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Passive Thermal Designs and Characteristics of LED Lighting Equipment for Broadcasting with Various Outputs

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Abstract.

BACKGROUND/OBJECTIVES: Compared to conventional lighting, LED lighting has a very high energy saving effect, has a long lifespan, has a low failure rate, and requires a low maintenance cost.

METHODS/STATISTICAL ANALYSIS: However, as the output of LED lighting increases, heat is generated, and LED characteristics are deteriorated and lifespan is shortened by this heat. Therefore, a separate heat dissipation device is required, but unlike general street lights, general lighting, and advertisements, LED lighting devices for broadcasting images cannot apply a radiator with noise.

FINDINGS: Therefore, we are trying to develop a new cooling system without noise while maximizing the functionality of LED elements and control units with heat sources of LED lighting devices for broadcasting images. In addition, if the LED board and the control board are separated from the PCB, heat dissipation is more effective, so develop a method that can effectively dissipate heat according to the material and shape of the LED package. The distance between the LED modules was set to 15mm to increase the density of the light source, and to share the LED board by model, the output per PCB was designed as 20W. The size of the LED board was 240mm*90mm for 80W and 120W, and 180mm*120mm for 200W. While designing a product for 120W, in order to compare and check the temperature change and its characteristics, boards for 80W with low light and 200W with high light were produced and tested.

IMPROVEMENTS/APPLICATIONS: According to the results, it is evaluated that it is possible to apply a high power of 300W or higher by applying an LED module with a high light source to the size of a 200W LED panel light.

Keywords: cooling system, LED lighting, separate heat dissipation, broadcasting images, LED module

1. INTRODUCTION

LED (Light Emitting Diode) is a semiconductor device with good energy conversion efficiency because it directly converts electricity into light. Among the various light sources, the incandescent bulb that emits light by heating of electricity, that is, the heating of the tungsten filament, and the fluorescent lamp that emits light by the discharge of electricity using mercury gas, are vacuum tube elements, whereas LED is a semiconductor element that emits light[1]. In addition, compared to incandescent lamps 10-15[lm/W] and fluorescent lamps 50-60[lm/W], LEDs have good energy conversion efficiency as 80-110[lm/W], have excellent durability, and have a lifespan of more than 50,000 hours. The brightness of the light is strong [2]. LED is a light emitting device made from semiconductor that does not require valve shape such as filament and vacuum tube compared to other light sources. As monochromatic light, light with a limited wavelength component such as a blue component or a yellow component emits a single wavelength[3]. The energy gap determines the emission wavelength. Silicon emits far-infrared light at 0.6-0.7V and GaAs emits far-infrared light at 1.4V, which is used for red LEDs. GaN has an energy gap of 3.5V, and blue LEDs were completed in 1922, and all colors could be realized [4]. Since the LED cannot directly use AC 220V, it is used by converting it to a low voltage of DC 1.5-6V. Because the light-emitting element is small, it is a point light source and because it is a point light source, it is possible to irradiate with high degree of freedom such as potable light or head lamp of automobile by combining lens and reflector. High-power light-emitting diodes such as traffic signs use dozens of diodes in bundles. In addition, since the light emitting device circuit is simple, it emits light with a small current and low voltage, and since there is no current suppression property in itself, resistors to suppress the current are installed in series [5,6]. Therefore, the most important conditions for emitting LED light are the setting of the applied voltage and rated current, and 15-35% of the electric energy is converted to light, and the remaining 65-85% is converted to heat, so a heat dissipation measure must be established[7]. The 3W power LED is capable of outputting about 0.9W of light. Since the light emission mechanism is not heated light emission, power consumption is low because the input energy is efficiently converted into light. The 9W LED bulb has the same brightness as the 60W incandescent bulb, so it has about 7 times the efficiency. However, even if the power consumption is low, it does not generate heat at all, and the element itself is accompanied by heat, so measures for heat

