sheet (LED\_1). This LED is cast down at 85 °C, so the relative luminous flux data is based on unity light output at an 85 °C of the junction temperature  $T_j$ [7].

The heat transfer through thermal conduction of the LEDs system is described by Fourier's Law. The representative thermal conductivity of materials used in an LED system is shown in Fig(2). The thermal resistance is utilized to appreciate thermal conductivity. At a given rate of loss, it gives the temperature difference between the temperature of air in one side and the junction temperature in the second side of the heat path. The second mechanism of heat dissipation from heat sink is concerned with natural convection, which represents the heat transfer between solid body (heat sink) and gas (air) medium. This value depends on the heat

transfer coefficient of the medium, area of the boundary layer and temperature difference. The last type of the heat transfer is concerned with thermal radiation. This type takes place without a carrier of the medium by the emission and absorption of electromagnetic waves. The standard thermal radiation equation for the special case of the emission of radiation into the space can describe by the Stefan-Boltzmann Law, which concise the impact factors to describe the heat flow alternate by thermal radiation.

The essential estimation of LEDs that calculated in this paper is junction temperature and LED power.

$$P_{LED} = I * V \dots\dots\dots(1)$$

From equation (1), we can calculate the power of each LED in (watt), and then the calculated with current junction according to catalogs of each LED. To determine the required dimensions of heat sink, its thermal resistance should be determined first. According to thermal resistance network as it is shown in figure(2), the thermal resistance of the board ( $R_{Board}$ ), interface material ( $R_{TIM}$ ), the heat sink ( $R_{HS}$ ) and the LED resistance ( $R_{LED}$ ) are determined. So from this network the total resistance can be determined as.

$$R_{total} = \frac{R_{LED}}{9} + R_{TIM} + R_{Board} + R_{HS} \dots\dots(2)$$

and by knowing the temperature difference and power that should dissipate then we can determine the  $R_{HS}$ , from this value of  $R_{HS}$  the other dimensions can determined by choosing length and width to calculate the heat sink height that make heat sink sufficient or suitable.

After the heat sink dimensions are determined now the change of junction temperature can be determined from this equation below.

$$T_j = T_{Air} + R_{total} * P_{LED} * NO_{LED} \dots\dots(3)$$

Where ( $NO_{LED}$ =Number of LEDs)

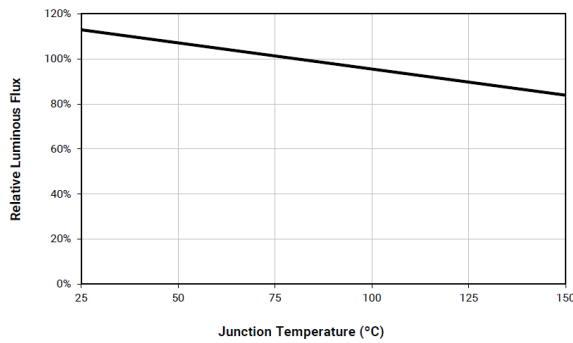


Figure (1) Relative luminous flux vs junction temperature of Xlamp XB-D LED[7].

