Implementation of the energy-saving lighting mode in the poultry-farming house due to the automated control system

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Abstract. The reduction of energy costs in the production of livestock products by maintaining the required illumination parameters is an important task. The results of studies on the development of a program for automatic control and maintenance of lighting parameters in premises for keeping birds, depending on the cross, technologies of keeping and the age of birds, using programmable logic controllers (PLC) are presented. The use of a dimming system will reduce the energy consumption of lighting equipment and increase the efficiency of electrical energy use.

1. Introduction
The current economic situation in Russia contributes to the fact that enterprises of the agro-industrial complex (AIC) are obliged to improve the quality and reduce the cost of products due to competition in the market. This leads to the need to reduce costs and increase profits. Therefore, enterprises need to use such scientific and technical developments, the use of which will reduce the cost of fuel and energy resources, which will lead to a decrease in production costs and improve its quality [1, 2]. Improving the productivity of biological objects in the agricultural industry is one of the most important tasks in the current situation of the global food market. The level of productivity depends largely on the conditions that are created in a particular field of activity of the agricultural sector [3].

In both livestock and crop production, microclimate conditions play an important role in increasing productivity indicators [4, 5, 6]. The microclimate of livestock and poultry premises has the most direct impact on productivity along with the feeding and breeding qualities of farm animals and birds [7]. Its deterioration provokes a decrease in bird productivity and an increase in feed consumption. Lighting in the house plays an important role in growing chickens in all directions, and allows you to manage the processes of the physiological development of the bird, to provide more comfortable conditions for its maintenance and to achieve a significant increase in the productivity of the herd. It also helps to increase the survival rate of the young, reduce feed costs and improve their absorption, reduce bird injuries, and electricity costs 4-5 times [2, 6, 8].

Currently, many studies have been conducted to increase the productivity of agricultural animals by changing individual parameters of the indoor microclimate [4]. Lighting belongs to the main factors of bird life support and has a significant impact on their growth, development, productive and reproductive performance [9].
At the same time, both the spectrum of light, and the luminance, and the duration of a day are important. Lighting accounts for up to half of all electricity consumption in poultry houses, the cost of which is a significant (from 3 to 8%) share in the cost of poultry products \[8, 10, 11, 15\].

In this regard, the need to find the optimal balance between all components of the light programs for growing and keeping birds in terms of impact on productive indicators and minimizing the cost of electricity for lighting is not in doubt. One of the options for progressive scientific and technical development is the development of an automatic control system for the lighting system for the implementation of energy-saving electrical technologies.

2. The object and method of research

The goal of the research project was to develop a lighting program (length of daylight and intensity of illumination) and light stimulation (increase in the length of daylight) taking into account the age and live weight of the bird in order to achieve optimal productive and reproductive indicators and improve the efficiency of meat poultry farming. That will allow one to lower significantly costs of fuel and energy resources and to improve product quality.

When developing the light management program, it has been taken into account that the house is a closed type room for the parent flock (controlled microclimate).

The basic requirements for the lighting control program are as follows:

- indication of daylight hours, h;
- light display, lx;
- smooth lighting control, allowing for artificial dawn and twilight;
- automatic maintenance of a given light mode;
- automatic switching of lighting modes between groups;
- warning indication of the transition to the next group.

In order to develop a program of automatic control by lighting in the premises for keeping birds, the parent flock was conditionally divided into four groups. Each group is formed according to the corresponding age of the bird. [12].

Table 1. Norms of illumination for the poultry house of the closed type

| № group | Age of bird, weeks | Duration of daylight, hours | Illumination norms, lx |
|---------|-------------------|-----------------------------|------------------------|
| 1       | 21-22             | 12                          | 30-60                  |
| 2       | 23-24             | 13                          | 30-60                  |
| 3       | 25-26             | 14                          | 30-60                  |
| 4       | 27 and older      | 15                          | 30-60                  |

It follows from the table that the duration of daylight should vary from 12 to 15 hours, and the illumination rate should be constant and be within (30-60) lx. It is most convenient to implement the program with the help of programmable logic controllers (PLC) of domestic production or imported programmable relays, which are now widely used as control devices for electrical equipment in the implementation of various electrical technologies in agriculture [13].

The program complex CoDeSys [14] was chosen as the programming environment. It allows you to use the project visualization to simulate various situations of controlling the parameters of light.

