Experimental Study on Temperature Distributions of High Power LED Floodlight

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Abstract: - In the recent times, with the feature of low-power and eco-friendly, the usage of LED (Light Emitting Diode) is increasing. But, for developing high power (more than 200W of power consumption) LED light, the problem on radiant heat has not been resolved clearly as ever. So in this paper, the experimental study was conducted to analyze the temperature distributions of 170W LED lamp. The distribution of temperature on LED lamp was observed by thermal image camera. Thermal image was obtained at an interval of ten minutes to know the time of reaching at steady state. Also, the temperature distributions were investigated with installation angle of LED lamp. As the result, it is found that the steady state in the temperature field was achieved after about 120 minutes since the LED had turned on and the cooling performance of LED light could be maximized as the maximum temperature is blow 60°C

Key-Words: - Floodlight, LED, Heat sink, Thermal image, Temperature distribution

1 Introduction

LED (Light Emitting Diode), which has the feature of low-power consumption, eco-friendly and is an alternative device for resolving global energy issues and global warming, gradually expanded to be applied in various fields. And the government plans to supply the proportion of LED up to 30% by 2015.

It is predicted that LED lighting market will grow up to about 50 to 60 trillion in 2015. And it is expected to grow as well as special lighting and general lighting market. In case of Korean domestic market, LED lighting of less than 100W is already under the dissemination process, but in the field of high power LED light (more than 150W), by lack of development, LED lighting device has been developed by installing two or more low power supply separately.

Because of its simple structure, LED can be mass-produced, is compact, has high vibration-resistant, long life and can represent various colors. However, it generates high output in relatively small size, so the cooling problem is pointed out as the biggest problem.

In particular, unlike LED device applied in small size appliances such as TV or a laptop, even though LED lights in street lighting, security lighting are generates tens to hundreds watts of output, its size are just about 10⁻⁵m³. So, if adequate cooling is not established, its reliability and life would be fallen. [1]

For maximizing performance of the products generating heat, it is important to maintain the optimal temperature conditions by cooling heated parts. At this, due to its simple structure, heat-sink used typically as cooling system, and it is usually made of aluminum alloy or copper alloy series. [2]

Currently, studies on cooling using heat-sink have been conducted actively. Wu et al [3] analyzed to radiant characteristics with several design variables by proposing mathematical model for a planar heat sink. Huang et al [4] determined the temperature distributions by experiment and numerical simulation on the various three-dimensional design models. In this paper, temperature distributions on lamp (heated part) and heat-sink of 170W LED floodlight were checked by using thermal imaging camera to utilize it as design data for high output LED light.
2 Apparatus and Method

2.1 Experimental Apparatus

LED floodlight applied in this study is primarily used for streetlights or sculptures, etc. Fig 1 shows the shape and measurements of LED Floodlight applied in this study. Heat-sink includes 32 of fins and every fin has 1.5mm of thickness. Also fins are arranged as 28mm and 37mm of height as shown in Fig 1.

Fig. 2 shows the internal structure of the LED light, lamp and an aluminum plate are combined with the heat-sink. And glass cover is located between two cover frames, all parts are combined by bolts. Further details on the LED light are shown in Table 1. Thermal imaging camera used in this study is the 'testo 880' model of German T company.

![Fig. 1 Drawing of LED floodlight](image1)

Table 1 Specifications of LED module

<table>
<thead>
<tr>
<th>Type</th>
<th>LED floodlight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage[V]</td>
<td>AC 220</td>
</tr>
<tr>
<td>Current[A]</td>
<td>1.0</td>
</tr>
<tr>
<td>Power consumption[W]</td>
<td>200</td>
</tr>
<tr>
<td>Efficiency[Im/W]</td>
<td>65</td>
</tr>
<tr>
<td>Size[mm]</td>
<td>400×200×100</td>
</tr>
<tr>
<td>Life[hr]</td>
<td>40,000</td>
</tr>
</tbody>
</table>

2.2 Experimental Method

Frame for installing LED light was made and LED light was combined with the frame by bolts. To minimize heat conduction on interface between LED light and the frame, four washers were inserted respectively to each bolt. Experiment was conducted at 21°C of ambient temperature, the wind didn’t blow.

