The Study on the Reliability of High Power LED Streetlights

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Abstract. This paper was about a reliable research on high-power LED lighting. Based on the samples of the self-developed high-power LED streetlights, an electrical stress ageing test was carried out and thermocouple method was used in the temperature test. The ageing test showed that the initial flux reduction was mainly due to the absorption of the light lamp or the block by some parts of the lighting. And the late light decling was mainly caused by the decay of the high-power LED light source itself. Some suggestions on improving the design of streetlights will be given according to my research.

1. Introduction
In recent years, light emitting diode (LED) has begun to play a more and more important role in many applications including back lighting for cell phones, LCD displays, interior and exterior automotive lighting such as headlights, large signs and displays, signals and illumination[1]. LED will soon be used in general illumination because of its distinctive advantages including high efficiency, good reliability, long life, variable colors and low power consumption. An expectation about high power LED is that it will be the dominant lighting technology by 2025.[2] But in the actual application process, LED's performance is not as expected as shown, but the emergence of various problems. For example, System life quoted by manufacturers, commonly 100,000 hours, is often based on the average lifespan of a single LED[3]. But in actual use conditions, only a few thousand hours. Therefore, if we want the energy-saving products for the LED lights to obtain a long-term development, and ultimately to replace the traditional street lamps, the study on its reliability is essential and urgent.

The study on the reliability of LED lighting belongs to the study on systemic reliability, LED light source which restricted the reliability of the overall reliability of lamps is an important part of the system. In this paper, we mainly study the LED’s ageing characteristics through the electrical stress on LED light source so that the reliability of the LED streetlights could be known and helpful advice could be given on the design of LED streetlights.

2. Experimental Design
Based on the self-developed LED streetlight, an ageing test was carried out to study the reliability of the LED source in the application. This LED lamp (patented) was made up of many article lamps from different angles. The amount of the LED light source needed depended on the photometric
requirements of article lamps. And then the secondary distribution of light on LED was done by reflective bowl. The article lamps with a structure of groove were made from the aluminium with suppression and shape. And the LED was fixed to the article lamps by reflective bowl directly. Then, thermal grease was coated on LED heat sink evenly, thermal conductivity coefficient of $> 1.5 \text{ W/m°C}$, working temperature $-60 \ ^\circ\text{C} \sim 250 \ ^\circ\text{C}$. Upon the experimental condition available of the laboratory. The test on some article lamps was made to give a reference for studying the reliability of the LED streetlights.

![Fig.1 Independent research of LED lamp](image)

10 LED lamps, 1w with white light, from the same factory were chosen as test samples. The samples were numbered from 1 to 10. And the initial test on the 10 samples showed the quality of samples can meet the requirements of the experiment. making NO. 1-2-3-4 LED lamps in series into LED article lamps; then installing the lamps on the cooling plate; and NO.9-10 LED lamps serving as a backup device. Before the test, light-colour-electricity experiment was performed on the 1-2-3-4 LED strings and the 5-6-7-8 LED strings respectively. And the ageing test was an electrical stress test under room temperature. To ageing the two LED in-series devices with 700mA DC accessed. From the comparison of the results, we can know whether the cooling effect of the article lamps can ensure the LED light resource had a high reliable quality. The ageing test on article lamps was easy to perform and cost little. And it can truly reflect the characteristics of LED in its aging process when used. This test was meaningfully creative.

3. Results and Discussion

(1) The curve of 1-2-3-4, it is parameter comparison of the light fitting which fore and after assembled.

|                        | 1-2-3-4# (before-stalling) | 1-2-3-4# (after-stalling) |
|------------------------|----------------------------|---------------------------|
| Voltage(v)             | 14.89                      | 14.8                      |
| luminous flux(lm)      | 498.88                     | 386.88                    |
| colour temperature(K)  | 5174                       | 5048                      |
| Luminous Efficacy(lm/w)| 48.9                       | 37.3                      |

Due to table 1, the LED voltage did not change seriously fore and after assembled, but the luminous flux and luminous efficiency change clearly, before assemble, luminous flux is 498.88 lm, the after assemble, it is 386.88lm, decreased about 22.5%, and the luminous efficiency arrive to 23.72%, the main reason is the absorb of the heating panel and the reflecting shade to the LED output light.

