High-Performance LED Light Source Mixed Optical System Design

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Abstract. Due to the increased quality requirements of lighting environment, high-performance LED mixed-light lighting research has become a trend. According to the principle of imaging optics, an optical system design method with dual optical path mixing with long mixing distance is proposed. The optical path includes nine lenses, the semi-reverse half lens is placed at the aperture stop, and the double optical path corresponds to different performance LED integrated chips. The optical system has a longitudinal magnification of −1, a curvature of field of 0.5 mm, and a distortion of less than 0.2%, and achieves light mixing of a high uniformity and high color rendering LED.

Keywords: Optical design · Double light path · LED · Uniformity · Color rendering

1 Introduction

With the expansion of applications and deep people, users have further demand for LED lighting. The main points of these requirements are: high enough uniformity to meet the demand for lighting environment brightness; further improve the color rendering of lighting sources Sex to meet the needs of high color rendering occasions, as well as special occasions to achieve high uniformity illumination and high color rendering of LED lighting [1]. The LED mixed light can be divided into two colors, three colors and four colors according to the color of the light source. The calculation method of the mixed light is slightly different, but the light mixing ratio is determined according to the target color temperature, thereby obtaining the spectral power distribution of the white light, and then Calculate other colorimetric parameters. Hsun-Ching Hsu abroad proposed a new method for designing reflectors that provide high unidirectional illumination and good directionality. The strategy is based primarily on the law of reflection in geometric optics and the illuminance and luminous flux in photometry. And some basic terms, by dividing the luminous flux and assigning each of them to the calculated area, high illumination uniformity and good directivity can be obtained [2]. Huang Ruibin et al. analyzed the Fourier transform of the lens, and the spatial transmission of the near-field to the far-field, the influence on the color distribution of the light, the Fourier transform of the lens, and the spatial transmission of the near-field to the far-field, resulting in the color distribution of the light. The impact [3]. In this paper, two different monochromatic optical paths are proposed. By using a red

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LED and other different monochromatic LEDs, the half-reverse lens is mixed to extend the mixed working distance to enhance the existing LED lighting. The optical index is mainly to improve the uniformity and color rendering of the light source. It is of great significance for the research of LED lighting and the improvement of LED lighting quality. It is the hot spot of LED lighting research and the direction of green health lighting in the future.

2 Design Principle

The research goal of high-performance LED mixed-light illumination is to use high-efficiency LEDs with other different monochromatic lights to form new types of illumination through scientific mixing to achieve high-performance LEDs with high uniformity and high color rendering. Lighting [4].

The traditional light mixing method mostly uses two different monochromatic light LEDs to mix the working area. The intersection point of the two optical paths is the working area, so the working area distance is very short, resulting in uneven mixing, short working distance, etc. The optical path performance is affected, as shown in Fig. 1. The traditional mixed light mode; therefore, in order to improve the uniformity of LED light mixing, this paper improves the traditional LED's light mixing mode, as shown in Fig. 2, using two monochromatic LED light paths, with red light. Adding other different monochromatic lights, using a half-reflex lens at the aperture stop, the two optical paths are combined into one optical path.

The difference between Figs. 1 and 2 is that the two light sources in Fig. 1 are in the same plane and only have an intersection point in a certain area, so there are disadvantages such as uneven light mixing; and the two light sources in Fig. 2 are in different plane dimensions. By synthesizing a light beam by the action of the semi-reverse half lens, it acts on the plane, which increases the working distance of the light

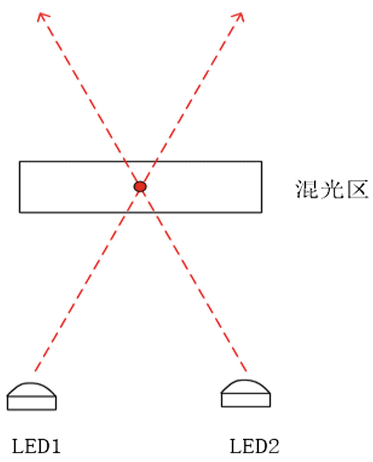

Fig. 1. Traditional LED light mixing mode

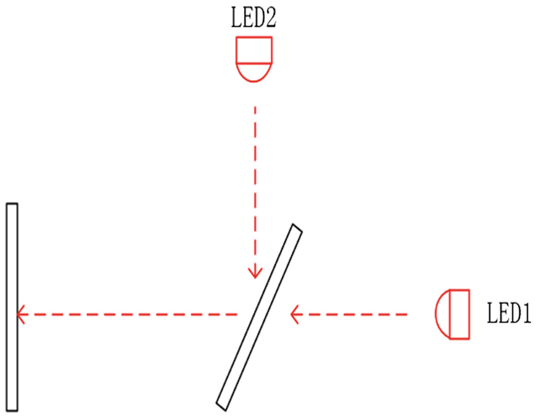

Fig. 2. Improved LED mixing mode

mixing, so that the light mixing is more uniform, thereby improving the performance of the mixed light output.