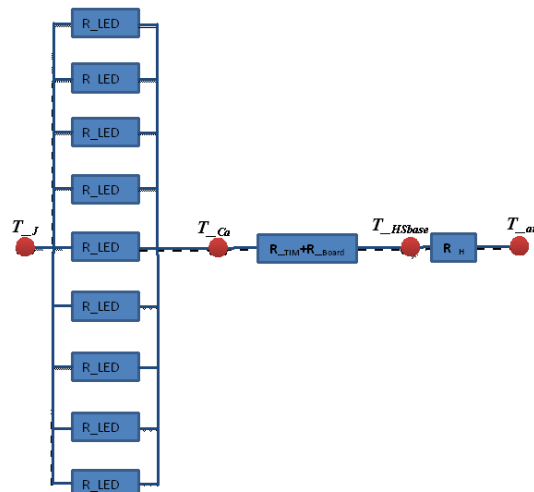


Figure (2) Thermal Network Resistance

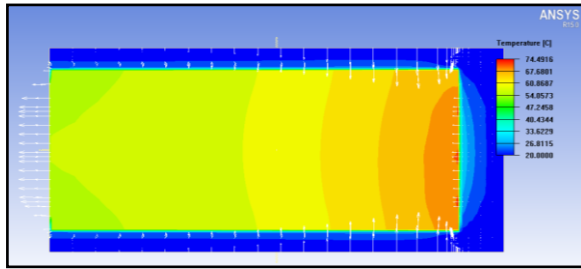
### III. Numerical Model And Boundary Conditions

ANSYS-Icepak 15 software package is a well-known and fully-decided software package, which has been utilized and validated under many different conditions[8-11], and also to solve natural convection problems with laminar flows. Three dimension numerical simulations are presented for all cases. The typical mesh elements size is 0.0005m, and the total element numbers are 342782. The three types of LEDs are Cree\_Xlamp(LED\_1), XPGWHT-L1(LED\_2) and XPEBWT(LED\_3) are chosen with normal specification from manufacturer. The our calculation with 95% reliability on these for the maximum junction temperature 85°C, we want in our design below the available limits and read out the maximum junction temperature  $T_j$ .

### IV. Results And Discussion

The 3-D simulation is doing for three different reading of heat sink dimensions. The length and width of all heat sinks are 35 mm and 30 mm respectively. The heights are 59 mm for LED\_1, 69 mm for LED\_2 and 74 mm for LED\_3. The numbers of fins are 8, 3 and 4 for LED\_1, LED\_2 and LED\_3 respectively. The temperature distributions of maximum junction temperature in three cases are shown in the list figures below. Figure (3) shows the temperature distributions of LED\_1 in x-direction while figure (4) clearly shows the natural convection array from the base of heat sink to air medium. The maximum junction temperature is 74.49 0C. Figures (5) and (6) show the temperature distributions of LED\_2 while figure(7) shows the temperature distribution of LED\_2 in y-direction. The maximum junction temperature reach to 59.120C.

Figures (8) and (9) represent the temperature distributions with velocity array in x and y-directions for LED\_3 at maximum junction temperature is 56.7 °C.



Figure(3) the temperature distribution of LED\_1 in x-direction.

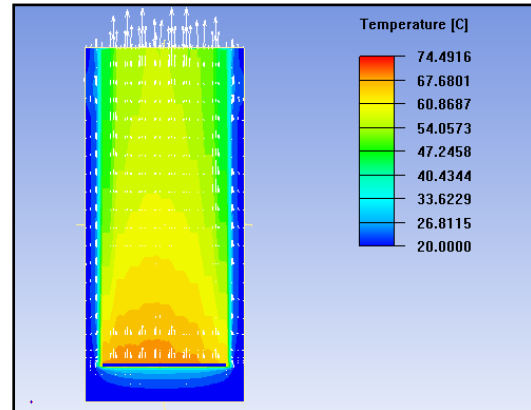
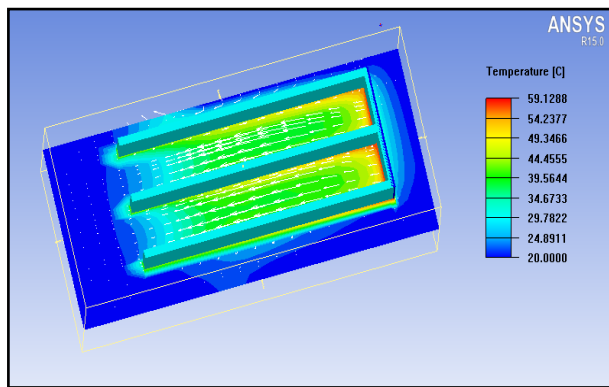
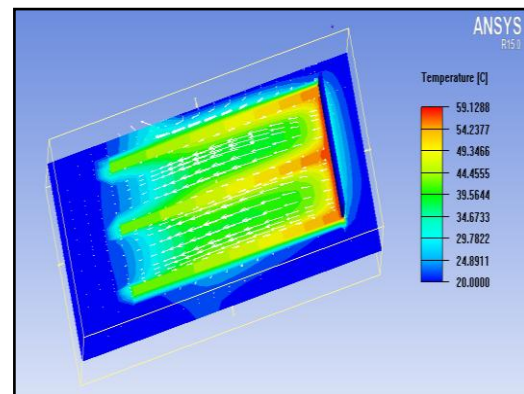


