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Research on the Application of Green Lighting Technology in Sports Lighting

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Abstract

With China's continued development of society and economy, the importance of ecological environmental protection is growing. This protection has become an indispensable part of social development. The use of various green environmental protection equipment can effectively promote ecological environmental protection and reduce the adverse effects of human activities on the environment. In the field of sports lighting equipment in China, traditional lighting methods constitute an inherent danger to the environment, leading to a waste of valuable resources and environmental pollution. This study involves a multi-tile-multifunctional-function controller, which effectively solves the control problem of the control light. In the sports lighting group, the high and low-level lighting of the sports lighting group, and adjust the light from the height highly effectively to adjust each height. The low-shot mode reduces the power consumption of the system by about 33% to 60%, which significantly helps energy saving. By optimizing the performance of the lighting system, promoting the preservation of power resources, reducing the adverse effects of pollution caused by equipment utilization and energy waste, and promoting the harmonious cohabitation of human and natural environment.

Keywords

Parameters of Metal, Z-Shaped Single-Ended Light Source, Green Lighting Practices, Sports Lighting System, Lamp Model

1. Introduction

In the context of China's rapid economic development, the environmental pressure and the contradiction between resource supply and demand have been in-

creasing. The construction of a conservation-oriented society is an essential approach to alleviate this contradiction. Green lighting, which reduces energy consumption and environmental pressure, aligns with the objective of building a conservation-oriented society in China. This research aims to enhance the lighting efficiency of sports lighting systems and promote power resource conservation through the use of green lighting. It not only meets the development needs of China but also provides an effective way to promote the harmonious coexistence of humans and nature.

2. Selection of Lighting Source in Sports Lighting System

2.1. Selection of Lighting Source Model in Sports Lighting System

In the realm of conventional sports lighting, the utilization of lighting equipment is commonly centered around high-pressure sodium lamps, metal halide lamps, and HMI lamps. These lamps, known for their high intensity gas discharge capabilities, are frequently employed. Additionally, incandescent lamps, specifically tungsten halogen effectiveness, lamps are commonly integrated into sports lighting systems. Due to the wide utilization of varied lighting light sources in the realm of illumination and their inherent lighting attributes, these light sources find extensive application in diverse sports lighting scenarios. For instance, halogen tungsten lamps are frequently employed for emergency lighting and spectator illumination within sports lighting systems, whereas HMI or metal halide lamps are commonly utilized for venue lighting. The distinct applications primarily stem from the fact that different light sources possess distinct lighting characteristics. For example, the lighting efficiency of halogen tungsten lamps remains consistent, making them a reliable choice. They are also easy to install during the construction process, and their compact size allows for versatile application. In the market, common halogen tungsten lamps have a lighting power range of 150 W to 1500 W. To achieve optimal lighting effects, higher power light sources, such as 1500 W or 1000 W, are commonly utilized in sports lighting systems that employ halogen tungsten lamps, taking into account cost-effectiveness. The halide lamp possesses a broad range of power, typically ranging from 400 W to 2000 W (as depicted in **Figure 1**). For sports lighting systems, lower wattage light sources like 400 W are commonly employed, primarily for indoor or audience lighting below 7 m. In the context of illuminating indoor stadium venues, higher wattage options such as 1500 W or 1000 W golden halogen lamps are utilized to guarantee optimal lighting effects within the facility [1]. In the development of conventional sports lighting infrastructure, the 1500 W metal halide lamp exhibits commendable whereas the 1000 W metal halide lamp is the prevailing choice. However, in instances where the indoor stadium's height exceeds certain limits, the 1000 W metal halide lamp may not suffice to meet the desired lighting standards. Consequently, the implementation of the 1500 W metal halide lamp is commonly employed in such scenarios. When it comes to outdoor sports lighting, it is insufficient to rely on metal halide lamps

Figure 1. Parameters of metal halide lamp.

below the 1500 W threshold to meet the requirements of a sports lighting system. Therefore, it is imperative to employ lighting equipment with a power rating exceeding 1800 W for sports lighting purposes.