dissipation are necessary[8]. Therefore, "How should I do a passive thermal design, a cooling device?" Is essential to maintain the luminous flux and efficiency of the HP LED? The design of a cooling system to maintain the efficiency of HP LEDs for broadcast photography has been studied recently. However, the cooling fan used as a cooling device for various electronic devices cannot be used because of its high noise. And because it is difficult to apply a water-jacket system that needs technical supplementation, a natural passive thermal design using a plate heat sink is being developed [9,10]. The higher the applied voltage, the more heat is generated and the temperature of use of the product increases. Then, the efficiency of the LED module is lowered and the color temperature, color rendering index, and amount of light decrease. As a result, the lifespan of the LED broadcasting video device is shortened, making it difficult to secure reliability. Therefore, by attaching a heat sink to the LED board as a heat source, a heat dissipation design was made using a natural cooling system.

2. MATERIALS AND METHODS

LED lighting devices have the disadvantage that the temperature continues to increase as the power increases, so a separate cooling system must be installed to suppress such heat generation. It is known that if a cooling system is not installed, heat generation increases and the temperature increases linearly. And as the temperature increases, the amount of light, the luminous flux, decreases. In particular, at temperatures between 120℃ and 140℃, the amount of light rapidly decreases, so it is essential to design a special cooling device to maintain the efficiency of high-power LED lighting devices[11]. In [Figure 1] a), when the input power applied to the LED increases, the temperature increases. If a separate cooling system is not installed, it increases almost linearly. b) shows that the luminous flux decreases as the temperature rises, and the amount of light falls sharply between 120℃ and 140℃.

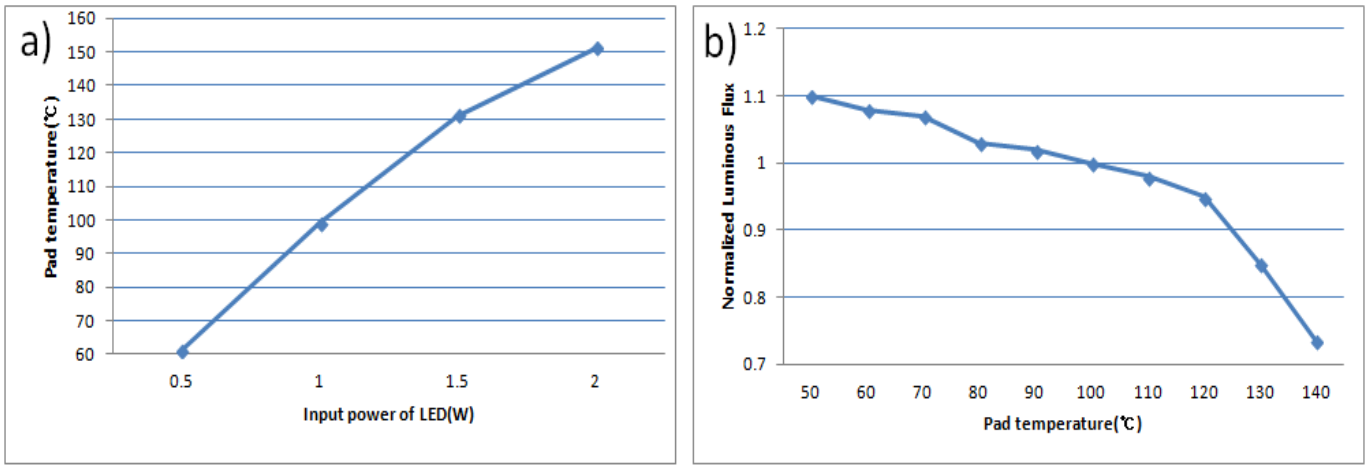

Figure 1. Temperature change and light flux reduction according to LED input power

