Design of Fins as Heat Sink for 80 watt Cob-Led Light

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Abstract*: *LED lights have revolutionized the world by their performance. They consume less power as compared to previous lighting generations. However, large amount of power is dissipated in the form of heat. Therefore thermal management of LED is necessary to increase its life span and make it environmental friendly. For thermal management, aluminium heat sinks are widely used because aluminium profiles are easily manufactured and are good conductors of heat. In this article, we have intended to design the aluminium heat sink of eighty watt COB (Chip on Board) LED canopy light used in petrol pumps all around the world. We have designed the heat sink for 80W COB LEDs (40W each), and analysed the junction temperature through ANSYS fluent simulation. This design of heat sink and its fins are optimum and Thermal Interface Material is also used.

Index Terms*: *COB, Fluent ANSYS, Heat sink, Junction Temperature, LED, Optimum Design, Thermal Analysis

I. INTRODUCTION

The consumption of (LED) Light Emitting Diode is increasing rapidly because it is environmental friendly and it uses less power [1]. Therefore it is more effective in those countries where shortfall of power is increasing day by day. The research work in the field of LED and its heat sinking is almost negligible as compared to other fields. Due to all of these factors, we determined to make an aluminium heat sink for 80 watt COB LED canopy light, which is used in petrol pumps. Almost 85% of LEDs stop working due to heat sinking problems [2, 3]. Therefore Thermal Heat should be handled carefully to improve life of LEDs.

Different heat sinking ideas are used to dissipate heat energy from LED Lights. We have chosen to make aluminium heat sink profile for this purpose. This heat sink will be attached to the printed circuit board (PCB) as a cooling system [4], to dissipate heat energy as quickly as possible. In order to get the optimum design of heat sink profile, the allowable junction temperature, area of aluminium heat sink and LED specifications should be kept in mind. We have studied all the features of this LED and have decided to design a heat sink for two 40 Watt EdiPower® II Series COB LEDs. After designing the heat sink area, we will do its thermal analysis using ANSYS fluent.

II. 80WATTS LED CANOPY LIGHT HEAT SINK

In the first segment we will emphasize on the COB LED and structure of the canopy light joint with it. In the second section, we will describe in detail the optimal area of heat sink and its fins. In the third section, we will do thermal analysis of this heat sink using ANSYS fluent.

A. *Canopy Light and COB LED 80 watts*

Canopy lights are very common and they are mainly used in petrol pumps. Figure 1 shows two COB LEDs with the canopy frame.

Figure 1 Canopy frame with COB LEDs

This canopy frame will be placed on the roof of the petrol pumps. We are using two COB LEDs each of 40 watts. These COBs are directly attached to Printed Circuit Board which is further bonded to the heat sink with the help of screws and thermal interface material. High power COB modules always generate more lumens while at the same time they produce more heat [5]. The printed circuit board (PCB) of each COB has the structure of arrays of 1 watt chips. Heat

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problem is likely to be expected because there is a total of 40 chips of 1 watt on each COB on a very small area shown in Figure 2 [6]. Since, there are two COBs for one canopy frame; they will cover wide range of area for lighting purpose. They will also provide us high luminous intensity and different colour combinations [7]. Sometimes, with the passage of time, the luminous intensity of COBs decreases, this problem occurs when heat sinking area for COB is not enough to maintain its working temperature [8].

Therefore, we have also done the thermal analysis to show that its junction temperature is not exceeding its limit. Otherwise, we will not be able to maintain its long life and luminous intensity, which is our main goal for this design. Using this analysis, we can estimate about maximum and minimum temperatures and can assure whether our design is safe or not. If the maximum temperature exceeds the junction temperature, then we need to improve our design or increase the heat transfer area by increasing the number of fins.