The HIM lamp, a type of high intensity gas discharge lamp, is extensively employed in the sports lighting system of China. Presently, the minimum power range for HIM lights in China starts from 125 W and extends up to 18,000 W. The temporary sports lighting typically operates at a power of 6000 W, enabling it to achieve a commendable color display index of 90, a color temperature of 5600 K, and an impressive luminous flux of 570,000 lumens. The HIM lamp structure bears resemblance to the aforementioned lamps, and its exceptional color rendering qualities make it highly suitable for sports lighting applications. The common 6000 W power for temporary sports lighting can achieve 90 color display index, 5600 K color temperature and 570,000 lumens. The HIM lamp structure is similar to the two lamps mentioned above, and its good color rendering makes it very suitable for sports lighting. Despite the evident competitive advantages of the HIM lamp, its application effectiveness will be significantly diminished due to the limited lifespan of its high-power lamp light source compared to other sources of light [2].

2.2. Selection of Light Source Parameters in Sports Lighting System

In the conventional illumination system for sports activities, the metal halide light source is commonly employed with color rendering indices of 65 and 90, alongside corresponding color temperatures of 3700 K and 5600 K, respectively (as depicted in **Table 1**). Metal halide lamps with a color rendering index of 90 are extensively employed in the realm of high-definition TV broadcasting. These lamps find frequent usage in the transmission of large-scale international events, including the world cup and the Olympic Games. The employment of the 65 color rendering index light source in worldwide color TV broadcasting is an established practice. The utilization regulations for metal halide lamps diverge across various geographical regions, and these regulations are particularly diverse when it comes to the specific standards for sports lighting. The parameters of the light source play a crucial role in determining the luminous flux. The luminous flux is influenced by the color temperature and color rendering index of

Table 1. Parameters of metal halide lamp.

No.	Power	Color Rendering	Color Temperature	Luminous Flux (Lumens)
1	1000 W	65	4000 K	105,000
2	1000 W	90	5600 K	90,000
3	1500 W	65	4000 K	155,000
4	1500 W	90	5600 K	128,000
5	1800 W	80	4200 K	170,000
6	1800 W	90	5600 K	155,000
7	2000 W	65	4000 K	200,000
8	2000 W	90	5600 K	180,000

the light source itself. When using a metal halide lamp as the light source, it has been observed that the lighting effect is more pronounced in lamps with lower color rendering index compared to those with higher color rendering index. The lighting efficiency varies under identical power conditions. Opting for a light source with enhanced lighting efficiency enables us to achieve significant energy conservation and guarantee the implementation of eco-friendly lighting technology.

The table reveals notable variations in the luminous flux as a result of alterations in both color rendering and color temperature index. Using a power capacity of 1500 W as an illustrative example, it can be observed that the luminous intensity of the metal halide light source with a color rendering index of 65 amounts to 155,000 lumens. Conversely, the metal halide light source with a color rendering index of 90 only emits 128,000 lumens. Consequently, the former yields a luminous output approximately 12% greater than the latter. Hence, when considering equivalent conditions of uniform illuminance and illuminance level, the latter option has the potential to achieve an energy savings of approximately 12%.

The recent lighting standard implemented by FIFA has brought about significant changes in several parameters of light sources. Notably, the color rendering index and color temperature of the light source have been notably reduced, (as illustrated in Table 2). By employing the conventional modulation of color temperature and color rendering index, FIFA has implemented a more energy-efficient approach to selecting light source parameters. This has played a significant role in embracing green lighting practices and fostering the advancement of eco-friendly technology in the realm of sports lighting.

2.3. Performance Comparison of Different Lamp Halogen Lamp in Green Lighting Technology

In terms of lighting efficacy and performance, distinctions can be observed between single-ended metal halide lamps and double-ended metal halide lamps.

Table 2. Examples of FIFA standards for TV broadcasting.

