Microclimate control system at poultry enterprises of closed type

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Abstract. The microclimate is a set of factors affecting the climate state in a limited space. Keeping and raising animals in agricultural premises is an important stage in the production of agricultural products. Maintaining a favorable microclimate in the room with animals ensures product safety and improvement of their quality. The cultivation of birds in industrial agricultural premises is an important stage in the production and further sale of agricultural products. It is necessary to maintain an optimal microclimate. The deviation of room factors from the norm leads to a decrease in the average daily weight gain and affects the safety of birds, especially in the autumn-winter period, as well as affects its productive egg-laying capacity. It is known that 40...50 % of all energy received by animals from feed goes to maintain a normal body temperature, and the rest - to gain weight and proper development. The food must be of high quality and contain all the necessary micronutrients. Ultimately, the temperature parameters affect the product cost. The ambient temperature directly affects the amount of heat released by the chicken in the initial stage, and the feed consumption accordingly. Deviations of the ambient temperature from the optimal one significantly reduce the growth and development of young birds and increase feed consumption, which leads to additional unplanned financial losses for the farm. An unsatisfactory microclimate, the determining parameter of which is the temperature regime, increases the product cost by 15-20 % and leads to an increase in the selling price for the final consumer. Due to the peculiarities of biological heat release and thermal regulation in young birds, the value of the optimal temperatures for their cultivation varies widely.

1 Introduction

Poultry farming is one of the most important and promising agriculture branches, which occupies one of the leading positions among other branches, both in Russia and in most

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countries of the world. The chicken productivity is closely related to the environmental conditions and is directly affected by them. Much attention is paid to automation of bird housing conditions [1-3]. Climatic conditions have a great impact on the life-activity of birds. Due to climate change, studies are currently being conducted to create microclimatic conditions for the conservation of high-altitude bird populations [4]. Environmental conditions have a direct impact on the bird condition and the result of their maintenance. The spectrum of these conditions is quite wide, and includes: temperature, humidity, air velocity in the area where the bird is located, oxygen richness of the air space, as well as the content of gases harmful to the bird, such as carbon dioxide, ammonia, hydrogen sulfide, and mechanical impurities, such as dust, microbial contamination, noise and stress factors [5]. The production qualities of broilers with various control systems and structural features of the building were studied in the work [6]. In order to better preserve the poultry population and achieve maximum productivity, it is necessary to maintain an optimal microclimate in the poultry premises. Lighting also has a great influence on the birds. The optimal microclimate reduces the cost of products in birds by 15-20%. In cold, damp, poorly ventilated poultry houses, birds are 3-4 times more likely to get sick, their productivity decreases by 10-50%, and feed consumption increases by 10-30% [7].

2 Methods of research

The research methods were based on the Order of the Ministry of Agriculture of the Russian Federation N 104 dated April 3, 2006 "On approval Veterinary rules for bird housing at closed-type poultry enterprises (poultry farms)". The theory of finite automata and ladder diagrams was used to develop the computer program.

3 The results of the study

3.1 Requirements for microclimate parameters at poultry farms

Poultry enterprises are classified into personal farmsteads of citizens, poultry farms of open and closed types, to which various parameters of the microclimate are applied. Special attention is paid to the microclimate for closed-type enterprises, which will be the subject of this work. Infectious diseases, such as avian flu, coronavirus, and other infections, also pose a great danger to birds. The general scheme of the microclimate monitoring and control system at the poultry farm is shown in Figure 1.

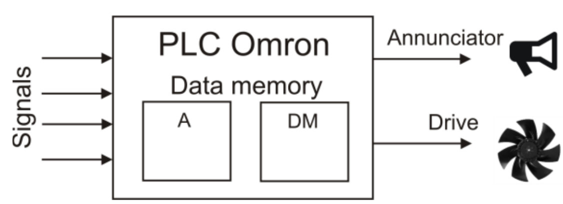


Fig. 1. General scheme of the microclimate monitoring and control system.

Let's group the indicators of the microclimate and lighting by the following parameters: noise, temperature, lighting, and harmful gases content (Table 1). It is proposed to use the Omron CP1L module as a processor unit [8,9]. The control of the equipment for regulating the system parameters is described in Table 2.

Table 1. Description of monitoring sensors.