In this paper, an optical system is designed. As shown in Fig. 3, a red LED is placed at the rear lens. A half-reflex lens is placed at the aperture stop of the front focal plane of the lens of the front lens, and an LED light path is added at the top. The group of lenses has different monochromatic light LEDs, which form the basic frame of the optical system, and then the position of the half-reflex lens relative to the rear group lens is variable to balance the aberration, and the optical path lens parameters and position are adjusted, and finally the two optical paths are made. Uniform light mixing and synthesis of a light path, and greatly improve the performance of the original LED light path, embodied in uniformity and color rendering performance.

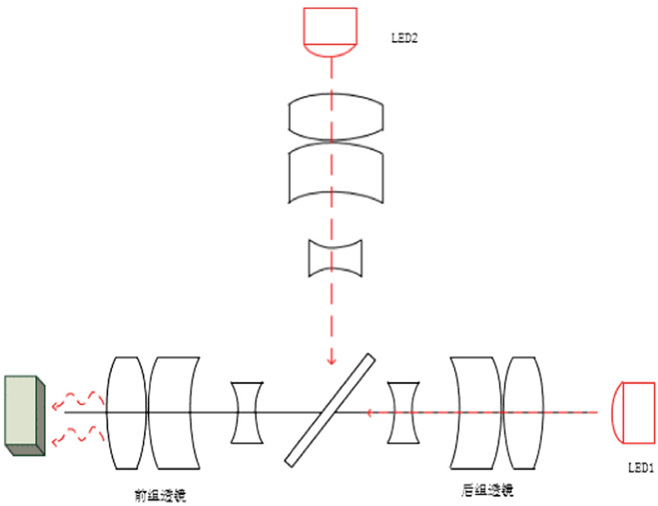

Fig. 3. LED light mixing optical system frame (Color figure online)

3 Design Goals

The uniformity of the light source is one of the important criteria for the light source. Single LED as a near-Lambert light emitting light energy output is low, and the divergence angle is large, it is difficult to directly use. In LED lighting applications, a beam with a smaller angle than the actual demand is usually designed, and then passed through a matte, microlens. Or the material is scattered and mixed [5]. In this paper, two monochromatic LED optical paths are used as the light source for mixed color light. The two optical paths are synthesized through a semi-reverse half-lens. By extending the working distance, the color light is fully mixed and output to improve the uniformity of the light source [6].

The color rendering of a light source is one of the important criteria for a light source. For high-color rendering places requiring a color rendering index Ra of 90 or more, such as printing, textile, printing and dyeing, movies, etc., we need to conduct research on high color rendering illumination on the basis of the original, and the research methods are mainly It is divided into improvements and reconstructions on the basis of the original. In this paper, by combining two different monochromatic optical paths to complement each other, Ra is improved by adding red light to improve color rendering [7].

The design of the optical system is to combine the original two different monochromatic LED optical paths, red LEDs and other different color LED optical paths, and uniformly mix the light through the semi-reverse half lens to form a complementary optical path to perform uniformity and color rendering. A holistic improvement.

4 Design Results and Analysis

Through the above theoretical analysis and parameter setting, the lens structure of the optimized 6-piece lens is selected. As shown in Fig. 4, the LED1 is placed behind the direct optical system structure, and then a semi-reverse lens is placed at the aperture stop to refract the optical path [8]. In another light path, as shown in Fig. 5, the LED 2 is placed behind the lens structure 2, and the two LED light paths are used as a light source for mixed output, and finally mixed into an optical path, as shown in Fig. 6 to obtain a high uniformity and high color rendering. Sexual high performance LED light path [9].