Most of the LED lighting devices for broadcast videos have high heat generation due to high output, so the luminous flux decreases significantly after a certain period of time. In addition, since the lamp life is shortened and various functions are rapidly deteriorated, various cooling devices have been developed to prevent these disadvantages. Most of the devices or systems currently developed and commercialized are cooling systems using heat conduction and convection. Although various designs using metal materials with high thermal conductivity, such as a Fin type with a wider surface area, are commercialized, there are many lighting devices that are inferior in efficiency and economy. In addition, since the LED main body and the control module, which are the parts where most of the lighting equipment generate heat, are connected to a single case in an integrated manner, the efficiency of controlling the heat generation with high output may decrease a lot. Therefore, the direction of development in this paper is as follows. First, it tries to reduce heat generation after dividing the heat generating parts from each other and making them apart. Second, by applying the method of effectively connecting the separated modules as described above, the cooling effect of the convection method and the conduction method is analyzed and compared with existing products to differentiate them. In the conventional cooling method, a method of increasing a heat dissipation effect by increasing a surface area and a method of dissipating heat using a mixed material are used. Increasing the surface area increases the weight and cost of lighting equipment, making it difficult to regard it as a complete heat dissipation system. Most of the LED lighting devices adopt a heat dissipation system using a heat sink and PCB. Broadcast video LED lighting equipment should have high brightness and high color rendering index. And since it should be easy to use and convenient to carry, it is necessary to develop a heat dissipation system using natural principles. In this study, in order to increase the cooling effect of the LED lighting fixture design, the controller PCB and the LED PCB are designed in separate cases, and the device is designed to be dualized and a heat sink attached. The LED module has a high color rendering index and is composed of 0.22 Watt Pure White and Warm White. LED module boards are made to increase or decrease the number of boards for each model by using the common LED module board size to produce three boards of 80W, 120W, and 200W. [Figure 2] shows the LED board circuit diagram.