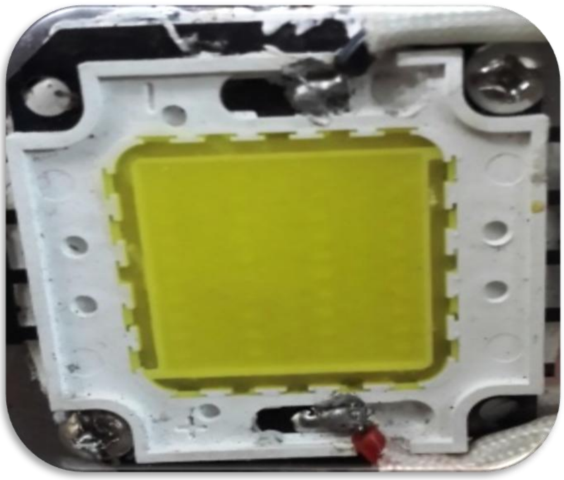

Figure 2: COB LED Product

B. The optimal Heat Sink design for COB LED

Figure 3 shows the basic thermal model for COB LED mounted on a heat sink. Usually, aluminium profiles with extended fins are used for heat sinking purposes because aluminium is light in weight and conducts heat efficiently. We can increase the number of fins to increase the heat sink area depending upon our requirement [9]. For an effective thermal management, it is important to create a rapid heat conductive path from the LED chip to the environment because the contact surface of the component and heat sink are not perfectly flat. Usually in high power LEDs and COBs, only 25% of input power is converted to light [10, 11]. Air between these materials can cause high thermal resistance. So, to reduce this resistance, we have applied thermal grease between the two interfaces and also used screws to enforce the adhesion between them.As we have discussed earlier, that before designing the heat sink of any COB LED, it is very important to go through all of its data sheets and specifications. The orientations of whole LED package were also widely studied [12-16]. The calculation of heat sink area is very critical and if calculated inaccurately then there are chances that the whole light will fail after a steady state is reached. Geometric parameters such as length, height and number of fins are most important. Figure 4 shows the design of the heat sink for two COB LEDs.

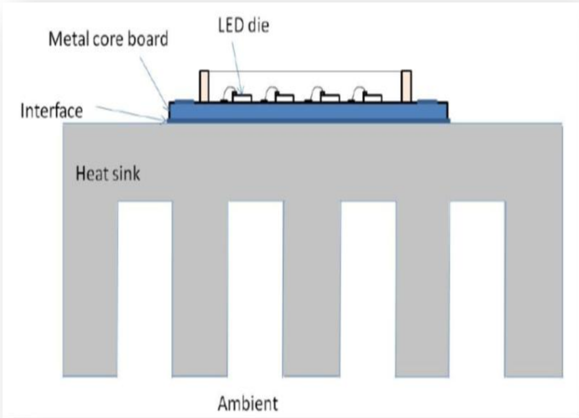

Figure 3: The basic structure of heat sink

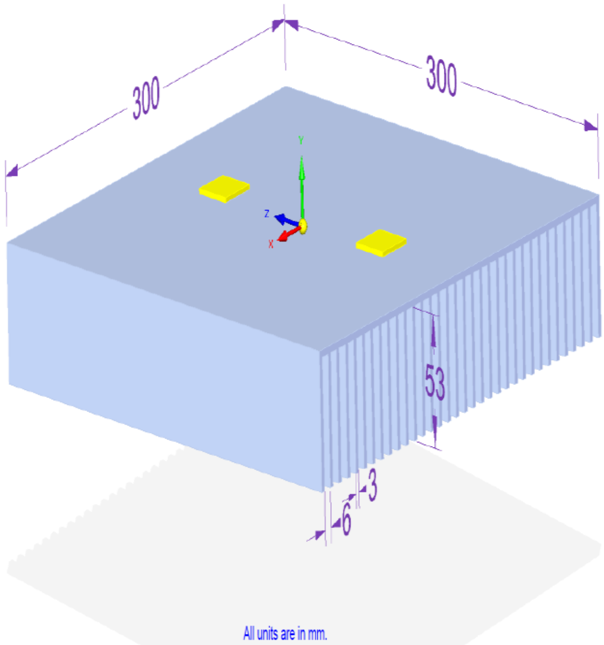

Figure 4: Design of the Heat Sink

This heat sink is square and it will fit accurately to the canopy size. Following is the calculation for this area:

Total length of one fin = 53 mm = 5.3 cm

Total number of fins approximately = 33

Heat Sink Length = L = W = 30 cm = 300 mm

Thickness of one fin = 0.3 cm = 3 mm

Dimensions for Pitch = 0.9 cm = 9 mm

Area of one fin should be

$= 2\{(30)\,(5.3)\} + \{0.3\,(30)\}$

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= 327 cm2

Total Area of all the fins = 327 × 33

= 10791 cm2

Total Base Area = Width {Length – (Total No. of fins ×thickness of one fin)}

= 30 {30 – (33 × 0.3)}

= 603 cm2

Overall Total Area = Total Area of Fins + Total Base Area

= 10791 + 603

= 11394 cm2

Therefore the designed area is approximately 11000 cm2. It is also recommended that the thickness of fin and pitch should not be less than 3 mm and 6 mm respectively and area for heat sink must not be less than 11,000 cm2.

