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The Application of Intelligent Lighting in Thermal Power Plants

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Abstract: With the rapid development of electronic information technology, the Internet of Things (IoT), Internet technology, and modern communication technology, people are demanding higher standards for the building environment. Especially in modern large-scale buildings with high levels of industrialization, lighting systems should also be optimized accordingly. This article explores the application path of intelligent lighting in thermal power plants for reference.

Keywords: Intelligent lighting; Thermal power plants; Application path

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1. Introduction

The intelligent lighting system mainly combines lighting control with various technologies which are computer networks, network communication, power electronics, sensors, and automation. This also includes control of lighting fixtures such as switching, dimming, and timing through network signal transmission. Its main function is to automatically adjust the brightness of the lighting fixtures or turn them off according to necessity. It can also automatically adjust and control the lighting fixtures according to different seasons and weather conditions to conserve energy, reduce emissions, and lower maintenance costs. It also has network communication and information management functions.

2. Control requirements for intelligent lighting systems

Firstly, the intelligent lighting control system can achieve real-time control of on-site lighting, including illumination, lighting time, brightness adjustment, etc., which can be automatically adjusted as needed. Secondly, the system allows lighting to be adjusted according to on-site conditions, times, and locations, achieving energy-saving and environmental protection. Thirdly, remote monitoring and management of lighting can be achieved through network communication technology, facilitating office automation. Finally, the system uses the international standard transmission control protocol/internet protocol (TCP/IP) for easy integration into the automation control system, aiding in system configuration and maintenance.

3. The advantages of intelligent lighting systems

3.1. Intelligent control is simple and convenient

Traditional lighting systems require manual intervention, leading to issues such as labor waste, complex control circuits, and low lighting quality. With the continuous progress and development of science and technology, intelligent technology has impacted people's lives. Intelligent lighting systems offer a certain degree of flexibility and convenience in design and installation. Generally, intelligent lighting systems are divided into three parts: information collection, information transmission, and information processing. These systems can achieve intelligent control and energy conservation by monitoring and adjusting different environments. Additionally, the intelligent lighting system can also independently control the lighting. For example, it can centralize the control of the lighting in a room or area, achieving both separate and centralized control. This is a function that traditional lighting systems cannot achieve.

3.2. Protection of lighting fixtures, extended lifespan, and cost reduction

Intelligent lighting systems can protect lighting fixtures at different stages of use, extend their lifespan, and reduce maintenance costs. During normal operation, the system can automatically turn on the lighting fixtures according to the set program. In abnormal situations, the system can automatically cut off the power supply to avoid overheating and damage. When an abnormality is detected, the system can automatically turn off or on the lighting fixture based on certain logic. Additionally, the intelligent lighting system has a remote diagnosis function, allowing for remote diagnosis and maintenance. For example, in a factory where the lighting system frequently malfunctions, leading to reduced production efficiency or safety accidents, this diagnostic function can quickly and effectively solve problems, improving both production efficiency and product quality.

3.3. Energy-saving and environmentally friendly

Energy conservation is an important indicator of lighting control systems. To achieve energy efficiency, multiple methods must be used, such as using dimmable and non-dimmable lighting fixtures. Dimmable lighting allows for controlling the brightness by making adjustments, while non-dimmable lighting changes the brightness by altering the on/off time of the light source or fixture. For example, a dimmable system can automatically adjust the brightness of lights based on environmental factors to save energy, whereas a non-dimmable system can only change the brightness by adjusting the switch time. Multiple lighting functions can be achieved by using different types of dimmers. Both dimmable and non-dimmable systems can be automatically adjusted according to environmental factors. The lighting control system can also use digital logic and analog signals for control to improve lighting quality and save electricity.

4. The main modes of intelligent lighting systems

4.1. Working mode

The working mode refers to the operation when the system is started. The system will first switch all the lights it controls in the order of the scene. When the system switches to the working scene, it will adjust all the lights involved in that scene accordingly. Similarly, when the system switches to accident lighting, it will adjust all the lights involved in that scene in the same order. When the system is in work mode and outdoor lighting is good (similar to indoor lighting), the intelligent lighting system will automatically adjust the brightness of the lights to meet the needs of the workers.

4.2. Adjust the illuminance according to different times and locations

Work mode refers to the operation of the intelligent lighting system during the day. The system will be fully turned on to maintain maximum illumination brightness in the lighting area. When the system detects someone entering or moving, it automatically adjusts the brightness of the lights to meet the requirements of the scene. In this mode, the entire illuminated area is at maximum brightness.

