Investigation of a controllable hybrid illuminator for use in photosynthesis

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Abstract— This study concerns a hybrid illumination device that applied lighting by sunlight, natural light, and light emitting diode (LED), artificial light. The device may provide natural light to all places needing sunlight by effectively using lighting and induction instruments at daytime and supply illumination using LED, an artificial light source, at nighttime. In addition, LED illumination may replace natural light in areas where natural light is hard to reach during daytime. This study examines a hybrid illumination device that may control intensity of illumination both at daytime and at nighttime. Sunlight varies by season; It has diversity according to changes in weather and in altitude of the sun. Therefore, the device may be used as constant, natural indoor illumination by controlling the intensity of illumination with LED lighting, assistant illumination, during daytime and major illumination during nighttime. This technology may utilize massive amounts of new and renewable energies radiated to the earth, may efficiently save energies used for existing illumination devices, and is eco-friendly. Such hybrid illuminator may be applied to a diversity of structures for growth of plants and animals that need light and for energy saving. The artificial light source part was made possible to adjust mol of photons at a range between 0 and 100%, thereby being able to grow various kinds of plants using mol of photons needed for their photosynthesis.

Keywords— Natural light , Artificial Light, Hybrid Illuminator, Automatic Control, Photosynthesis, Energy Saving

I. INTRODUCTION

Illumination intensity of the sun changes with the seasons. In addition, Changes in the altitude of the sun among the day illumination intensity is different. Depending on the intensity of sunlight for photosynthesis plants have changed. Sun plants and shade plants for plant growth photosynthesis are different. photosynthesis certain characteristics to prevent the growth will be affected. Greenhouse growth of plants according to the crop requires a certain amount of light. Therefore, the entire illumination device using a light source and an auxiliary light source is needed. Solar and artificial light to the illumination system can be used simultaneously greenhouse growth hybrid system can be used as an extremely useful. To freely control the light amount of the illumination function by adding a variety of potential applications in plant growth is high. Photovoltaic solar green house and underground parts are not reached by applying the energy-saving effect.

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II. HYBRID ILLUMINATOR

In this work a hybrid illuminator was designed consisting of a Fresnel lens, a light collector, light transmitter, optical fiber and LED lighting module.

Fresnel lens (300x300 mm) was produced by applying a dual axis motor with a solar sensor. The reason to use solar sensor to track the movement of the sun light as much as possible because it can collect. Light is collected from the individual light collector summed the light transmitter. combined light toward the optical fiber transmission to be passed to the LED lighting module. LED lighting module accepts the photovoltaic solar irradiation can be outside. The electrical energy to emit light of an artificial light source portion can be irradiated to the outside. This means that you can use both sunlight and artificial light in the structure. Fig 1 shows a schematic diagram integrating natural light-artificial light

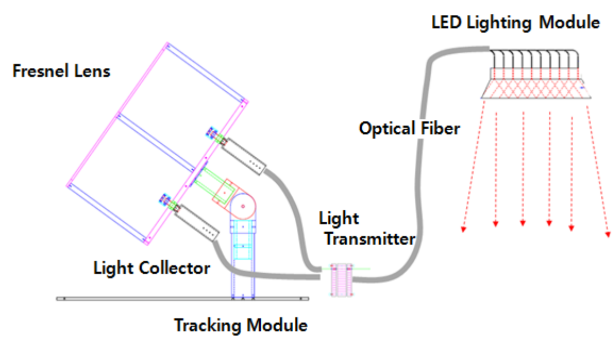

Fig 1. Schematic Diagram Integrating Natural Light- Artificial Light

A. Design and implementation of the sun tracker

Altitude and azimuth of the sun change with the season and time and therefore in order to collect more sunlight than a light collector, a sunlight tracking device than may track the sun according to its direction is needed[2-3]. The sunlight tracking device is composed of a optical sensor and a controller that can detect the light amount of the sun and mechanical components that operate according to electrical signals resulting from the amount of light. This study made a basic design in order to develop a sunlight tracking device suitable for the structure of a

Fresnel lens type light collector to use a commercialized light sensor and produce a sunlight tracking device suitable for it. The changeable altitude and azimuth of the produced sunlight tracking device were set at 90 degrees and 180 degrees, respectively. The sunlight tracking device produced in this study is a program using a Cds light sensor with dual axis motor mechanism by the method of tracking of light receiving.
The characteristics of solar sensor and tracking circuit are shown in Table 1.

