Fiber optic light guide device based on photoelectric tracking

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Abstract. In the field of indoor lighting, the sunlight introduction device has a good development prospect. On the one hand, using solar energy directly as an indoor light source eliminates the loss caused by the conversion between different forms of energy; on the other hand, it saves a lot of electricity and reduces the load on the daytime grid. This device is based on photoelectric tracking and realizes the automatic steering of the light collector. Compared with the fixed tracking device, it has the advantages of high utilization and high degree of freedom. In this paper, the optical waveguide part and the photoelectric tracking part are separately described. In the collector part, the principle, role, and mounting position of the collector, light guide, optocoupler, and diffuser are described. In the photoelectric tracking part, the composition, operation and principle of hardware machinery and the transmission of signals are introduced: optical signals to electrical signals. The SCM auxiliary team controls the motor to achieve the purpose of turning the light collector. The development and utilization of solar lighting technology is of great significance and can save electricity and energy. At the same time, it also reduces environmental pollution, in line with the "green lighting" concept and the requirements of sustainable development in modern society.

Keywords: light guide, light guiding efficiency, photodiode.

1. Background

With the process of urbanization, buildings in cities tend to be dense. The traditional direct lighting of the sun can no longer meet people's needs. Therefore, many buildings such as basements, windowless conference rooms, etc., require electric lighting, which on one hand exacerbates the use of electricity and losses, and on the other hand exacerbates the grid load.

The introduction of sunlight into the room as a light source can solve the above problems. With regard to this system, many scholars at home and abroad have already done research on it. In 1979, Japan's LaForet Corporation produced the first solar light collection lighting system. In 1995, the Oak Ridge Laboratory in the United States introduced a new lighting system based on sunlight and complemented by electric lighting [1].

However, in the field of practical application, the introduction of sunlight into the indoor lighting system has more or less disadvantages such as low light utilization, small degree of freedom, and large errors. This article hopes to design a solar light system that can overcome the above drawbacks to lead into the indoor lighting system and achieve automatic steering based on photoelectric tracking. It has the advantages of high precision, high light utilization rate, and large degree of freedom.
to tests, when the external conditions are the same, the solar energy received by the light collector using the automatic tracking device is increased by about 35% when the condenser is fixed. Solar tracking devices mainly include optical tracking and sun-tracking. The former is a high-precision closed-loop control system, which has the advantages of high precision, low cost, and quick response. A photodiode is arranged on the solar receiver board, and a shadow cast by the shading rod is displayed on the panel. The current in the photodiode changes to feel the change in the angle of the sun. Using a microcontroller and a three-bar mechanical system, through the transmission of photoelectric signals, so as to achieve the tracking of the sun.

The principle of the light introduction system is that the sunlight is collected by the outdoor lighting device. During the period, the photoelectric tracking device keeps the lighting board in direct sunlight at all times, keeping the maximum collection of sunlight. The collected light is transmitted through the optical fiber into the room, and then diffused by the diffuser to naturally and uniformly diverge to the place where light is needed to achieve natural lighting.

2. **Light guide device**

The main components of the collector are: Fresnel lenses, circular tables, filters, and optocouplers. Compared with the general convex lens condenser effect, the Fresnel lens is not inferior, but also can save more materials, so its cost is lower. On the one hand, the filter can filter out infrared rays or ultraviolet rays harmful to the human body in the sunlight, and on the other hand, lower the temperature at the focal point, so that a lower-cost plastic optical fiber can be used instead of the quartz optical fiber. The Fresnel lens is mounted above the circular table and the center of the bottom is equipped with a light guide fiber holder to connect the fibers. The flat surface of the Fresnel lens fits tightly with the filter and faces the sun. The area of the filter must not be smaller than the lens to ensure the effectiveness of the filter [1]. It has been verified that when the sun shines perpendicular to the filter, more than 90% of ultraviolet rays and infrared rays can be filtered out. Optocouplers are placed at the end of the fiber to minimize the loss of concentrated sunlight into the fiber and improve utilization.

The light guide refers to the light guide fiber. Plastic fiber is used here, which is easy to bend and can be used for different modification lines; it has a large core diameter, which easily causes the spot radius to be smaller than the core diameter, thus achieving total reflection in the transmission fiber [2]. Although its high temperature resistance is poor, due to the use of filters, the thermal effect of infrared rays is reduced, so the optical fiber can withstand the sunlight temperature and prolong its service life.