The control program for indoor lighting of birds is created in the CFC language, which is a scheme of continuous functional blocks with feedback (Figure 1).
For smooth lighting control, a software functional block PID controller (PID) is used. It allows you to control the LED lamp, maintaining a given mode of illumination (setpoint). The task of the PID controller is to bring the monitored value of the illumination to the specified value.

The illumination control of LED lamps is carried out by voltage. In analog control mode, the PID controller calculates the deviation $E$ of the current value of the monitored illuminance value from the preset value (i.e. the error). As a result, at the regulator output, an analog signal $Y$ is produced, which is aimed at reducing the error $E$. This signal is fed to the actuator of the regulator in the form of a voltage pulse (PWM).

If the output device is a key type controller (relay, transistor or triac optocoupler, output for controlling a solid-state relay), the output signal is converted into a sequence of control pulses with duration $D$:

$$D = Y \times \frac{T_{pr}}{100},$$

(1)

where $D$ - pulse duration, s; $T_{pr}$ - pulse repetition period, s (set by the user during programming); $Y$ - regulator output.

If a DA converter is used as an output device, the output signal is converted into a current proportional to $4 \ldots 20$ mA or a voltage of $0 \ldots 10$ V.

The program took into account the norm of the length of daylight depending on the age of the bird according to the technological requirements. So, for each group, the time of daylight hours is 12, 13, 14, and 15 hours, and the period of darkening is 12, 11, 10, and 9 hours. [9]

The BLINK function block is designed to control the length of daylight. The BLINK block has two inputs that work with variables that have TIME data types. The first input TIMELOW is the time during which there is no signal (depending on the group number, the value of 9, 10, 11 or 12 hours is given). In this paper, this means that there should be no coverage for a specified time. The second input TIMEHIGH is the time of daylight (the time is 12, 13, 14 or 15 hours). Thus, the BLINK block allows you to automatically transfer the lamp from the on state to the off state after the required period of time.

The automatic transition between the values of the time intervals that go to the TIMELOW and TIMEHIGH inputs is carried out using the Vremya_low and Vremya_high custom function blocks, respectively.

They are set up so that changing the number of the group leads to a change in the value of the duration of daylight hours and the lack of light. The group number is changed automatically by the user function timer block.

The current value of the group number is increased by one (from the first group to the fourth) after a period of time, the duration of which corresponds to the difference between the ages of the birds of two neighboring groups. Thus, the first, second, third and fourth groups correspond to the age of the bird in (21-22), (23-24), (25-26) and (27-slaughter) weeks. This means that the numbering of the group should change in two weeks. The ordinal values of the group number are input to the Vremya_low and Vremya_high function blocks.

In the program, the TP timer is used to control the user function block signal. This unit controls the operation of the light signaling, which notifies about the change of parameters of the light mode. In turn, this indicates a change in the number of the group, and, consequently, the age of the bird.

In the program, functional blocks Svetovoy_den and Vozrast are provided to indicate the length of daylight and the age of the bird. These variables display the corresponding textual information in the form of the age of the parent flock and the length of daylight hours.

The variables vozrast and vremya have the data type STRING, which is a string of characters. Thus, these variables display the corresponding text information in the form of the age of the parent flock and the length of the daylight hours.

To implement the program, a PLC 63 was selected, which has up to 16 analog inputs and up to 6 analog outputs. The advantage of using this controller is that its design provides the ability to connect
additional I/O modules. The presence of additional functions in the PLC 63 will allow you to control a large number of LED installations and use a sufficient number of light sensors to ensure uniform distribution of the light flux over the entire area of the poultry house. In addition, the PLC 63 has a sign-synthesizing display and an embedded real-time clock. Using the real-time clock function will ensure the launch of the program at a specific time.

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3. Conclusion
The analysis of the state and prospects for the development of lighting control in poultry farms shows the need to use automation software to implement energy-saving modes of operation of lighting installations based on LED equipment. The proposed program of regulation of illumination in livestock houses allows you to set and maintain the required level of illumination depending on the cross, age and live weight of the bird, monitor the duration of daylight hours, provide artificial dawn and twilight, warn about emergency operation. The use of a system of automatic dimming allows you to achieve optimal microclimate parameters in poultry houses and increase productive and reproductive indicators of the efficiency of meat poultry farming. An effective automatic program for regulating the lighting system in the poultry-farming premises through the use of a PLC has been developed, which makes it possible to efficiently use optical radiation by reducing the consumption of electrical energy within 30% with constant lighting quality in order to maintain optimal microclimate parameters.

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