To confirm the time to reach steady state after the operating start-up, thermal images were taken at intervals of 10 minutes. In addition, by changing the angle of installation of LED light, the effect of natural convection on temperature distributions was to check.

![Fig. 2 LED module and assembly diagram](image2)

3 Results and Discussions

3.1 Temperature distributions with operating time

To confirm the time to reach steady state after the operating start-up, thermal image of front (lamp) and side view of LED light was taken at intervals of 10 minutes with lamp facing upward. At this time, to check the temperature of heated part (lamp), glass cover was removed.

Fig 3 shows the temperature distributions on heated part according to operating time. Considering almost no difference between the temperature distributions on lamp at 120 and 150 minutes, about 120 minutes after start-up LED light was reached to steady state and the maximum temperature on heated part was about 70°C at this time. On the other hand, the temperature on aluminum plate was about 30°C, it because the aluminum plate was exposed to ambient air and it was cooled by the convective heat transfer to ambient air.
Fig. 3 shows the temperature distributions on side of LED light according to operating time. As shown in Fig. 4, steady state was achieved at 120 minutes after start-up. In case of the temperature distributions on side view, the maximum temperature was about 60°C at the boundary surface between aluminum plate and heat-sink. And it because high heat resistance at this surface. But the temperature distribution on heat-sink was relatively low as about 35°C~40°C.

3.2 Temperature distributions with Installation Angles

Installation angles can be changed by the use of LED light, so in this study, temperature distributions according to installation angles of the light were analyzed. Thermal images were taken after 30 minutes to change the angles.

Fig. 5 shows the temperature distributions on heat-sink according to installation angles. At this, 0° indicates the lamp facing upward and 180°, 90° indicates the lamp facing bottom and front respectively.

The temperature distributions at 0° and 180° were almost identical. But in case of 90°, due to high heat conduction, it can be shown to high temperature at the boundary. Even though some washers were inserted for minimizing heat conduction on this surface, heat conduction occurred because the washer is not insulation and the gap was too small to insulate.

Fig. 6 shows the temperature distributions on glass cover according to installation angles. Same to the case of heat-sink, the temperature distributions at 0° and 180° were almost identical. But in case of 90°, the area of high temperature is shown in upper parts of glass cover. It because high temperature air, which have high density, transfer to upper part of glass cover by natural convection.
3.3 Temperature profiles at primary sections

Temperature profiles at primary sections of glass cover and heat sink were obtained by using data processing software, shown in Fig. 7 and Fig. 8.

Fig. 7 shows the temperature profiles at center section x-x of the glass cover. As shown in the graph, temperature drops through glass cover and again increases at 460mm. The graph is symmetric with origin at 240mm. On the glass cover, the highest temperature, 42°C, is shown at center of the glass cover. It because the highest temperature of frame by heat conduction through the bolts and heat generated at lamp located in the center of LED light was transfer to the glass cover by natural convection.

Fig. 8 shows the temperature profiles at center section y-y of the heat-sink and it shows the shape that high and low temperatures are repeated. In the graph, low points mean the temperatures at the end of the fins and high points mean those at base of fins. In other words, the temperature of fin base, which is closer to heated part, are high, and as far from fin base, heat transfer to the ambient air is higher and it leads to low temperature at the end of fins.

4 Conclusion

In this study, temperature distributions on 170W of LED floodlight were analyzed by thermal imaging camera to utilize it as design data for high output LED light. And the detailed results are as following.

(1) At about 120 minutes after LED light start-up, it was reached to steady state. At this time, the maximum temperature, 70°C, was represented on lamp. Also, the temperature on boundary surface between aluminum plate and heat-sink was about 60°C.
When the LED light was installed by 90°, the area of high temperature was represented in upper parts of glass cover by natural convection.

By analyzing temperature profiles of primary sections on glass cover and heat-sink, it could be confirmed to the characteristics of temperature distributions on each part.

References:


