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Development of a microclimate control system for a quail farm

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Abstract. Poultry farming in most countries of the world occupies a leading position among other branches of agricultural production. In recent years, quail breeding has become particularly relevant in Russia and European countries. Intensive growth and development, a short reproduction period, as well as meat and egg productivity, early maturity, high egg production, all this together allows them to be successfully used to obtain high quality products. At the same time, this gives grounds for the competition of quails with chickens for meat and egg productivity. Quail products are recognized as environmentally friendly, easily digestible, a rich source of valuable macro and microelements, as well as a variety of vitamins. In addition, quail eggs are a hypoallergenic product that has tonic properties and contains a large amount of protein. In terms of nutritional properties, quail eggs are healthier than chicken eggs, since they do not contain cholesterol. When growing poultry, no additional costs are required for the prevention of infectious diseases, as well as drugs that accelerate the growth of individuals. Creating optimal microclimate parameters in poultry houses is one of the important conditions for realizing poultry productivity, as well as minimizing the unit costs of material and technical resources. Violation of zoohygienic requirements for keeping quails has a significant impact not only on the productivity of poultry, but also on the health of the personnel working at the factory, as well as on environmental pollution. Microclimate control using an automated system makes it possible to provide optimal conditions for the functioning of the physiological state of individuals, which is reflected in various forms of ethological manifestations, on the reactions of eating behavior.

1. Introduction

Currently, the poultry industry is one of the highly developed branches of agricultural production not only in our country, but also abroad [1, 2]. Many works are devoted to the peculiarities of quail breeding, in particular, the pre-incubation selection of quail eggs is described in the article [3], the effect of prenatal environmental temperature on Japanese quails is described in a scientific report [4]. The development of quail breeding in recent years has become particularly relevant due to the rapid reproducibility of products, the cost recovery in a short time, as well as the high content of easily digestible and beneficial nutrients in egg and meat products [5–7]. An integral part in the process of keeping quails is monitoring compliance with the zoohygienic parameters of the poultry house, such as: temperature, humidity, air velocity, gas composition, which have a significant impact on the development, health and productivity of quails [8]. In this regard, the development of automated technologies aimed at regulating and maintaining optimal microclimate parameters in poultry houses, improving the ventilation system, makes it possible to keep birds indoors in regions with sudden temperature changes, as well as with a high number of quails in the same room.

2. Methods and equipment

The methodology for developing a microclimate management system for indoor farms was Order No. 104 of April 3, 2006 "On Approval of the Veterinary Rules for Keeping Birds at Closed Poultry Farms (Poultry Farms)". When developing the control system, the theory of graphs, the theory of analysis and synthesis of logical equations were used. For programming the industrial controller, GOST R IEC 61131-2015 was used. OMRON controller was used as hardware.

3. The results of the study and their discussion

3.1. The composition of the microclimate control system

The microclimate control system on a quail farm includes a module for initializing microclimate parameters for keeping birds indoors in accordance with Order No. 104 of April 3, 2006 "On Approval of the Veterinary Rules for Keeping Birds at Closed Poultry Farms (Poultry Farms)". The unit for monitoring and controlling the drive of the equipment is designed to generate control signals to start the electric drive of the equipment for maintaining the boundary parameters of the microclimate. When the parameters go beyond the allowable limits, a signal is sent to the siren module. Figure 1 shows the block diagram of the designed system. The formation of the address system for the industrial controller is shown in Table 1.

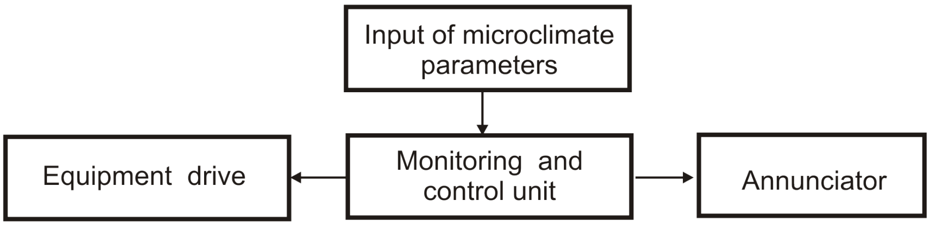

Figure 1. Block Diagram of the Climate Control System.