C. Analysis of Heat Sink Using Ansys fluent

In order to get good analysis of the Heat sink, we should first determine the ambient and initial temperatures. To calculate the initial temperature, we should first calculate the junction temperature theoretically. The equation for the junction temperature is given below

$$Tj = Tc + Rjct \times Pd \quad [17] \ldots\ldots (1)$$

As

Tj is the temperature of the junction of the LED

Rjct is known as thermal resistance from junction to case of the LED COBTc is the case temperature of the LED COB (Figure 5) Pd is the total power in watts

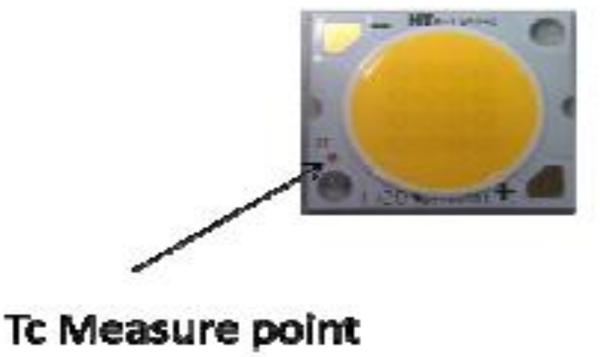

Figure 5: Measuring point of Case Temperature

Since, here in this case, we are going to assemble multiple COBs on a single type of heat sink, thermal resistance (Rjct) should be calculated by applying the rule of parallels. As given in the datasheets,

Rjc of this COB = 0.6 °C/W [18]

Case Temperature Tc = 55°C

Total power in watts, Pd = $80\ watts$

$$1 / Rjct = 1 / Rjc1 + 1 / Rjc2 = 1 / 0.6 + 1 / 0.6$$

Rjct = 0.6 / 2

Rjct = 0.3 °C/W

So, putting the values in equation (1)

$$Tj = Tc + Rjct \times Pd$$

Tj = 55 + 0.3 × 80

Tj = 79 °C

So, the temperature at junction point for this COB LED is around 80°C. For a good quality thermal examination, we must consider that the initial temperature is equal to the junction point temperature. We are going to analyse the heat sink shown in figure 6 using ANSYS fluent software. It is analysed under severe conditions. As, in summer season of many countries, the temperature reaches above 40 o C .Therefore, we will choose the ambient temperature 45o C. The coefficient of Heat transfer film has a value of 5 W/mo C [19] and the initial temperature is 80°C.

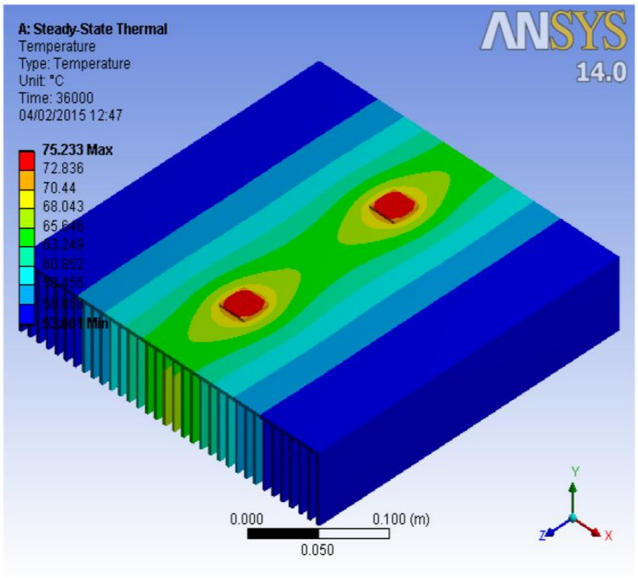

Figure 6: Heat Sink and Fins Thermal Analysis

This figure shows the distribution of temperature on the heat sink. The Junction Temperature shown by the red points have a temperature 75.233 oC and this temperature is under a very safe limit. Although it should be noted that we have not used thermal interface material in simulation (TIM). If we use this material, then temperature will reduced further. [20].

III. CONCLUSION AND FUTURE WORK

In order to maintain the luminous intensity and lifetime of COB LEDs, the case temperature and junction temperature must have a safe limit. So, optimal design for heat sink is required. We have designed a heat sink for canopy light under maximum conditions where the initial temperature is 45oC. The maximum junction temperature is around 75oC, which is slightly on a higher scale because no TIM was included in this analysis. However, there are no chances of failure using this design.The absolute maximum rating of junction temperature provided for this

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LED is 150oC. It was observed during our experiment that the LED failed when the junction temperature was about 120oC. Consequently, it is advisable that the working temperature should remain between 50oC to 90 0C.

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