To ensure uniform illumination, it is generally necessary to divide the lamps into several groups. The illumination of each group can be controlled separately through a panel. Additionally, the illuminance of each group can be merged into one group and controlled with a single switch.

In daytime mode, indoor lighting will be adjusted from low light to a darker state. For frequently used areas such as stairwells, corridors, etc., high-brightness lighting is recommended to improve work efficiency. For larger indoor spaces such as offices and meeting rooms, medium or low-brightness lighting is recommended. Attention should be paid to the human body sensing system to ensure personnel safety. When all indoor lighting fixtures are turned off in night mode, significant energy savings can be achieved. Considering the short rest time of night workers, a small period (such as 7:00 pm–8:00 pm) should be set as a working period in night mode to ensure that the lighting area provides workers with a comfortable working environment to the maximum extent at night.

4.3. Accident lighting mode

The function of accident lighting is to provide timely warnings during emergencies such as fires, ensuring swift measures are taken. In environments like thermal power plants where electrical failures leading to power outages are common, restoring power promptly is essential to minimize disruptions to work and ensure safety. Therefore, it is necessary to immediately activate accident lighting when an accident occurs.

The accident lighting control system mainly consists of an automatic fire alarm system, fire detectors, emergency lighting controllers, etc. Upon detecting a fire, the fire detector activates audible and visual alarm signals and relays this information to the fire control room. Simultaneously, the automatic fire alarm system signals the emergency lighting controller to activate on-site emergency lighting fixtures. The controller manages the operation of these fixtures based on real-time conditions.

Emergency lighting activation relies on synchronized alarm and control signals. When a fire is detected, the fire detector triggers audible and visual alarms and communicates with the fire control room. It also sends signals to the emergency lighting controller, prompting it to illuminate emergency lighting fixtures on site. Control of the emergency lighting controller can be managed from the fire control room via keyboard or mouse, facilitating swift response to on-site issues and restoration of the power supply.

5. The main functions of intelligent lighting systems

5.1. Controlling lighting areas

Tailor electricity usage to regional specifics to achieve energy-saving goals and accomplish the following functions:

(1) Automatically adjust the lighting based on electricity usage to avoid unnecessary energy waste.

(2) Adjust lighting brightness according to the different requirements of each area at any time, ensuring the working environment and improving the lighting quality.

(3) Controlling the lights in specific areas to turn off at any time during emergencies, ensuring safety and energy conservation.

5.2. Illumination adjustments across different times and locations

The intelligent lighting system can regulate the lighting fixtures through computer control devices, and adjust its illumination according to different times and locations. Illumination adjustment mainly includes two aspects:

(1) During the day and night, the illumination can be adjusted according to different times and locations.

(2) At night, the illumination can be automatically adjusted based on the human body sensing.

5.3. Network communication and information management functions

The intelligent lighting control system adopts TCP/IP network protocol and can communicate and exchange information with an on-site programmable logic controller (PLC) and other automation systems. This network communication method can meet the information communication needs between different control units and higher-level monitoring computers. The network communication interface and management platform facilitate centralized control and remote monitoring of lighting areas.

5.4. Remote monitoring function

The intelligent lighting control system features remote monitoring and can manage lighting fixtures via computers. In addition, the system can be monitored for operational status and fault diagnosis through intelligent lighting controllers and various sensors. This provides real-time monitoring of the entire system. For example, you can switch to manual operation mode as needed at any time during emergencies.

5.5. Multiple modes and timed switch functions

According to the requirements of different regions and times, different intelligent lighting control methods can be set. For example, during the day, the lights in various areas can be turned off whereas at night, the lights are turned on based on the human body sensing. Under normal conditions, the lights in each area can be turned off as needed at any time. Additionally, the timed switch function can also be used to adjust the lighting switch time in various areas.

5.6. Strong anti-interference ability

When installing intelligent lighting controllers or sensors of different types, brands, quality levels, and price ranges in different areas, their anti-interference ability will vary significantly. For example, ballast isolation technology is suitable for dense installation positions of lighting fixtures while photoelectric isolation technology is more suitable for sparse installations. High voltage discharge technology applies to dense installations whereas surge absorption technology is effective for sparse installations. This enhances the anti-interference ability of intelligent lighting systems against various signals, including surges, electromagnetic interference, and signals from other sources.