Test system is the Three-color 8716S Digital Optical parametric test systems, including: IT6800 Series Power, CCD fiber spectrometer, 1.5m integrating sphere and test software.
(2) The aging of assembled light fitting

In the process of aging, we tested the light, colour, electricity characters of assembled light fitting and 5-6-7-8 LED. From the figure 2, 3 and 4, we analyzed the change of luminous flux, colour temperature and luminous efficiency, and obtained the result as follow:

1. Due to the LED of assembled light fitting and 5-6-7-8 are produced by the same manufacturer, and they have better uniformity after initial filter. So in the experiment, they had the uniformity performance change, it is agree well with the theoretical.

2. Toward luminous flux, assembled light fitting and 5-6-7-8 LED have the same tendency of change, and it can maintain above 80% of the initial after 7500 hours later, so these LED have higher reliability. In another side, it indicate that the heating panel and meet the needed of LED, and keep the LED work normally, and in the process of aging, it can emanate the heating of LED timely, decrease the decay of luminescence of LED.

3. During the process of aging, the colour temperature increase gradually, the change of assembled light fitting and 5-6-7-8 LED are uniformity, it is clearly that the light fitting itself and reflecting shade have less effect on the colour temperature. It is caused by the LED itself; the main reason is the decay of fluorescent powder.

4. The ability of LED invert electricity into light is luminous efficiency, due to the light absorb of the light fitting, as table 1, the luminous efficiency of it is 3/4 of the 5-6-7-8 LED, in the process of aging, it has the same result (figure 2).
From the exterior of the assembled light fitting, the main change is reflecting shade, the colour change from cream white to pale white and the shape is changed, and it shows that the reliability of reflecting shade is not good, it need amelioration.

LED chip junction and heat sink temperature is linear, the higher temperature heat sink, LED light the greater the decline[4]. Then, in the process of aging, we tested the different places of assembled light fitting using thermocouple, the result shown that, the average temperature of assembled light fitting is between 17°C and 36°C. So, this type of assembled light fitting can meet the needed of LED radiating, and can maintain the LED work stable and long-term.

4. Summary

Based on the equipments available of the laboratory, the ageing test on LED streetlights was designed. The results showed that the initial flux reduction was mainly due to the absorption of the light lamp or the block by some parts of the lighting. And the late light declining was mainly caused by the decay of the high-power LED light source itself. There was a direct relationship between the degree of the attenuation and the quality of LED products. So we should choose feasible high-power LED light resource when designing LED streetlights. Moreover, we should try to avoid existence of light blocked. And materials with high thermal conductivity should be used on the contacts of the LED light resource and the cooling plate of lighting. Because LED lighting system to add thermal coating can improve the cooling efficiency of LED systems, the higher thermal conductivity material, the better heat dissipation[5]. In addition, the design of article lamps and the use of the reflective bow should be improved. The structure should be optima led. And we should try to lessen the energy loss due to the absorption of the light lamps so that the efficiency could be improved. Furthermore, although the reflective bowl could meet the requirements of light distribution, the light lamp was less reliable. It needed for further improvements to ensure that the whole LED circuit was reliable for a long time.

To sum up, to design a good LED streetlights products, designer’s knowing the quality of LED products well and having a good knowledge on the differences between the unique nature of LED light source and the nature of traditional LED source are not enough. Furthermore, the cooperation and communication between the workers from LED manufacturing industry and lighting-made industry should be strengthened and the standards for road lighting, corresponding to the performance of LED source, should be drawn as soon as possible.

5. References

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