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Design and Implementation of a Smart Control System for Poultry Breeding's Optimal LED Environment

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Abstract

In this paper, a LED smart lighting control system is developed for applying to poultry farms. There are disadvantages of the conventional system adjusting incandescent bulbs of illumination, of which energy efficiency is very low. In order to solve this drawback, a smart control system is applied to poultry farms. The proposed smart control system has several advantages as follows. First, the energy efficiency can be increased in comparison to the existing system. Secondly, the illumination control range can be increased. The maximum illumination is improved by 10 times more than that of the existing system and the calorific value inside the poultry house can be reduced. Furthermore, using the developed smart control system a farmer can control remotely his poultry farms through real-time monitoring with a personal computer and smart phone.

Keywords: *We would like to encourage you to list your keywords in this section*

1. Introduction

Recently, the difficulties experienced by domestic farms are coming from various factors such as rising fuel prices, soaring cost of fodder, and natural disasters. Due to the FTA with the US and China, farm houses were leapt into the world of infinite competition [1]. The introduction of automation techniques for crops and stock farmers provides the opportunity to practice the automation and curtailing labor culture. Especially, many studies are in the process of applying LED to the area of agriculture [2]. The livestock in most stock raising farms are under stress from the artificial lighting environment such as incandescent lamps and fluorescent lights whose illumination, wavelength, and photoperiod are controlled by hands. The illumination intensity for most broiler houses in the country is below 5 lux. This is a very low figure compared to over 20 lux of illumination recommended by FAWC (Farm Animal Welfare Council, 1992) in the UK [3]. Therefore, in order to have a production standard, energy cost reduction and optimized lighting, some improvements are required. A windowless poultry house in most modernized chicken farms has manual controllers. This controller depends on a timer to switch the incandescent lamp and fluorescent light on and off or asks a manual operation in order to follow the growth of the chickens every week giving annoyance to the farmers. Further, the farmers shall conduct observation on the hen house by periods and take various measures. In terms of energy efficiency, the current control system is less efficient [4].

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Light Emitting Diodes (LED) has high energy efficiency, longevity, and durability. LED is not only developed and applied for various fields of industry but also attracts attention as the lighting of the next generation since it is environmental friendly and a light source with high efficiency. In this study, it has intentions to develop the smart lighting control system with LED and apply the system to poultry farms. The study constructed the LED environmental management system for stock farms and installed the system in a real broiler house to monitor. From the first day to the fifth week (35 days) of broiler growth, it programmed the intensity of the LED light. With 256 steps of LED illumination level control, detailed control became available. The real-time monitoring system is constructed by the installation of PLC and connection of CCTV. Also, the IP camera installation facilitates the real time surveillance via smart phone. The system suggested in this study was planned to allow the control of forage and temperature according to a weekly schedule of chickens in the future as well as the intensity of illumination. By that, the special and temporal limitations are settled and all-weather real-time smart management, which is following the gigantism trend of stock farmers, is available.

2. Theory and Background

2.1. Characteristics and trends of chickens

According to the definition of chickens, chickens come from one of the pheasant species. Chicken is a long-day animal which accepts light stimulation to continue the spawning process. The direct effects of light to chickens stimulate endocrine organs to either delay or boost maturity during the brooding period. It also stimulates spawning induction [5]. The modern poultry industry is largely divided into two categories by products; broiler for chicken meat and layer chickens for eggs. The hen house structures are divided into an open-sided poultry house and a windowless hen house. Figure 1 presents the open-sided poultry house and windowless hen house.

(a) open poultry house　　(b) windowless poultry house

Figure 1. Open poultry house and windowless poultry house

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Table 1. Breeding poultry farms and the number of farmers [2012, Korea Poultry Association]

Division	No. of breeding(1000, %)			No. of farm(No., %)		
	No.	0~30	30~	No.	0~30	30~
2009	138,768 (100)	27,276 (19.6)	111,491 (80.4)	3,539 (100)	1,748 (49.4)	1,791 (50.6)
2010	149,200 (100)	25,795 (17.3)	123,405 (82.7)	3,604 (100)	1,646 (45.7)	1,958 (54.3)
2011	149,511 (100)	23,896 (16.0)	125,615 (84.0)	3,403 (100)	1,484 (43.7)	1,919 (56.3)
2012	170,026 (100)	26,040 (15.4)	143,986 (84.6)	3,751 (100)	1,590 (42.4)	2,161 (57.6)

Table 1 is the material for the number of chickens and the number of poultry farm houses in the commercial poultry industry from 2009 to 2012 June [6]. As Table 1 shows, the field of poultry farming is in a more advanced phase of professionalization and corporatization than other stock farming areas. The number of entire chicken farm houses and breeding chickens appears with mild increase.