6. Application of intelligent lighting systems in thermal power plants

6.1. Central control room

The central control room is the core area for the production and operation of thermal power plants and requires continuous on-duty management. It consists of three areas: the duty room, distribution room, and duty area. The duty room is located at the top of the central control room. The lighting supports the daily office tasks for duty personnel, as well as their safety readiness for emergencies. The distribution room is located below the duty room. The lighting in this area ensures equipment operates smoothly. The duty area is located below the distribution room. The lighting caters to the daily life of the duty personnel. Due to the large space in the control

room, the lighting system must be designed to meet specific needs. Intelligent lighting controllers installed in areas such as entrances and exits, stairwells, passages, and corridors ensure unified control over all light sources and fixtures throughout the control room, facilitating centralized management of the entire lighting system.

6.2. Using high-efficiency and long-life electric light sources

To meet the current requirements of energy conservation and emission reduction, the power industry continues to promote efficient and energy-saving electric light sources. Due to its characteristics, it is necessary to consider meeting the lifespan requirements of electric light sources during the design and construction stages. Generally, electric light sources with a lifespan exceeding 10,000 hours are required. From an energy conservation perspective, high-efficiency options like incandescent lamps, halogen tungsten lamps, etc. are the preferred choice. However, advancements in materials, technologies, and processes are driving the adoption of high-efficiency, long-life electro-optical sources, gradually replacing traditional lighting sources. Commonly used electric light sources in large industrial plants include high-pressure sodium lamps, metal halide lamps (mercury-containing or mercury-free), and gas discharge light sources (e.g., high-pressure mercury lamps, metal halide lamps). When selecting these sources, performance and applicability should be comprehensively considered to ensure lighting quality while minimizing electrical energy consumption. Furthermore, optimizing lighting fixture design, such as using multi-cavity absorptive light emitting diode (LED) fixtures can enhance light efficiency, reduce electricity consumption, and achieve superior lighting effects.

6.3. Optimal wiring practices

In electrical design, reasonable wiring is the key to ensuring the stable and reliable operation of intelligent lighting systems. Reasonable wiring should consider the following points:

(1) Circuit configuration: According to control requirements, determine the number of circuits and length of each line. Utilize centralized or decentralized power supply in the same lighting control circuit. In different lighting control circuits, centralized and decentralized power supply should be used separately.

(2) Distribution level: Determine the distribution level of the lighting circuit based on the type and capacity of the electrical equipment used. For single-phase, three-phase, and low-voltage distribution lines, the wiring should be carried out according to the “three-phase five-wire system” principle, and a dedicated distribution box or neutral grounding device should be installed inside the cabinet.

(3) Fixture selection: In low-voltage distribution systems, suitable lighting fixtures should be selected. Currently, there are various lighting fixtures available for selection in the market, such as energy-saving lamps, LED lamps, metal halide lamps, etc. Improper selection will lead to significant waste and increase electricity costs. Therefore, select lighting fixtures based on site-specific conditions. Consider replacing traditional lighting fixtures with new products such as energy-saving lamps, LED lamps, and metal halide lamps to improve lighting efficiency.

6.4. Adopting effective lighting control methods

There are mainly two types of intelligent lighting control methods: manual and automatic. Currently, most lighting systems in thermal power plants in China still use manual control methods with gradual automation enhancements being implemented. Specifically, light or motion sensors are strategically installed in each circuit to meet site-specific needs. When someone or a vehicle enters, the relevant lighting circuits will be automatically activated. Conversely, when no movement is detected, the lighting circuit will be automatically turned off. This approach can effectively manage energy consumption and reduce labor during maintenance and repair periods, especially at night. However, this approach has its limitations. It may prove inadequate

in scenarios requiring frequent circuit activation for personnel inspections or maintenance. Additionally, adjustments are necessary when on-site illumination falls short of requirements.

7. Epilogue

The intelligent lighting control system has a good control effect, which not only makes good use of traditional lighting but also saves energy. It is a new energy-saving product for thermal power plants, and the system can automatically adjust the light source according to the on-site conditions. The application of an intelligent lighting control system in thermal power plants can also effectively reduce operating costs. The system has good flexibility and scalability, capable of ongoing refinement and enhancement in tandem with the development of thermal power plants. This aligns with the future trend of our intelligent lighting control system.

Disclosure statement

The authors declare no conflict of interest.

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