No.	Sensors, measuring unit	Designation		Controller address
1	Noise, dB	SH	Current	DM10
		SHR	Maximum level	DM15
2	Timer, hour	TIM	Current time	A352
		TON	Lighting switch-on time	DM55
		TOFF	Lighting switch-off time	DM56
3	Temperature , ^0C	TEM	Current	DM20
		TEML	Minimum level	DM25
		TEMR	Maximum level	DM26
4	Air flow, m/s	V	Current	DM27
		VL	Minimum level	DM28
		VR	Maximum level	DM29
5	Gas SO_2, mg/m^3	G1	Current concentration	DM40
		GR1	Maximum level	DM45
	Gas NH_3, mg/m^3	G2	Current concentration	DM46
		GR2	Maximum level	DM47

Table 2. Equipment control system.

No.	Equipment	Designation	Controller address
1	Lighting	Y2	CIO 100.01
2	Max noise level alert	Y1	CIO 100.02
3	Heater	Y3	CIO 100.03
4	Fan	Y4	CIO 100.04
5	Maximum permissible concentration alert	Y5	CIO 100.05
6	General condition	M	CIO 101.00

3.2 Analysis and synthesis of control systems

The microclimate monitoring and control system will include five modules: 1) lighting control module, 2) noise monitoring module, 3) air temperature and speed control module, 4) alert module for exceeding the maximum permissible concentration of harmful gases, 5) general safety monitoring module.

3.2.1 Development of the lighting control scheme

It is proposed to use a general lighting system in the poultry house. Let's assume that the lighting in the poultry house should be turned on at 8 am and turned off at 10 pm. The graph-diagram of the lighting control is shown in Fig. 2. The real time (Tim) is read from the memory card located in the address range A351 - A352 of the Omron controller and compared with the values in the memory cells DM55 and DM56 (Table 3).

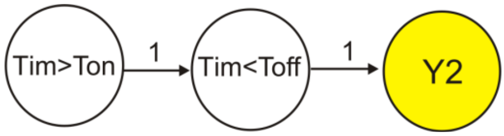


Fig. 2. Lighting control graph-diagram.

Table 3. Omron PLC real-time memory card

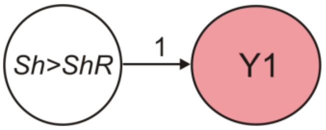
Address	Content
A351.00 ... A351.07	Second: 00 ... 59 (BCD)
A351.08 ... A351.15	Minute: 00 ... 59 (BCD)
A352.00 ... A352.07	Hour: 00 ... 23 (BCD)

The logical equation of lighting control is described by the formula

$$Y2 = (Tim > Ton) \& (Tim > Toff).$$

3.2.2 Development of the alert scheme when the permissible noise level is exceeded

The noise is measured in octave ranges, divided so that each subsequent octave is twice large than the previous one. To measure the noise level, a logarithmic indicator is used – decibel. The total noise level should not exceed 60 dB. The graph-diagram of the noise level monitoring and the logical equation are shown in Figure 3.

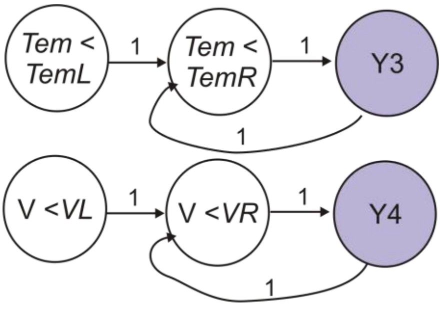


$$Y1 = Sh > ShR$$

Fig. 3. Graph-diagram for noise level monitoring and logical equation.

3.2.3 Development of a scheme for monitoring and control of the air environment parameters

Maintaining the temperature within the acceptable range is the main parameter in bird housing. The Perm region is characterized by an unstable climate, there may be rainy cold summers, sharp temperature changes, and therefore the presence of a temperature support module is a necessary condition. The graph-diagram of the heater and fan control is shown in Fig. 4.

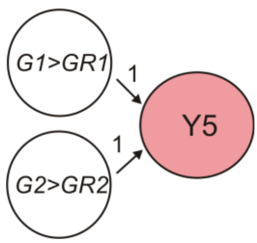


$$Y3 = (Y3 \vee (Tem < TemL)) \cdot (Tem < TemR)$$
$$Y4 = (Y4 \vee (V < VL)) \cdot (V < VR)$$

Fig. 4. Graph-diagram diagram of the heater and fan control.