Table 1. The characteristics of solar sensor and tracking circuit

Solar Sensor	Detection Wavelength	400~1200nm
	Output Current	2mA @5Volt
	Operating Temp	-35 ~ +85 C
Tracking Circuit	Power supply	12 ~ 36V (DC)
	Sensor Inputs	0 ~ 6 (DC)
	Output voltage	12 ~ 36V (DC)
	Continuous output current	2.5 Amps
	Duty cycle control voltage	2.2 ~ 4.5 (DC)

Fig 2. A Sunlight Tracking Device Using Light Sensing

B. LED module

In order to efficiently diffuse solar light that flow in, this study produced a natural light diffusion plate and an illuminator using LED and devised an LED and optical fiber integrated hybrid illuminator[4-5]. A light diffusing plate serves to scatter. scattering of light inside the lighting system so the outside to be a lot of light extraction. Natural light is input through a fiber bundle. They are attached to the left and right sides of the LED in order to heighten usability of solar light. An illumination intensity sensor is attached to the part where solar light is injected and illuminated so that the amount of light may be checked. \
LED modules attached to the illuminance sensor detects the solar illumination. When the sun is low light intensity of the LED light intensity automatically hardens. Plant growth is enough sunlight illumination, the LED does not work. When the intensity is weak, the LED modules operate. Behavior that is necessary to meet the illumination intensity that keeps the functionality[6-7]. It is produced into a single illuminator form and an illumination intensity sensor is attached within the illuminator; When the illumination intensity of naturally lighted is weak, the LED illuminator automatically works so that constant illumination intensity may be maintained. With 100% light brightness as the standard, when the lighted light has 50% brightness, the LED illuminator illuminates the rest 50% and when the lighted light has 70% brightness, the LED illuminator illuminates the rest 30%. LED module is connected to the AC 220V power. Attached to the lighting modules through the SMPS is converted into DC 48V. To increase or reduce the illumination intensity of the lighting module is attached to the controller to adjust. increasing the illumination of the LED module, thereby requiring more power. However, when compared to halogen lights or incandescent sphere 30 to 70% decrease in power.
Fig 3 and 4 show a natural light(sunlight) -artificial light (Red/Blue/White LED) combining illuminator assembled with parts made according to the above design drawing. Natural light may be connected in flank and artificial light source may be operated using power. The center where red light is turned on shows operation of artificial light source. Natural light may be connected in flank in the left and right sides of the artificial light source.

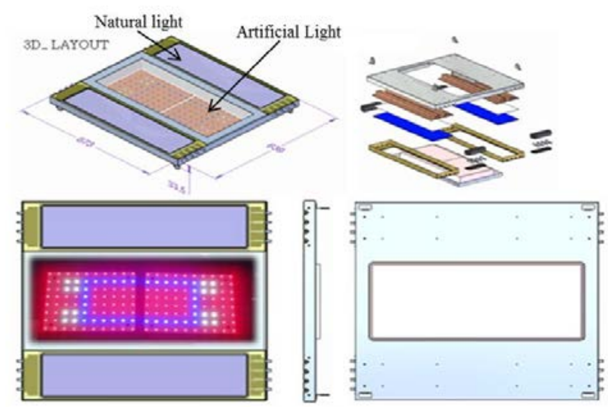

Fig 3. Blueprint of natural light-artificial light combining Illuminator

Fig 4. Photo of natural light-artificial light combining illuminator

III. Result and Discussion

The light collector showed that the moles of photons using light coming from the natural environment were sufficient for plant growth and the moles of photons changed according to the condition of focusing[9]. In the artificial light source part, intensity of illumination was able to be adjusted from 0 to 100% using an illumination control device as a high-power LED illuminator.

Figure 4 show that intensity of illumination drastically changes according to illumination control rates

Fig 4. An Experiment Picture with Intensity of Illumination Controlled from 0 to 100% Using an Illumination Control Device

In relation to plant absorption and action spectrums of the high-power LED illuminator, the maximum photon density that can be used by leafy, fruit, and root vegetables [8] was measured from a distance of 20cm, which was the targeted value, and more than 200μmol/m^2s was obtained by light measurement meter (Mavolux, Gossen), verifying the implementation of the hybrid device was successful.

This study produced an illuminator with a diversity of structures and functions that may be adjusted according to functions and users' demand; It can be applied to various areas such as architectural illumination and lighting for plant growth. The red light promotes the growth of length and the blue light the growth of stem thickness. When plants are illuminated by the two lights, produces grown by the two wavelengths may be obtained.

IV. Conclusion

This study designed and produced a light collector using a Fresnel lens, a connector connecting POFs, a transmission device transmitting solar light from the light collector to an illuminator and a light diffusion plate, and an LED illuminator with changing mols of photons. With the combination of them, this study developed an energy-saving hybrid illumination system with combined used of natural light/artificial light. In addition, an illumination intensity sensor was built in an artificial light illuminator to sense the strength of light from outside.

In the experiment, moles of photons were measured after beams collected in the Fresnel lens passed through an extended line for some distance. The Fresnel lens light collector was found to have sufficient moles of photons using light coming from the natural environment for plant growth and the condition of focusing led to considerably varying moles of photons. The artificial light source part was made possible to adjust mols of photons (200μmol/m^2s) at a range between 0 and 100%, thereby being able to grow various kinds of plants (leafy, fruit, and root vegetables) using mols of photons needed for their photosynthesis.

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