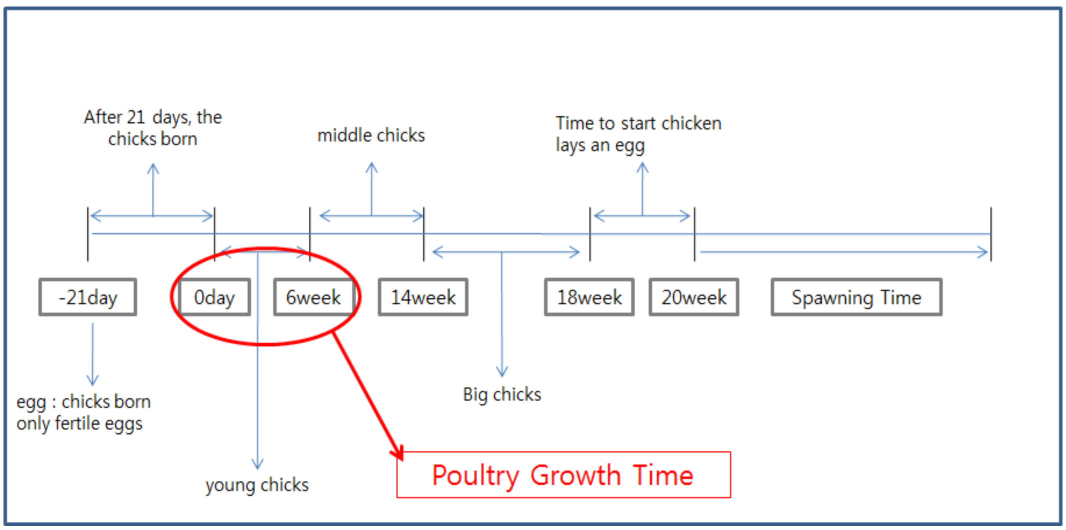

Figure 2. Growing step-by-step specification of chicken

The period of chickens of interest in this experiment is the growth period of broiler as shown in Figure 2. Usually this period starts from 0 days to 5 or 6 weeks old. This is a very important time for chicken growth. Diverse environmental elements should be under the watchful eye of the farmer such as lighting, temperature, humidity, feed managements and so on.

2.2. Comparison between incandescent lamp and LED

An incandescent lamp is a gaslight or lamp with white light. It is a light bulb which is inserted a thin filament of tungsten into an evacuated glass bulb. The principle of the shining

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incandescent lamp is the physical phenomenon called temperature radiation. The incandescent lamp used by most chicken farms in modern age is a 220V 60W light bulb which consumption shows a gradually decreasing trend by the declining production and the prohibition of use and sale on a global level. LED, so-called Light Emitting Diode, is one of the compound semiconductors shining when receiving electrical signals. By the characteristic of compound semiconductors, LED has been used for various purposes converting electrical signals to light. Incandescent lamps only use 5% of the power consumption to produce light while the rest of the 95% disappears with heat. In contrast to this, LED has much less power lost through heat. This advantage reduces unnecessary power waste. The power consumption of LED is one sixth the level of the incandescent lamp and its burnout time is 8 times longer than the incandescent lamp, which is very economical. In addition, no hazardous substances are contained, which is very eco-friendly.

2.3. Conventional poultry breeding system

2.3.1. Conventional poultry lighting and system structure

Domestic poultry farms used to turn on the light for up to 24 hours since chickens eat fodder when they have light. But this 24 hour lighting system suggests that the system increases the weights of chickens but power consumption and mortality are high. The existing lighting systems of chicken farms have AC 220V 60W light bulbs and the rheostat is installed in order to control the intensity of illumination. However, as mentioned before, controlling the illumination of a light bulb largely drops energy efficiency. Also, it requires the farmers to control every output as well as the hours manually. The rheostat for the existing system in presented in Figure 3.

Figure 3. The conventional incandescent light control dimmer

3. LED Smart Control System Design

3.1. Smart control system for poultry keeping

In this study, the system was installed in a windowless hen house of a chicken farm in Imsil-gun, Chon-buk, Korea in order to apply the smart control system for the optimum LED environment of poultry keeping. Twenty LED bulbs with 48V rated voltage and 50W power consumption were installed zigzagged in two lines. CCTV cameras were also installed and on the outside of the hen house, a LED illumination control panel for poultry farming is realized. Figure 4 presents the structure of the smart control system for poultry keeping.