Figure (4) the temperature distribution of LED\_1 in y-direction.



Figure(5) the temperature distribution of LED\_2 in x-direction with fins



Figure(6) the temperature distribution of LED\_2 in x-direction without fins.

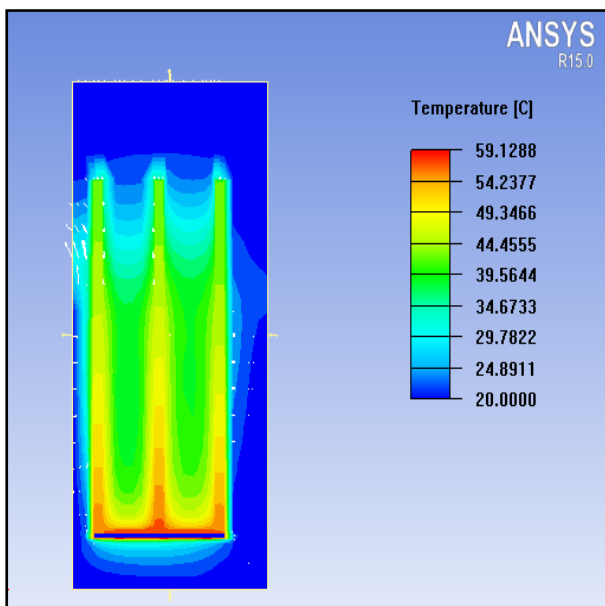
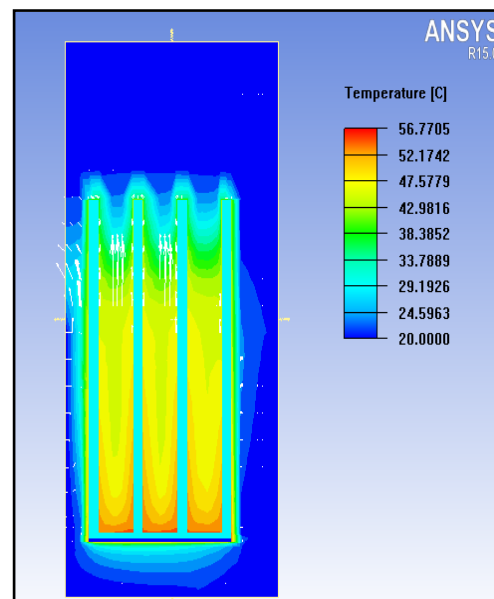
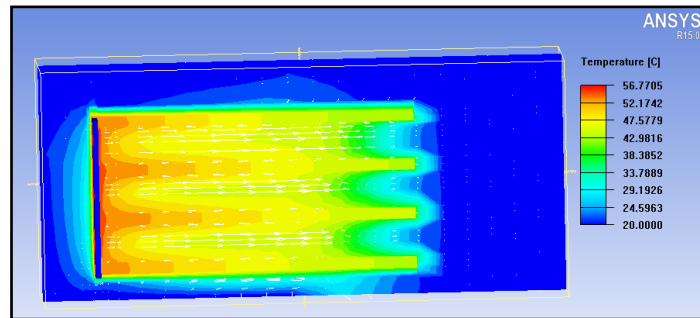


Figure (7) the temperature distribution of LED\_2 in y-direction.



Figure(9) the temperature distribution of LED\_3 in y-direction with fins.



**Figure(8)**the temperature distribution ofLED\_3 inx-direction.

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