FIFA Standards for Television Broadcasts	Competition classification	Camera type	Vertical illuminance			Horizontal illuminance			Light source color temperature	Light source color rendering index
			Ev. ave	Illumination uniformity		Eh. ave	Illumination uniformity			
			lx	U1	U2	lx	U1	U2	Tk	Ra
Standard in 2007	Class V	Fixed camera	2400	0.5	0.7	3500	0.6	0.8	>4000 K	≥65
		Site camera	1800	0.4	0.65					
	Class IV	Fixed camera	2000	0.5	0.65	2500	0.6	0.8	>4000 K	≥65
		Site camera	1400	0.35	0.6					
Standard in 2002	Class V	Fixed camera	1800	0.5	0.7	1500 - 3000	0.6	0.8	>5600 K	≥80
		Site camera	1400	0.5	0.7					
	Class IV	Fixed camera	1000	0.3	0.5	1000 - 2000	0.6	0.8	>4000 K	≥80

The single-ended metal halide lamp possesses structural attributes that are noteworthy. Firstly, its reflector design is intricate, allowing for a sophisticated manipulation of light. Additionally, the lamp demonstrates a high light utilization rate, ensuring efficient use of emitted light. Moreover, it offers a greater degree of control over light distribution, providing a multitude of options in this regard. Lastly, the lamp maintains consistent ignition within a range of ±15˚ from the horizontal direction, further enhancing its reliability. The double-ended metal halide lamp exhibits several noteworthy characteristics. These include a slight disparity in color, a significant impact from strong lighting, and the ease of managing color variation. Additionally, this lamp design is more streamlined, leading to improved lighting efficiency. The beam can be efficiently regulated, resulting in reduced overflow of light. Moreover, the ignition position remains within a horizontal range of ±5˚. The performance of this lamp remains stable over time. However, it is worth noting that controlling color variation is more challenging for this type of lamp. Furthermore, the double-ended gold halogen lamps possess a higher inclination coefficient compared to single-ended metal halide lamps. Metal halide lamps perform optimally when ignited in the vertical direction due to the continuous migration of chemical substances outside the arc column. This migration results in a reduction in the lamp's light output. Placing the arc tube in a horizontal position results in a decrease of approximately 5% in the light output. It is noteworthy to mention that a tilt coefficient of 0.95 is employed in such instances, thus emphasizing the significance of light source products and lamps [3]. The examination of single-ended and double-ended metal halide lamps illuminates the importance of carefully selecting the appropriate light source and lamps for sports lighting systems based on the specific site and practical application requirements. This strategic approach ensures enhanced energy efficiency and overall performance of the sports lighting system.

2.4. Improvement of Light Source Design Technology in the Field of Sports Lighting

China has conducted extensive research on lighting products that are both highly efficient and of superior quality. As a result, they have developed a Z-shaped single-ended light source by leveraging the benefits of two metal halide lamps, as depicted in Figure 2. This Z-shaped single-end light source demonstrates enhanced lighting capabilities and energy-saving effects, making it suitable for a wider range of sports lighting scenarios. The implementation of a z-shaped single-end light source demonstrates a noteworthy reduction in light leakage, resulting in a decrease of approximately 50% without the need for an external glare controller. By incorporating an lV-8 external glare controller, the overflow of light can be further diminished by an impressive range of 90% to 95%. Advancements in light source design technology have played a crucial role in the advancement of sports lighting. This progress has led to increased lighting efficiency and reduced energy consumption, thereby fostering the development of environmentally-friendly and energy-saving lighting technology. Consequently, this has significantly contributed to the sustainable development of China.

3. Application of Green Lighting Technology in the Field of Sports Lighting

3.1. Multi-Watt Multi-Function Controller

In the conventional method of illuminating sports facilities, the lighting lamps are controlled using a time grouping control mode. This control mode enables precise regulation of each individual group of lamps. The utilization of a grouping control method is highly justified in stadiums due to their extensive size, demanding lighting requirements, and the extensive use of multiple lamps and lanterns. In the context of school sports lighting, the application is often constrained by site limitations. Consequently, a limited number of lighting lamps are utilized, resulting in significant distances between each group of lamps. The lamps that require activation are switched on, while the lamps that do not necessitate operation are switched off. This particular mode of lamp control is commonly employed in numerous expansive stadiums, there by significantly