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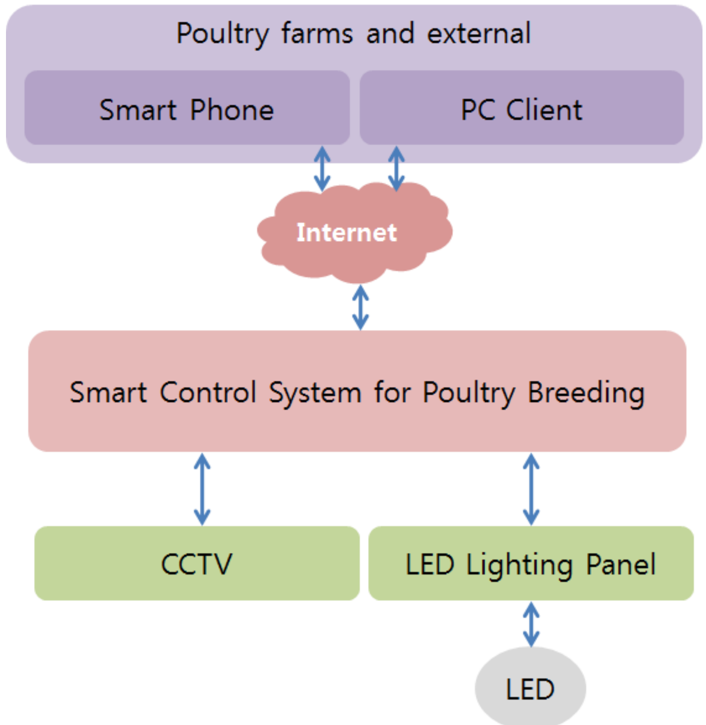

Figure 4. The structure of the smart control system for poultry breeding

The advantage of this system is unlimited system access via the communication network and internet, real time monitoring, and rapid response for disorder. The unlimited system access availability only requires either a smart phone or PC connected to a network to overcome the space. Through this freedom of access, the farmer can do real time monitoring through the video information of CCTV and control it. This leads to quick response for abnormal conditions of the hen house such as temperature anomaly. Also, this system is designed to allow control of LED illumination intensity and real time control of the lighting hour whenever it is needed.

3.2. Poultry managing experiment method by the proposed system

The experiment included 22,500 chicks with an average weight of 0.035kg. The LED system controlled the illumination intensity in phases from 0 to 255. It takes 5~6 weeks to raise broiler chicks up to an average weight of 1.5kg to ship. During the period, the system conducted the lighting control in order to conduct the experiment. The illumination was measured by an illuminometer at a height of chick's eye level. Through CCTV, real-time checking and monitoring was available. A laser thermometer was used to measure the temperature changes such as the temperatures of the hen house, incandescent lamp and LED. After the installation of LED and the smart control system, Table 2 shows the lighting hours and intensity level of LED for each day.

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Table 2. LED illumination and lighting time on days

Day	LED level	Illumination (lux)	lighting time/day	light out time
1-3	255	250	24 hours	None
3-6	200	203	22 hours	5-6, 17-18
7-12	140	140	20 hours	5-7, 17-19
13-18	80	90	19 hours	5-7:30, 17-19:30
19-24	40	38	18 hours	5-8, 17-20
25-29	20	14	18 hours	5-8, 17-20

3.3. Implement and application of the proposed smart control system

Using the proposed smart control system, it produced the LED light control panel as Figure 5 presents.

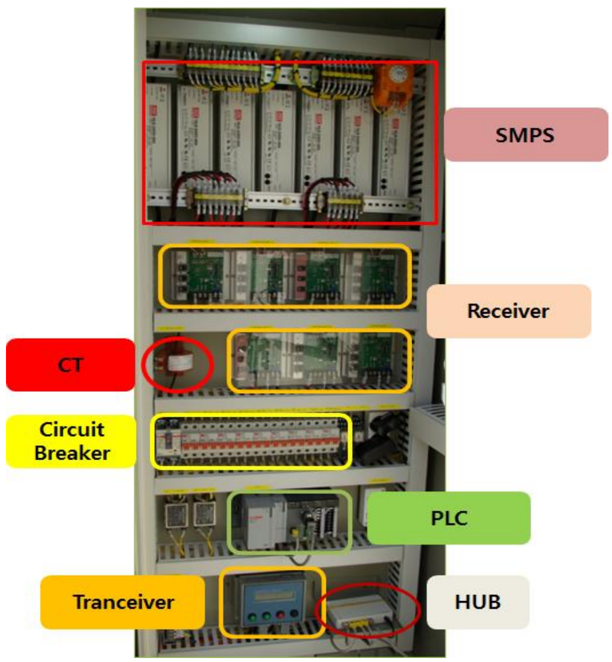

Figure 5. The actual system applied to the inside of the control panel

The operating sequence of the installed system is as follows: As the user gives an order, it is transferred from the user's smart phone or PC to the PLC through the HUB. It uses a RS232 communication line, and passes the DMX512 transceiver and receiver to control the LED lighting installation. Figure 6 presents the entire LED smart control system diagram designed in this paper.