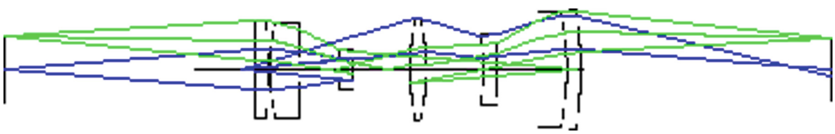

Fig. 4. Direct optical system structure

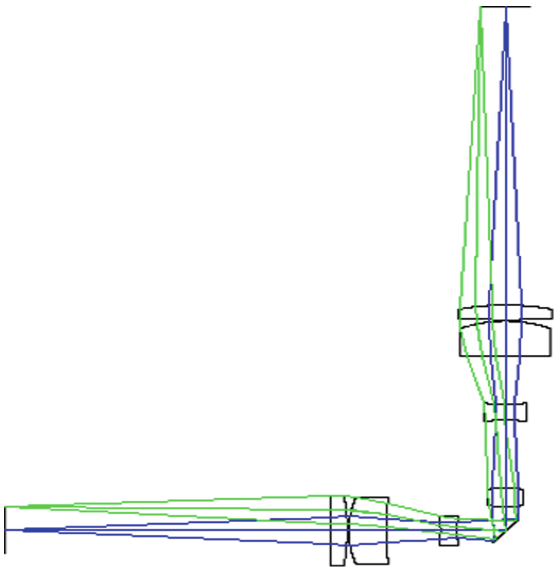

Fig. 5. Reflective optical system structure

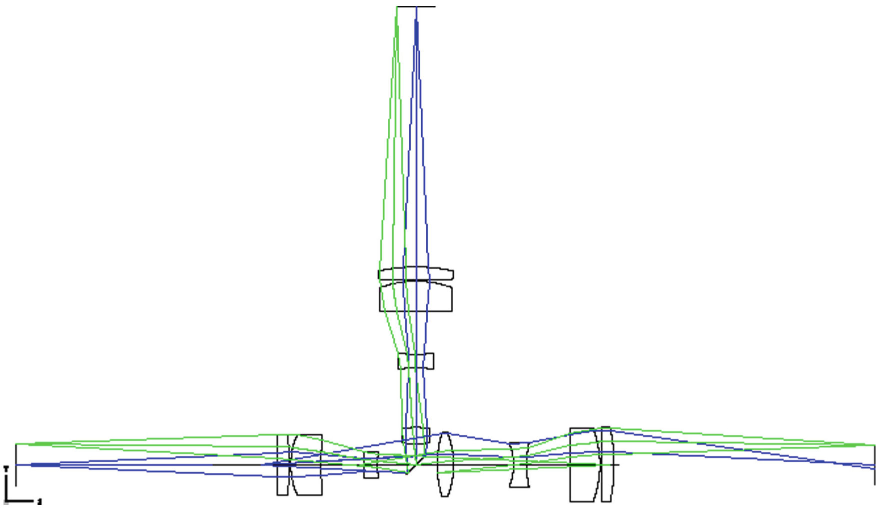

Fig. 6. Total lens structure

As shown in the figure below, after optimization, the satisfactory MTF function and small chromatic aberration can be obtained under the premise that the point map meets the requirements. The optimization result is shown in Fig. 7.

This Spot Diagrams is used to study the imaging quality of the system by achieving the convergence of the image surface light and the size of the imaged dots. As shown in the Spot Diagrams of Fig. 3, the optical system has a certain astigmatism, but no coma

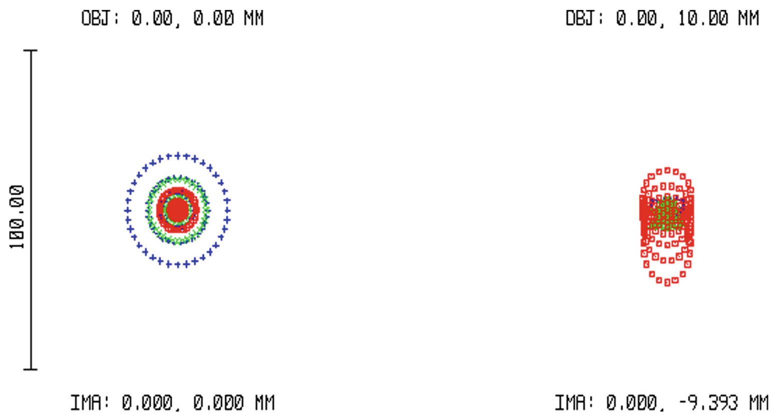

Fig. 7. Spot Diagrams

is generated. The size of the spot reaching the image plane is not perfect, but it is similar to the size of the Airy spot, and in the two fields of view. The maximum root mean square radius is 7.236 μm, which means that the design meets the requirements.

It can be seen from the MTF function curve of Fig. 8. When the cutoff frequency is below 100, the MTF value of the field of view is greater than 0.3, that is, the image reaching the image plane can be clearly seen, so the imaging quality of the lens satisfies the design requirements.