Table 1. Table of monitoring and control addresses.

Input signals sensors	Mnemonics, drive unit	Port address controller, current, left, right border	Adjustable Range
Temperature, ^{0}C	Z1, 100	DM 001, 002, 003	18 – 25
Relative humidity	Z2, 101	DM 101, 102, 103	55 – 75
Dust concentration	Z3, 102	DM 201, 202	no more 5 mg/m^3
Air speed, m/s	Z4, 103	DM 501, 502, 503	0.3 – 0.6
Hydrogen sulfide concentration	W1, 104	DM 301, 302	no more 5 mg/m^3
Ammonia concentration	W2, 105	DM 401, 402	no more 15 mg/m^3

3.2. Development of the system of logical equations

The block for monitoring the physical parameters of the microclimate (temperature, relative humidity, dust concentration, air flow) will be based on the use of a trigger element to generate control signals to maintain the microclimate parameters in an acceptable range (Figure 2). Figure 3 shows a diagram of the formation and retention of the control signal.

Figure 2. Limits of the permissible range of physical parameters of the microclimate: green - acceptable, red - out of bounds.

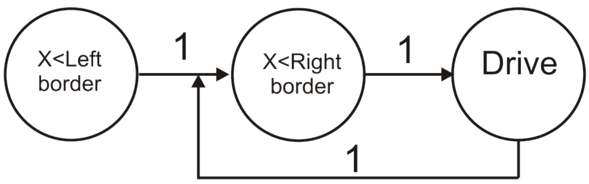

Figure 3. Structural diagram of the formation of a control signal for the physical parameters of the microclimate.

The generalized logical equation for controlling the physical parameters of the microclimate is shown below:

$$Z = \left(Z \vee \left(X < Left\right)\right) \cdot \left(X < Right\right)$$

The control block of chemical parameters will consist in monitoring only the right border, not exceeding the maximum permissible concentration (Figure 4). The diagram of the formation of the control signal for the chemical parameters of the microclimate is shown in Figure 5.

Figure 4. The limit of the permissible range of chemical parameters of the microclimate: green - acceptable, red - out of bounds.

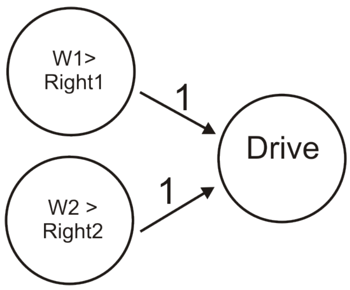

Figure 5. Structural diagram of the formation of the control signal. for chemical parameters of the microclimate.

The generalized logical equation for controlling the chemical parameters of the microclimate will be formed using the "disjunction" operator:

$$\mathrm{W} = (W1 > Right1) \vee (W2 > Right2)$$

The operation of the annunciator unit will consist in exceeding the permissible parameters, taking into account the time, which is reflected in figures 6 and 7.

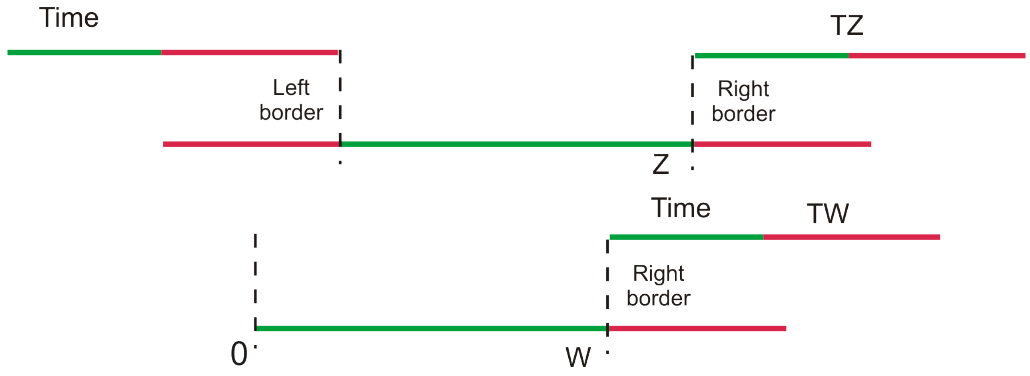

Figure 6. Control signal generation diagram for the annunciator: upper figure - for physical processes, lower figure - for chemical processes.