Optocouplers function to hold one end of the fiber while the fiber end is fixed at the focal point of the lens. [3] Attenuation occurs when an optical signal is transmitted through an optical fiber. This loss is divided into additional loss and inherent loss. Among them, the inherent loss is mainly caused by the structure of the optical fiber and the transmission law of light and will not be discussed here. The additional loss can be further divided into bending and splice loss, which are mainly caused by the unreasonable bending of the fiber at the entrance and exit ends of the fiber. Additional losses can be artificially avoided. Here, the additional loss is mainly caused by the connection of the fiber end face with the concentrated light. Under the fixing of the optical coupler, the area of the sun gathered on the end face of the optical fiber should be less than or equal to the area of the end face of the optical fiber.

The diffuser is used as a lighting device. The light is transmitted through the optical fiber and enters the diffuser from the end of the fiber. The sunlight can be efficiently and evenly scattered in the room.

Guide light path schematic:
3. Optoelectronic tracking device
In the sunlight introduction system, there are two types: stationary and tracking. Among them, the former fixes the light collector, ignoring the change in height and orientation caused by the sun rising over the east. The structure is simple and the cost is low, but the efficiency of using solar light in this system is greatly reduced. The tracking system is divided into open-loop and closed-loop tracking. The open-loop tracking system calculates the elevation angle and operating speed of the tracker in advance according to the local latitude and longitude and the sun's operating law to make it track the sun, but its accuracy is low, cannot correct the error automatically. Closed-loop tracking system is based on single-chip microcomputer, photodiode, and programmed motor control. Although the initial cost is high, it has high accuracy, strong anti-interference ability, and can be automatically corrected to maximize the efficiency of solar light introduction [4].

The automatic tracking device consists of a three-rod mechanical device, a photodiode, and a low-power motor. Next, its signal transmission mechanism will be analyzed.

3.1. Hardware Mechanism
Similar to the principle of the sundial projection, the photodiode is closely arranged along the tangential direction on the disk, and a thin rod is formed at the center of the disk and perpendicular to the disk. Under the irradiation of sunlight, the thin rod will be projected on the disk. At this time, the photodiodes in different regions receive different light intensities, so the current values are different. A voltage comparator is used at the output to connect two adjacent photodiodes to compare voltage magnitudes.

In the solar panel area, a load-bearing rod is erected vertically and universal joints are attached to both ends of the rod. Two other slave rods are placed parallel to the main bearing rods. When the solar panels are horizontal, the three rods are isosceles right triangles. The length of the slave rod can be changed by running the motor at the bottom of the two slave rods. As the sun moves, the altered photoelectric signal enters the microcontroller. The motor is controlled to change the rotation speed so that the rod can be stretched to ensure that the solar panel is always directed towards the sun. The schematic diagram of the three-bar type mechanical device is as follows:
3.2. Signal transmission mechanism

As the sun moves, the shadow of the pole moves with it, because the diode currents in the sunlit and shaded areas are different, so use them as two input signals respectively. Set the thickness of the rod so that the rod shadow covers at most two diodes at the same time. Photosensitive diodes make up the photoreceptor ring and thus produce a time-varying signal. If the rod shadow covers two diodes at the same time, then the ratio method is used, that is, the ratio of two signals generated by light and shadow is used for the ratio operation to determine the specific position of the shadow. If at the same time, the photoreceptor is affected by shadows in different positions, the system is disturbed and needs to be checked.

The sun position signal is transmitted to the single chip microcomputer, and a unique low voltage signal is selected using a preprogrammed program to obtain a unique corresponding height angle and azimuth angle. Then by the role of the MCU, the rotation speed of the motor is calculated and the drive signal is generated to the motor. Move back and forth until the shadows cannot be mapped into the photoreceptive circle. At this point, the low voltage signal disappears and the system enters standby mode.

4. Conclusion

Solar introduction technology has opened up new ways for us to use solar energy. This paper presents a design scheme of fiber optic light illumination system based on photoelectric tracking. Due to factors such as cost, solar light introduction devices have not yet been widely used. However, with this high light-conductivity device, the utilization rate of sunlight is increased by about 35%. And it can shorten the recycling cost and give users a better experience. In the future, it hopes to contribute to the popularity of such devices. At the same time, the device uses renewable energy to replace part of the power energy, responding to the call for a “low-carbon life”, which will help us build an “environment-friendly” society.

References

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