3.2.4 Development of the alert scheme when the maximum permissible concentration of harmful gas emissions is exceeded

Harmful and hazardous gases, such as sulfur dioxide, ammonia, and other gases, can form at poultry farms. Exceeding their maximum concentrations can lead to poisoning of birds and explosions, and therefore monitoring of the chemical composition of the air environment is necessary. The development of the alert system for exceeding the maximum permissible concentration of harmful gases in the air is also necessary for conducting a safe and cost-effective economy. The maximum single concentration of sulfur dioxide (GR1) should not exceed 0.03 mg/m^3, and ammonia (GR2) should not exceed 20 mg/m^3 (Fig. 5).

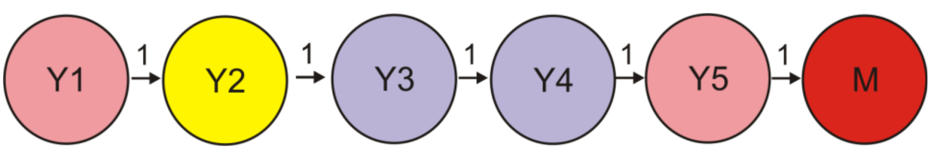


$$Y5 = (G1 > GR1) \vee (G2 > GR2)$$

Fig. 5. Graph-diagram of alert in case of the exceed in the maximum permissible concentration of harmful emissions in the air.

3.2.5 Development of the general alert scheme

For operational monitoring of physical and chemical parameters in the premises, a general alert scheme is provided, which provides signal information when the monitoring parameters exceed the permissible limits (Fig. 6).



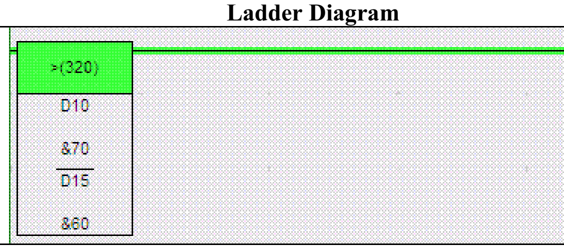
$$\mathrm{M} = Y1 \cdot Y2 \cdot Y3 \cdot Y4 \cdot Y5$$

Fig. 6. Graph-diagram of the general alert scheme of the safe state in the poultry house.

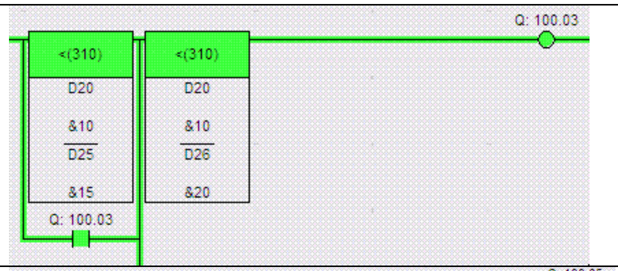
3.3 Simulation of the operation process of relay-contact circuits

Based on the synthesis of logical equations, relay-contact circuits were compiled and their operation was simulated, as shown in Table 4.

Table 4. Simulation of the operation of relay-contact circuits

Monitoring object	Ladder Diagram
Max noise level alert 70 dB noise exceeded max permissible level	

<table>
<tr>
<td>Heater

The air temperature is below the min level, the heater is working</td>
<td>
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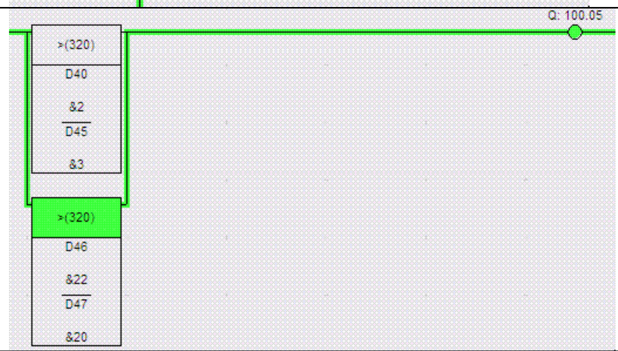
<tr>
<td>Maximum permissible concentration alert

The concentration of ammonia has exceeded the maximum single release, the hazardous state alert is active</td>
<td>
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4 Conclusions

The analysis and synthesis of logical equations for monitoring and controlling the parameters of the production environment at closed-type poultry enterprises was carried out. A computer program based on the construction of relay-contact circuits has been developed. The simulation showed the correct logic of the developed schemes/diagrams. The introduction of this computer program will improve the technical and economic performance of poultry farms in the Perm region.

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