Experimental analysis on heat transfer performance of LED lighting radiator

Fumin Shang[1], Chaoyue Liu[1,*],Yang Wang[2]， Kangzhe Yang[1]， and Jianhong Liu[1]

[1]Changchun Institute of Technology,School of Energy and Power Engineering，Changchun, China
[2]Changchun Cedar Electronics Technology Co., LTD, Changchun, China

Abstract: At present, LED lighting is gradually replacing the traditional lighting and becoming the fourth generation of light source. In the process of LED lighting, a large part of electric energy is converted into heat energy. If it can not dissipate heat in time, the device efficiency will be reduced or even damaged. Therefore, the heat dissipation problem of LED needs to be solved. By testing and recording the working temperature of the existing LED lighting radiator in different positions, the performance of the radiator was compared and tested. The experiment shows that the radiator works best when the light source is downward, and the temperature difference between the top and the bottom of the radiator is the smallest in this case, and the temperature at the top of the radiator is higher than that at the bottom in the working process. When the position of the LED lighting radiator changes, the heat dissipation performance of the top and bottom of the radiator changes.

1 Preface

With the development of semiconductor materials technology, large-scale light-emitting diodes are widely used in LED lighting. LED light-emitting diodes have the advantages of low energy consumption, high lighting intensity and long service life. They can be designed in different sizes. They are called new light sources in the 21st century and are gradually replacing traditional lighting. However, the energy used in the luminous efficiency of LED can only account for about 20%, and 80% of the energy is emitted as heat[1,2]. If the heat generated by high-power LED is not dissipated in time, the junction temperature of the chip will rise, the luminous efficiency of LED will be reduced, the normal use of LED will be affected, and finally the chip will be burned[3-11]. Therefore, heat dissipation is the key problem to be solved for high-power LED lighting, the heat generated will be emitted in time to ensure that the chip works in a safe temperature environment, so that led lighting can truly reflect its own advantages[12-16].

In the actual use of LED lighting, there are different lighting angles in different occasions, so the difference of heat dissipation efficiency of radiator under different angles will also affect the LED lighting. According to the existing LED lighting device, the performance of radiator under different angles is recorded and analyzed.

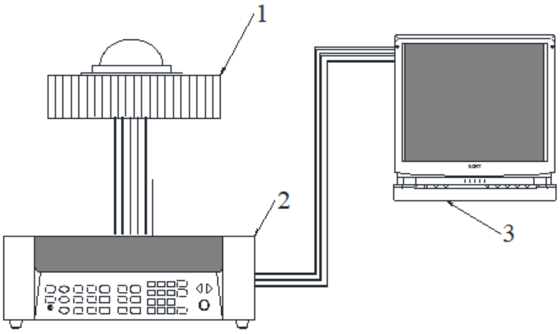
2 Experimental system and method

The experimental system consists of LED chip, radiator, Agilent 34972A data collector, computer and K thermocouple. Agilent 34972A data collector is a multi-functional data collector, and its temperature measurement accuracy is 0.4%. In this experiment, high-precision K-type thermocouple is used to measure the wall temperature information of the measuring point. The temperature measurement range is 0 ~ 1300 ℃, and the measurement error is ± 0.4 ℃.

The Agilent 34972A data collector is connected with the computer to collect the temperature of six groups of K-type thermocouples, which are 101, 103, 105, 107, 109 and 111 respectively. Among them, 101, 103, 105 and 107 are connected with the top of the radiator to measure the temperature and analyze the temperature uniformity in four directions of the top of the radiator, 109 is connected with the bottom of the radiator to measure the temperature difference between the top and the bottom of the radiator, and 111 is connected with the bottom of the radiator Measurement of room temperature is used to measure the room temperature difference at different time during the experiment and analyze the influence on the radiator. The experimental system diagram and LED lighting cooling device are shown in Fig. 1(a).The physical diagram of the experimental system is shown in Fig. 1(b).

After the LED lighting radiator is powered on, thermocouple, data collector and computer are connected, the experiment is divided into three groups, namely, the LED lighting chip is placed upward, vertically and downward, and the corresponding radiator direction is placed upward, vertically and downward. The data are recorded for comparative analysis. After each group of experiments, the power is cut off and the LED lighting device is scattered After heating to room temperature, the next experiment was carried out.