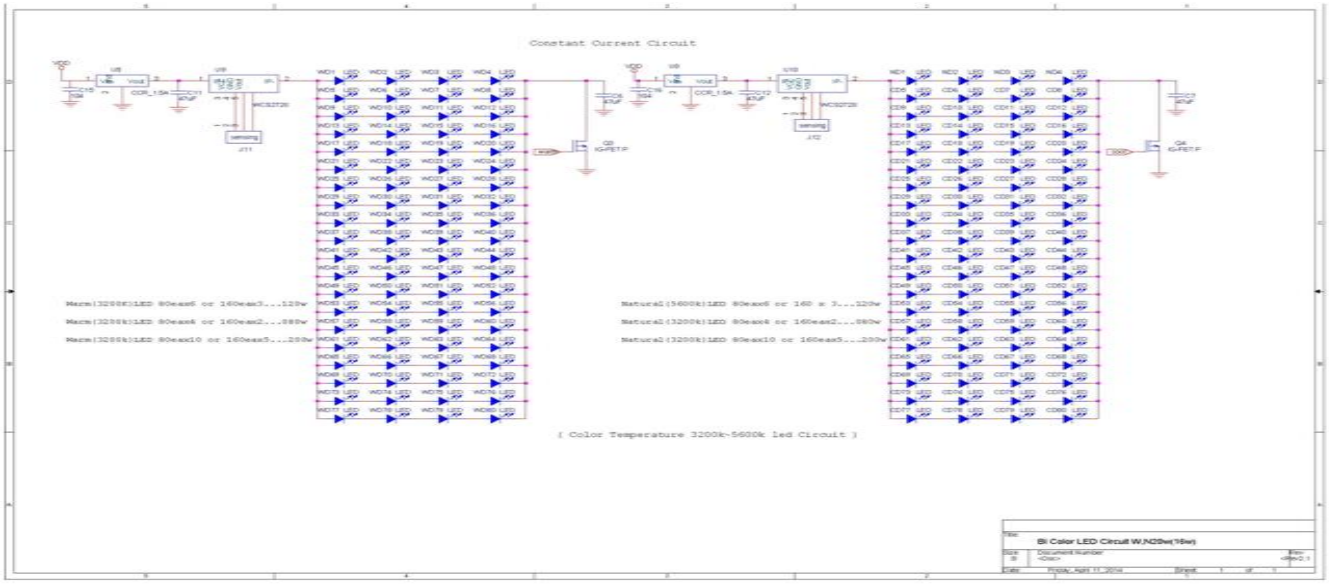

Figure 2. LED board circuit diagram

In order to increase the density of the light source and reduce mutual interference of heat generated from the LED module, the distance between the LED modules is set to 15 mm to reduce heat generation. In addition, by making a via hole around the LED module, the air through the via hole flows at the front and rear of the board to obtain a heat dissipation effect by convection. This heat dissipation system greatly improved the heat dissipation efficiency of the LED board by attaching the LED board to the 3mm thick aluminum flat board in consideration of the life and efficiency of the LED module. The output is designed as 20W so that the LED board can be selected by model. Six 0.22W LEDs were connected in series, and 96 were connected in parallel in 16 single layers, and the output was 20W. For 200W, 96 Warm White LEDs and Pure White LEDs are arranged in 12 rows and 8 rows, respectively, on 20W individual boards. LED lighting is bi color, with 96 warm white LED modules with a color temperature of 3200K and 96 pure white LED modules with a color temperature of 5600K. It was made to be variable to 5600K. In the LED board with the LED module attached, heat generated from the LED module is conducted to the heat sink, and heat dissipation is generated by convection on the surface of the heat sink. So, in order to increase efficiency, a via hole was made in the board and designed as shown in [Figure 3] so that heat dissipation by convection. A is an LED board and B is a via hole designed for heat dissipation by convection.

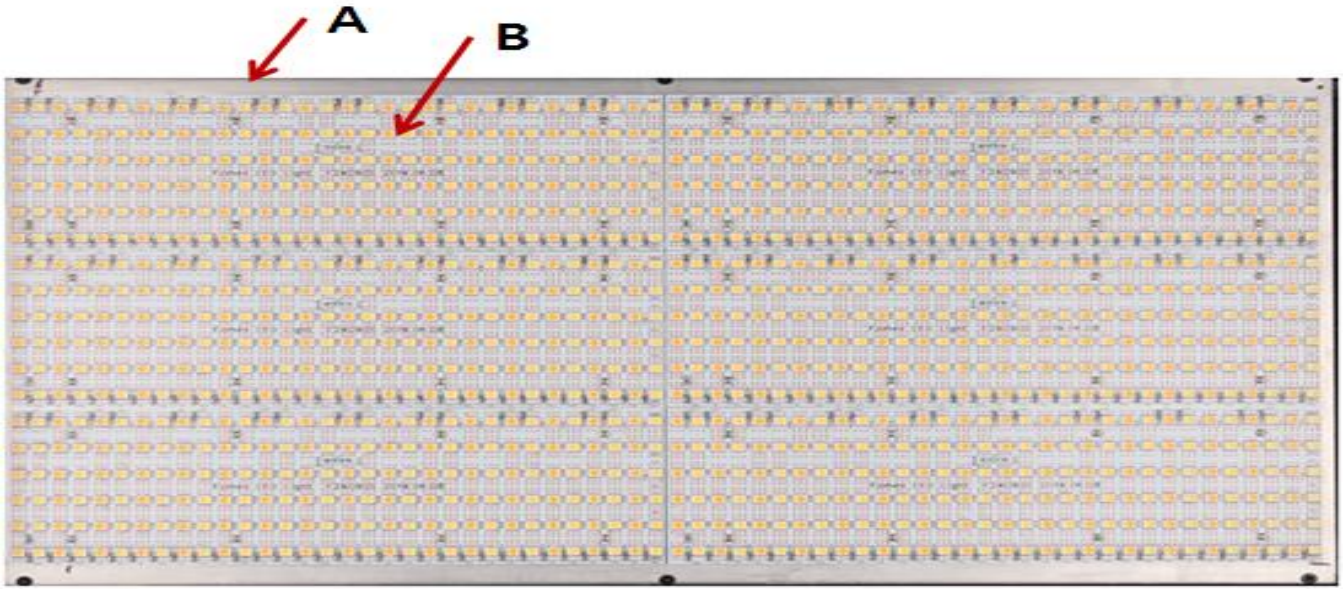

Figure 3. Photo of attaching 6 pieces of LED 20W board

In addition, external functional parts such as LCD and DMX control for operation and status display of LED lighting were reviewed and applied to the design. The LCD module that displays the status is black and white, and the background is white LED and the display is black, making it easier to identify the display.