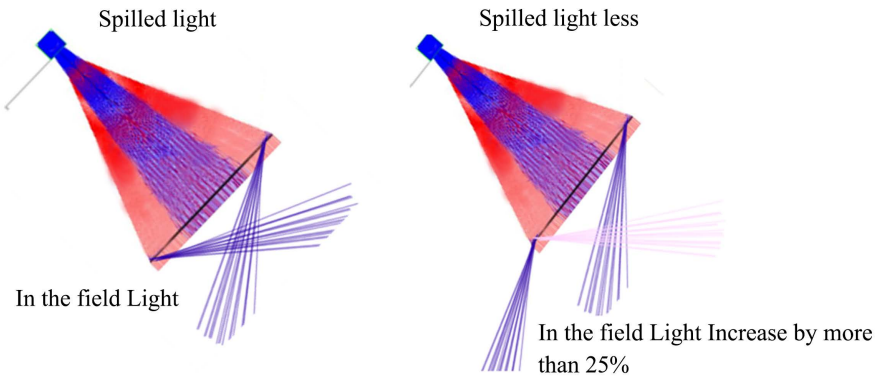

Figure 2. Z-shaped single-ended light source.

enhancing the energy-conserving efficacy of the sports lighting system. However, the use of group control in this scenario proves inadequate to satisfy the lighting requirements of the entire stadium or area. As a consequence, the overall lighting effect is compromised.

The current state of school sports lighting necessitates the development of a multi watt multifunctional controller, which effectively addresses the issue of grouping control of lamps. The multifunction controller with multiple wattage capacity enables the toggling of high and low levels of illuminance within the sports lighting group. By adjusting the illuminance at various heights, it effectively regulates the light emitted by the lamps with precision. The low illuminance mode significantly contributes to energy conservation by reducing the power consumption of the system by approximately 33% to 60%. Furthermore, this mode also plays a crucial role in minimizing the impact on the surrounding environment by reducing the overflow light by approximately 20% to 50%, as demonstrated in Table 3. Instant switching of the lamp upon activation enables immediate energy conservation within the lighting system, thereby facilitating the advancement of eco-friendly lighting practices.

3.2. Future Prospect of Green Lighting Technology

First and foremost, within the realm of green lighting technology pertaining to sports lighting, there is a focus on the selection of light sources, parameters, and the installation of lamps and lanterns. The goal is to enhance and advance the technology while ensuring that the lighting effect of the sports lighting system is not compromised. This approach effectively reduces the overall operating cost of the lighting system, while also promoting energy efficiency. The concept of green lighting technology has played a pivotal role in the advancement of China's social and economic development [4]. Additionally, it has been introduced as a response to the environmentally unfriendly and economically inefficient design methods and prevalent application modes in China's early implementation of sports lighting. The adoption of traditional, unscientific design concepts has resulted in a growing number of challenges during the sports lighting design process in China. In the context of China's modernization, it is imperative for sports lighting design to adhere rigorously to the fundamental principles of ecological civilization construction [5]. Consequently, the conventional model of sports lighting design is no longer appropriate for the requirements of China's

Table 3. Multi-Watt multi-function controller switching mode.

Lamp model	Illumination level	Illumination output (lux)	Power consumption (KW)	Energy saving
1500 W lamps	1500 W/1000 W	50%	67%	33%
	1500 W/600 W	20%	40%	60%
1000 W lamps	1000 W/667 W	50%	67%	33%
	1000 W/400 W	20%	40%	60%

present development. The progress of our society should be founded on ecological environmental preservation, the advancement of energy conservation, and the integration of green lighting technology throughout all aspects of sports lighting design.

4. Conclusion

The utilization of green lighting technology aligns with China's contemporary development strategy and sustainable development strategy. By judiciously implementing this technology, it can significantly diminish the energy consumption associated with sports lighting applications while simultaneously decreasing transportation expenses. The prudent utilization of green lighting technology contributes to advancing the collective advancement of energy preservation and socio-economic growth within the course of Chinese societal development. It fosters the sound development of the energy utilization landscape, diminishes the adverse repercussions of energy squandering on social progress, and fosters the harmonious cohabitation of humankind and the natural environment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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