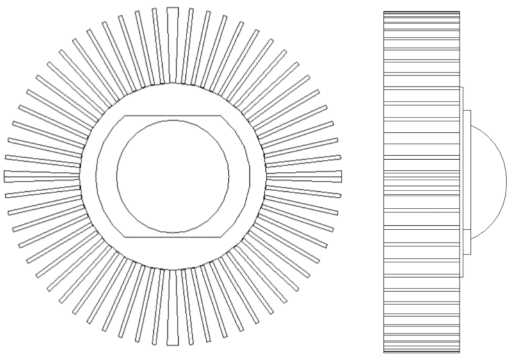
* Corresponding author: liuchaoyue1012@163.com



1 - LED lighting cooling device;2 - Agilent 34972A data collector;3 - Computer

(a) Experimental system diagram

(b) Physical diagram of experimental system



(c) LED lighting cooling device

Fig. 1. Experimental system diagram and LED lighting cooling device

To ensure the accuracy of the measurement data, the experiment is carried out according to the following steps:

(1) The reliability and accuracy of data acquisition system are tested. LED lighting radiator, K-type thermocouple, data collector and computer are connected in a sequential manner. First, the power supply of data collector and computer is connected, and whether the K-type thermocouple is normal to collect data and whether there is no error in data.

(2) Put the LED lighting and heat sink light source down, run the data acquisition system and quickly connect the LED lighting radiator. The device starts lighting and cooling, observes the data trend, and after each test point is stabilized, then record for a while, the experimental binding will be conducted under the condition of this placement position.

(3) Before the next placement position, the LED lighting heat sink is placed in the air to cool to room temperature, so as to avoid the influence of the experimental results butt connected by the previous group of experiments. Place the LED lighting heat sink vertically and repeat the above measurement.

(4) The experimental study of the LED lighting and heat sink light source up is carried out by the same experimental method. The angle change sequence during the experiment is shown in Fig. 2.

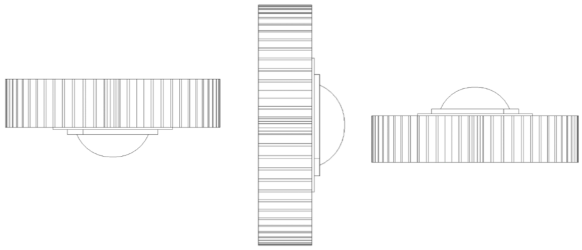


Fig. 2. Schematic diagram of the change process of the placement position of LED lighting and cooling device

3 Analysis of experimental data

After the end of the test, get the temperature data of LED lighting radiator in different positions, compare three groups of data, through comparing the measured room temperature in the process of the experiment to reduce the impact of the experimental data when the room temperature changes, analyze the data and study the performance of LED lighting radiator.

Fig. 3. shows the radiator temperature and room temperature when the light source is down. After the LED lighting radiator is powered on, the device heats up rapidly, and the temperature is stable at 2160s. The four temperature curves of the same plane of the radiator basically coincide, and the temperature uniformity is good. It can be seen that the temperature at the top of the radiator is lower than that at the bottom of the radiator. The temperature difference between the top and bottom of the radiator decreases with the decrease of room temperature.

By comparing the temperature data of three positions of LED lighting radiator, it can be concluded that when the light source of LED lighting radiator is downward, the temperature fluctuation is the largest, and the temperature curve of room temperature also fluctuates greatly. During the experiment, the maximum temperature difference of room temperature reaches 3.23 ℃, so the temperature fluctuation of LED lighting radiator is partly affected by room temperature.

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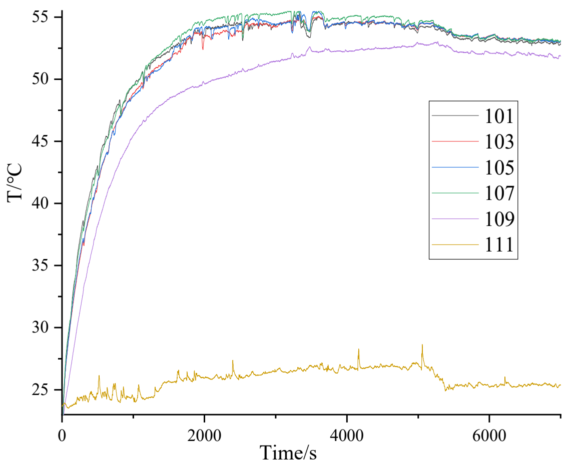


Fig. 3. Temperature of LED lighting radiator with light source downward

Fig. 4. shows the radiator temperature and room temperature when the light source is vertical. After the experiment, observe the curve generated by the experimental data, we can find that the radiator heat dissipation effect is the worst in this case. After the LED lighting radiator is connected to the power supply, the radiator temperature rises slowly, and the temperature reaches 68℃ in 3000s. At this time, the radiator temperature has no stable trend and continues to rise If the LED chip is damaged, stop the experiment. The experimental data show that when the light source is vertical, the temperature of the radiator can not reach a stable state in a certain period of time. At this time, if it continues to work, the efficiency of the LED will be affected, and even the LED lighting wick will be burned. Therefore, the light source should not be placed vertically in the actual work.