[Figure 4] is a drawing of the left and right frame extrusion molds. Extrusion was performed to a thickness of 4mm, and cut and tapped. The side frames, which are the left and right frames, are mounted in two layers on each side to ensure robustness when shooting outdoors. In addition, although the shape of the two-ply is different and the

left and right sides are different, the left and right sides and two side frames were processed and applied when extruding with one extrusion mold. The surface was treated with black anodizing without light reflection from the product. The upper and lower frames are designed to be equipped with a protective PC panel, a light diffusion diffuser, and a barn door. The reason for examining the frame by extrusion is that the size of the product changes according to the amount of light of the broadcasting video LED panel lighting. Designing for press molds or plastic injection molds increases the price of the product, so the design was designed to be excellent in consideration of this.

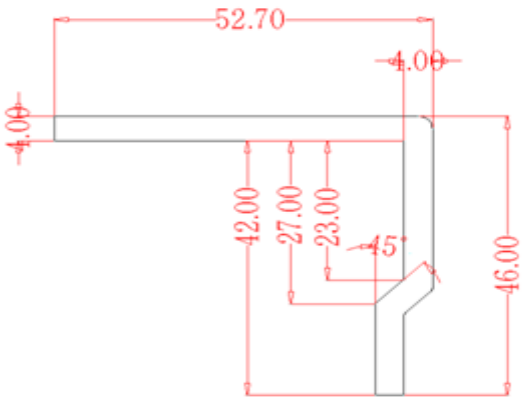

Figure 4. Drawing of left and right frame extrusion mold

The side frame has a number of vents in the same shape as the back panel, so that the heat of the heat sink, which is the combination of the LED board and the power board, can be cooled by convection and conduction. The handle lever nut plate that fixes the yoke and the product was fixed. [Figure 5] is the back panel design of LED lighting. The back panel part of the product is designed to fix the hinge, the battery plate, and the AC adapter plate. The back panel has multiple vents in the same shape as the side frame for cooling effect. So, the heat of the heat sink combined with the LED board and the power board can be cooled by convection. The back panel was subjected to NCT or laser processing on a 3mm aluminum plate and then black anodized in the same way as the outline frame.

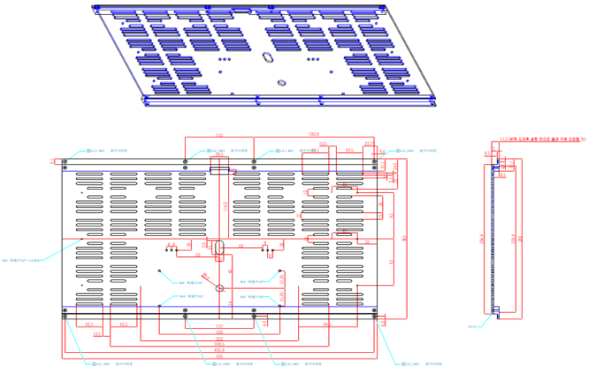

Figure 5. Back panel processing drawing

3. RESULTS AND DISCUSSION

The LED lighting barn door is essential as a device that directs the light source only to the required place when installing by fixing products such as studios to the ceiling. In outdoor shooting, this device is sometimes used. It is designed to be able to adjust the angle and install it with 4 wings. This device is installed by sliding it into the groove in the upper and lower frames of the product and pushing it to fix it. It is designed to be sturdy so that it can be easily removed by releasing the fixing part when detaching and removing it. And in order to prevent light reflection, black powder coating was applied and the surface was treated. [Figure 6] shows the finished product of Barn door.