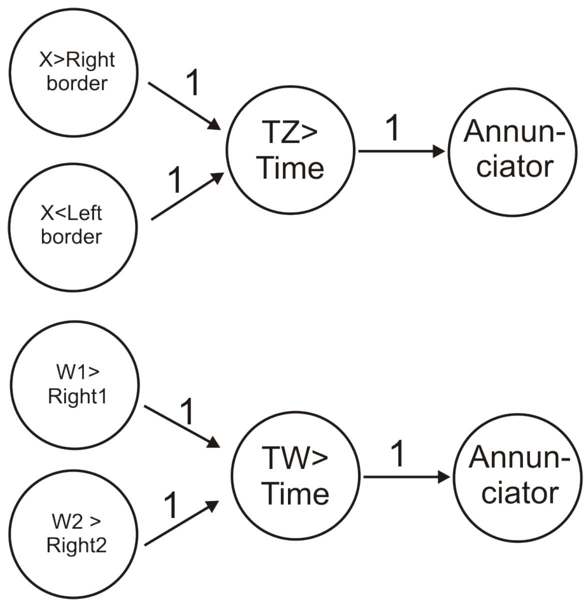

Figure 7. Formation of the control signal of the siren.

The system of generalized logical equations for the control of the siren will be written in the form:

$$\mathrm{AZ} = ((X < Left) \vee (X > Right)) \cdot (TZ > Time),$$
$$\mathrm{AW} = ((W1 > Right1) \vee (W2 > Right2)) \cdot (TW > Time).$$

To initialize the programmable logic matrix of an industrial controller, a program was developed in the language of relay-contact circuits. A fragment of the program mnemonics is shown in Figure 8.

3.3. Simulation of the operation of the relay-contact circuit

Using the CX-Designer program, a farm operator screen was developed, which reflects the current states of physical and chemical processes and equipment operation modes [9–11]. If the maximum permissible parameters are exceeded, an alert is issued if the automated control system is unable to provide the required mode of operation. Figure 9 shows a simulation of how a ladder diagram works to provide temperature and humidity control conditions on a farm. In Figure 10, the system has entered the state of acceptable operating parameters, the equipment is in standby mode.

Rung	Step	Instruction	Operand	Value
0	0	LDNOT	I: 0.08	0
	1	MOV(021)	&18	
			D2	0012 Hex
	2	MOV(021)	&25	
			D3	0019 Hex
	3	MOV(021)	&55	
			D102	0037 Hex
	4	MOV(021)	&75	
			D103	004B Hex
	5	MOV(021)	&5	
			D202	0005 Hex
1	6	LD<(310)	D1	&20
			D2	&18
	7	LD<(310)	D1	&20
			D3	&25
	8	OR	Q: 100.00	0
	9	ANDLD		
	10	OUT	Q: 100.00	0
2	11	LD<(310)	D101	&35
			D102	&55
	12	LD<(310)	D101	&35
			D103	&75
	13	OR	Q: 101.00	1
	14	ANDLD		
	15	OUT	Q: 101.00	1
3	16	LD>(320)	D201	&1
			D202	&5
	17	OUT	102.00	0
4	18	LD<(310)	D501	&1
			D502	&0
	19	LD<(310)	D501	&1
			D503	&0
	20	OR	I: 1.03	0
	21	ANDLD		
	22	OUT	103.00	0
5	23	LD>(320)	D301	&0
			D302	&0
	24	OR>(320)	D401	&0
			D402	&0

Figure 8. Fragment of program mnemonics.