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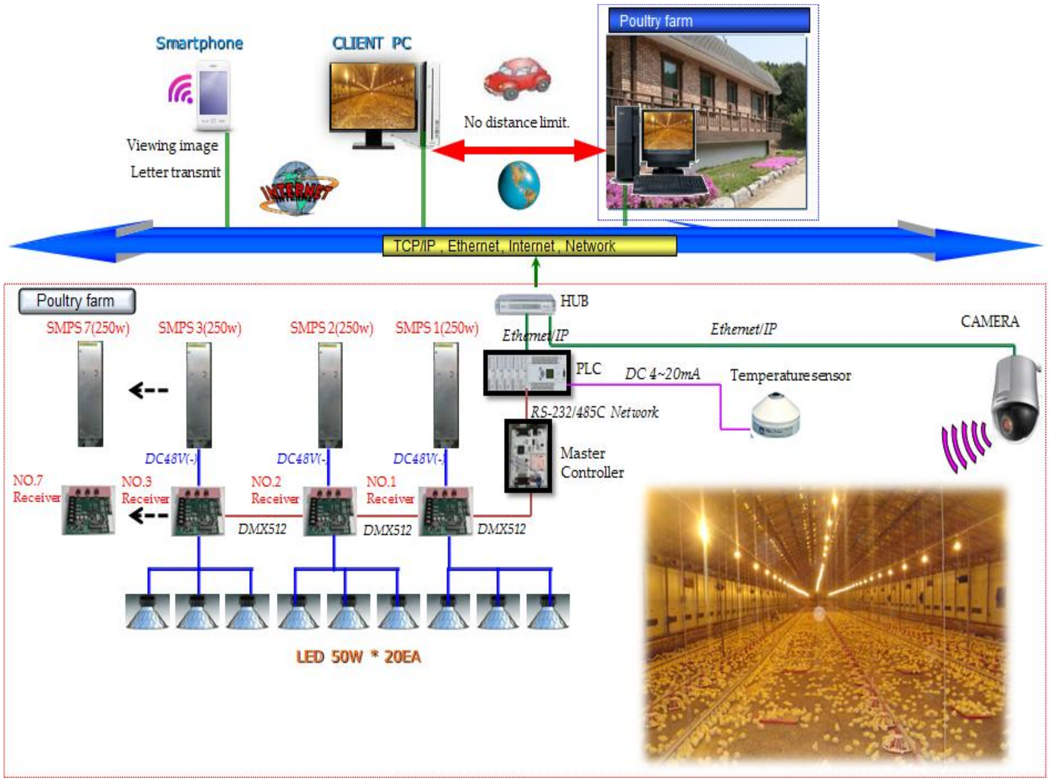

Figure 6. Overall LED smart control system configuration

Figure 7 shows the access screen of the smart control system on a smart phone.

Figure 7. Smart control system screen using smart phone

3.4. Comparison between the existing system and the smart control system

Table 3 presents the differences between the characteristics of the existing system and the suggested system.

Table 3. Compare to features of the proposed system and the conventional system

System / Items	The conventional system	The proposed smart control system
PC control	Impossible	Possible
Smart phone control	Impossible	Possible
Regular Monitoring	Impossible	Possible
Energy efficiency	Low	High
Power consumption	3kW	1kW
Illumination control range	23 Lux	250 Lux
Calorific value	37 ^{o}C	30 ^{o}C

Like Table 3 proves, the following improvements were confirmed. The control functions and constant monitoring became available in both the PC and smart phone. In addition, in terms of energy efficiency, the suggested system has higher value of 1kW/h compared to the existing power consumption 3kW/h. The strongest illumination level is also multiplied 10 times. The heat value decreases 7°C from the existing system's temperature.

4. Conclusion

This paper developed a LED environment control system for stock farmers and installed the system in a real poultry farm allowing monitoring. During the growth period of broiler chickens from the 1st day to 5 weeks old (35 days), the system programmed the LED intensity to prevent setting the control time more than twice until the shipment. By 256 steps of LED illumination power control, the system is able to control the intensity more precisely according to the chicken's weekly growth. The PLC, control panel and CCTV installation and the connection between the program and sever created a way to access the real time monitoring via smart phone. The strengths of the proposed smart control system are as follows: First, the energy efficient is improved compared to the existing system. Second, the illumination control range is widened. The strongest intensity of the light leaps 10-folds higher than the existing one. The heat generated from the lighting system is decreased which leads to a reduction in the effects on the inner temperature of the hen house. From the installation and application of the smart control system, the poultry farmers will be free from the chicken farming restrictions which did not allow them to leave the farm. Due to real-time monitoring via smart phone, the farmer can observe the conditions of environmentally sensitive chickens without delay and take appropriate measures on a timely basis. It is also expected to help improve productivity. For future research, it is considered to incorporate the smart control system into other parts of chicken keeping such as meal feeding, water supply, control of temperature and humidity as well as LED lighting.

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