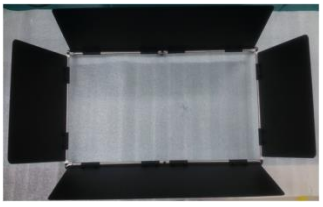

Figure 6. Barn door finished product

The control unit designs a functional part and consists of a part that controls functions, displays, and connects to the outside. It is designed to be fixed to the back panel with a hinge so that the control unit and the back panel are tilted within 90 degrees so that the row of the back panel and the row of the control unit are separated from each other. The control unit is connected with a function to adjust the amount of light, a color temperature control function, a power input socket to supply power, and an LCD display to display the product status. In addition, there is a power switch, a switch that controls the contents of the display, and a DMX control function that controls the light source by wire. The IR receiver that receives the IR remote control, the function for using the wired remote control, and the control unit are arranged to be fixed to the back panel. The case of the control unit is designed on the side in the same shape as the ventilation hole of the back panel for cooling effect, and the ventilation hole for preventing foreign matter penetration is designed on the rear side. [Figure 7] shows the finished product with the control unit design with these functions.

Figure 7. Control unit design and finished product

The battery plate part is designed to be used by attaching a plate that can mount the battery plate to the back panel as it is for mounting the battery when lighting is used from outside without an AC adapter. When using the battery, it has to be replaced every time it is consumed after charging the battery, so it is designed to facilitate battery detachment. In addition, the battery V-mount type is installed as a standard, and in the case of the gold-mount type, a converter is used or a battery plate is mounted in the gold-mount type. The output power of the battery is connected to the main body of the product through a power socket, so that the battery plate can be detached when using an AC adapter. In order to increase the cooling effect of LED lighting, the circuit configuration is to separate the LED PCB, the power supply PCB and the control PCB, and the LED PCB is directly attached to the heat sink. The LED lighting can be controlled by the amount of light, color temperature, and address, and the control method is controlled by DMX and IR remote control.

4. CONCLUSION

It was confirmed that the higher the amount of light, the more heat generated and the temperature of use of the product increased. Because the temperature of the product rises, the efficiency of the LED module decreases and the amount of light, color temperature and color rendering index decrease. This shortens the life of the product, making it difficult to secure product reliability. A heat sink was attached to the LED light source board as a heat source, and the heat dissipation was designed as a heat conduction path. It is possible to secure product reliability by applying a heat dissipation system that allows heat dissipation by convection by designing a number of via holes in the LED board and a number of radiating holes in the case. The reliability of the product was secured by the heat dissipation effect by attaching a heat sink, but there was a phenomenon that the weight became heavier when used for external movement, so the thickness of the heat dissipation plate suitable for the heat dissipation effect was confirmed. In general LED panel lights for photographic images on the market, heat generated from the LED light source board and the control board, which are heat sources, interfere with each other, resulting in a decrease in heat dissipation effect. However, in order to prevent mutual interference between the heat sources by separating the heat sources from each other, and to increase the heat dissipation effect by convection in the case of the control unit and the LED light source unit, the heat dissipation effect is improved by designing a number of heat dissipation holes, and reliability can be secured. Using heat conduction, the heat sink was directly attached to the board of the heat source, and the heat dissipation effect was confirmed by designing a via hole in the heat source board and a heat dissipation hole in the case. In addition, the heat dissipation effect was confirmed by combining the technology of separating the LED board as a heat source and the control unit. With such a heat dissipation system, it became possible to

produce highly reliable LED panel lights for photographic images. In addition, it is estimated that the LED panel light for high-power photographic images with high light intensity and high density of light sources can be produced by changing the heat sink thickness and shape of the LED board. The value of the forward current applied to each LED module during PWM control was accurately controlled, and the light and color transmittance were determined by reviewing a number of diffuser maker products. If the color rendering index is 85 or higher, there are many products that reproduce high-quality images such as TV lighting for the original color reproduction, but in this project, the color rendering index was 97 or higher at a color temperature of 3200K. Looking at the results of this project, the camera's performance was good when shooting photographic broadcast videos, but the phenomenon that the color reproducibility was poor due to lighting was greatly improved. In this project, the lifetime of LED lighting was reviewed by maintaining the current and voltage appropriately applied to the LED board and the operating temperature based on the lifetime of the LED package of the photo-video lighting LED panel light. The point at which constant output is maintained is about 30,000 hours, and the point at which it reaches the level of 75% of the output is about 50,000 hours. It has secured technology for developing high-power products of 120W or higher that, and obtained heat dissipation system technology to be applied to products with higher output.

5. ACKNOWLEDGMENT

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