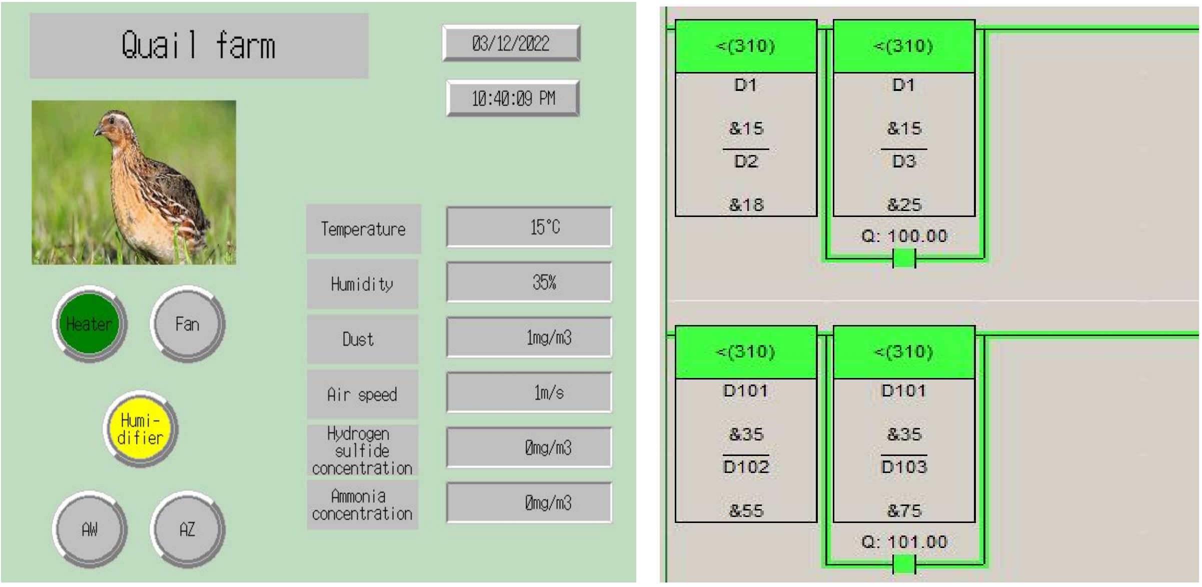

Figure 9. The operation of the heater and humidifier is shown, since the adjustable parameters are less than the permissible value.

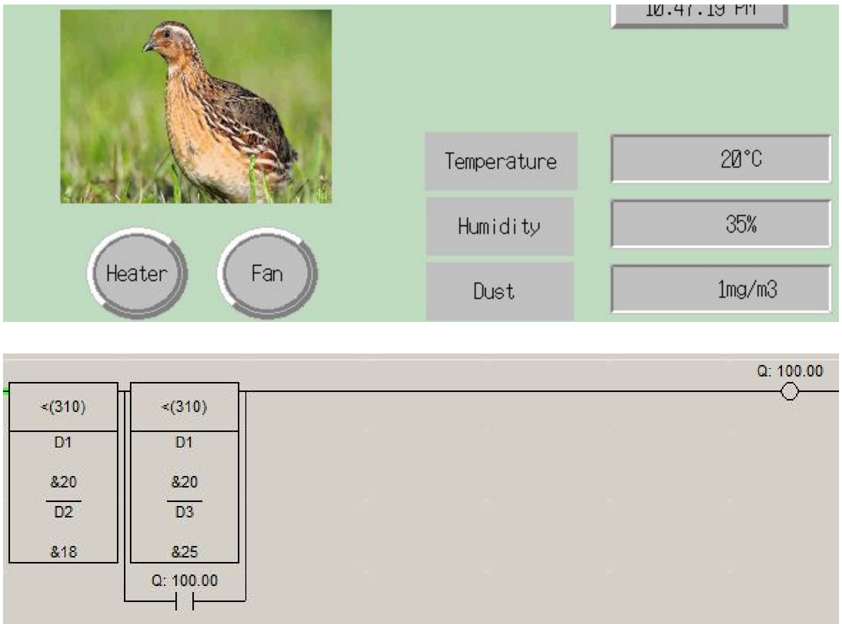

Figure 10. The temperature is within the allowable range, the heater block is in standby mode.

4. Conclusion

Simulation of the work of the developed microclimate control system for quail farms shows the correct operation of the equipment. With the introduction of the developed automated system for regulating, monitoring and maintaining zoohygienic parameters in the poultry house, the conditions for keeping quails will improve and, accordingly, the yield of products will increase, which is of particular relevance in the context of sanctions.

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