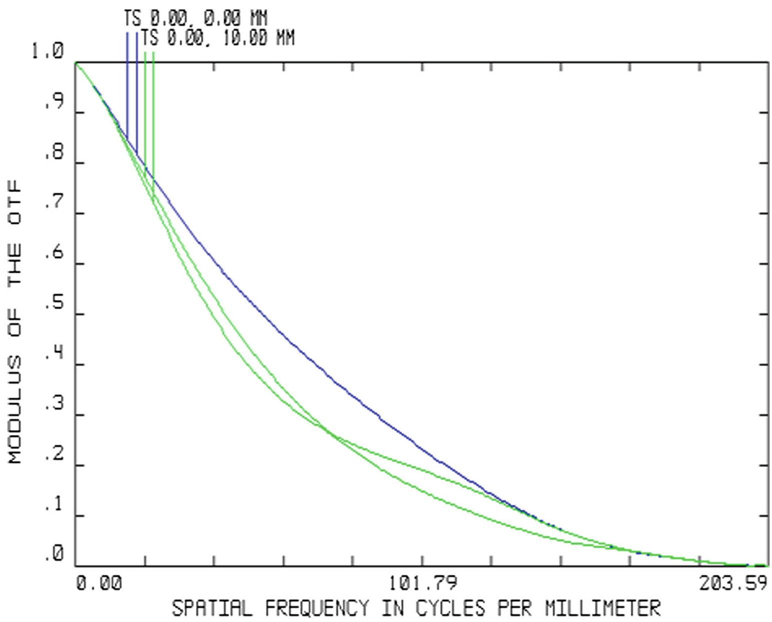

Fig. 8. MTF function

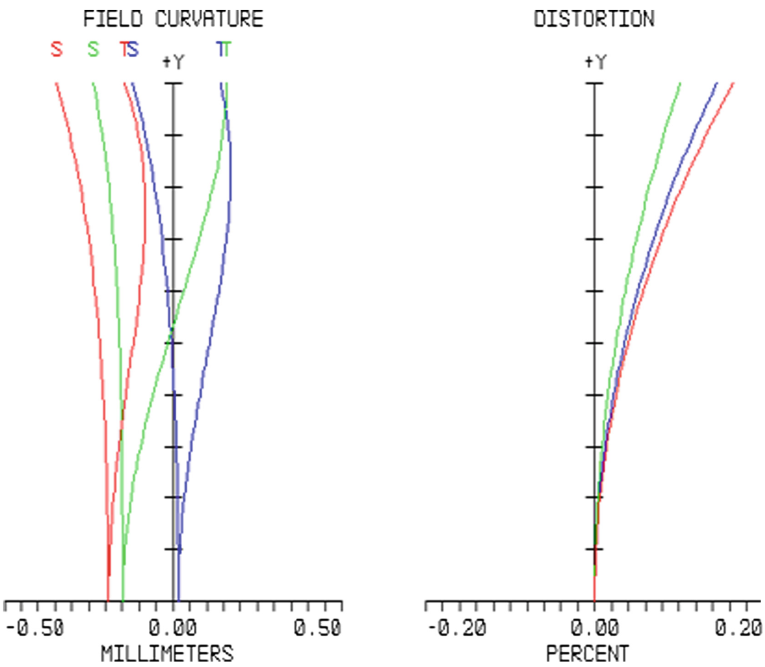

Fig. 9. Field curvature and distortion map

The field curve is an important parameter reflecting the quality of the image, which reflects the degree of surface curvature of the image [5]. As shown in Fig. 9, the field curve is in the range of 0.5 mm, which satisfies the requirements. Although the distortion does not affect the imaging quality, the distortion size affects the accuracy of the imaging, and the distortion of the system is corrected to about 0.2% by design requirements, which meets the design requirements.

5 Conclusion

In order to improve the uniformity and color rendering of the optical system, the design uses two different monochromatic LEDs as the light source to lengthen the working distance and synthesize the complementary output light source through the semi-reverse half lens to improve the uniformity of the system imaging. And color rendering, research and design of high-performance LED light source hybrid optical system.

The optical system design uses Zemax as the main design tool to design two optical path structures, one basic 6-piece lens optical structure, and the other optical structure is to add a half at a 45-degree angle to the aperture stop of the original basic optical structure. The anti-half lens makes the optical path of the rear group lens refract at 90 degrees, and then combines the two optical paths into one optical system by using multiple structures, and adds two light sources of LED1 and LED2 respectively after the two optical systems, and the two optical paths are fully synthesized and complemented. The output of the light source is improved in uniformity and color rendering. Finally, the optical quality of the optical system is analyzed by simulating the optical system. The designed optical system has a certain astigmatism, but no coma is generated. The MTF meets certain imaging standards and field curvature. The optical system with distortion control within 0.5 mm and 0.2% improves the traditional mixed light illumination mode and greatly improves the light source performance such as the uniformity of the light source.

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