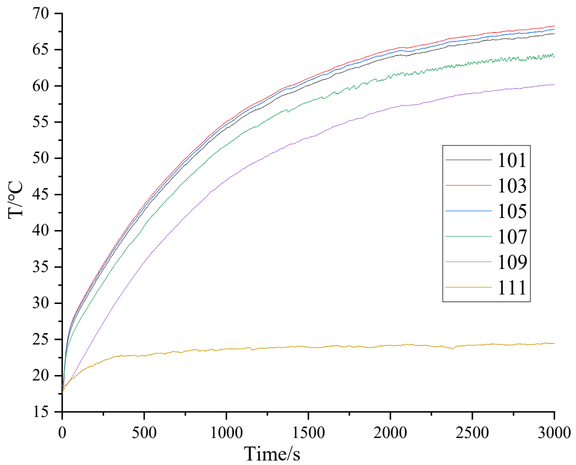
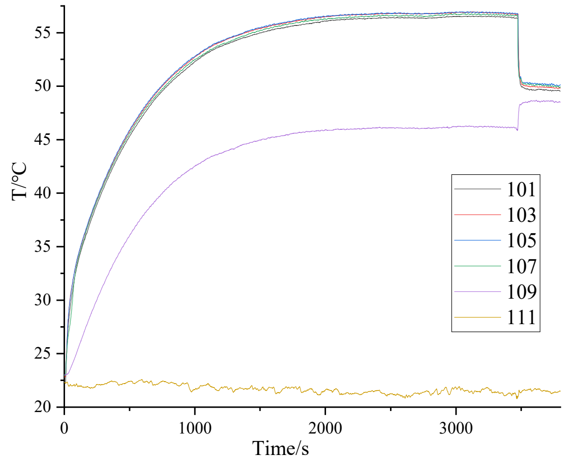
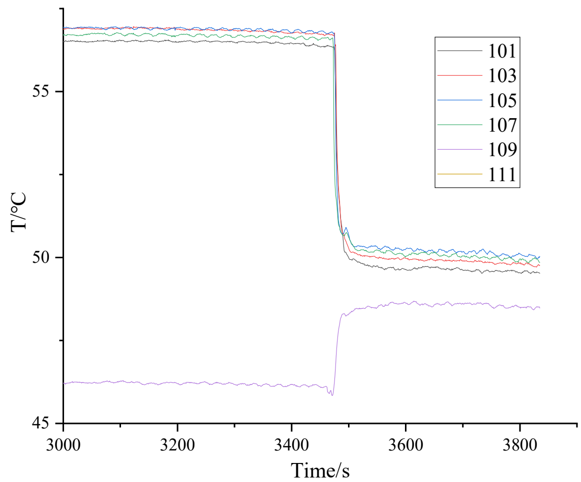


Fig. 4. Temperature of LED lighting radiator when placed vertically

Fig. 5. shows the radiator temperature and room temperature when the light source is up. In this case, the temperature difference between the top and the bottom of the radiator is the largest, reaching 10 ℃. After power on, the temperature of the radiator increases and tends to be stable quickly. The temperature basically reaches a stable state in 1960s. At this time, the temperature difference between the top and the bottom of the radiator reaches 10.73 ℃. In order to clearly compare the heat dissipation of the radiator when the light source is up and down, rotate the light source 180 ° at 3489s, and the temperature of the radiator changes rapidly after overturning, and it stabilizes again at 3498s. At this time, the temperature at the top of the radiator decreases, the temperature at the bottom of the radiator increases, and the temperature difference between the bottom and the top of the radiator decreases.



(a) Radiator temperature from the beginning to the end of the experiment



(b) Radiator temperature when working condition changes

Fig. 5. Temperature of LED lighting radiator light source placed upward

As shown in Fig. 5.(b) This is the change of temperature when the light source of LED lighting radiator is placed downward after the temperature is stable when the light source is upward. It can be seen that the temperature at the light source of LED lighting radiator decreases rapidly and gradually forms a new stability after a decrease of about 6.22℃. By comparison, it can be found that the performance of LED lighting radiator is better when the light source of LED lighting radiator is placed downward than when the light source of LED lighting radiator is placed upward.

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4 Conclusion

(1) After the LED lighting radiator starts, the device temperature rises rapidly and then gradually stabilizes. When the light source is down, the radiator has the best effect, and in this case, the temperature difference between the top and the bottom of the radiator is the smallest;

(2) The temperature at the top is higher than that at the bottom in the working process of the radiator, and the temperature difference is different with different placement methods;

(3) When the radiator angle changes, the temperature changes rapidly. When the radiator with the light source upward is rotated 180 degrees, the temperature difference between the top and bottom of the radiator decreases, and the heat dissipation effect is enhanced.

5 Future prospects

At present, the power of LED lighting appliances is increasing. For LED lighting devices, heat dissipation is an essential problem to be solved in the process of LED lighting. This paper optimizes the LED lighting radiator, further studies the influence of the radiator when other parameters change, analyzes the performance of the radiator under different working conditions, reduces the temperature of the LED wick, and makes it work in a safe, stable and efficient state[17-20].

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