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APPLICATION OF ALTERNATIVE ENERGY SOURCES FOR HEAT SUPPLY OF POULTRY HOUSES

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Summary: There is a need for using an energy efficient infrared heating system in places where poultry are placed. Infrared heating systems, unlike other systems of providing microclimate in poultry houses, carry out local heating. In addition, infrared radiation positively affects on the body of the bird, especially on young animals. Due to the ever-increasing price of energy in the whole world, alternative energy is intensively developing: wind, solar, biogas, geothermal, etc., which indicates the relevance of developments in this direction.
The article presents the developed system of heat supply for the poultry house with the integrated application of a soil heat exchanger for heating the tidal air and an infra-red heater for local heating of the bird's stay. The results of research of rational structural sizes of the module for poultry growing are obtained.

Keywords: Infrared heating, soil heat exchanger geothermal energy, poultry houses.

1. INTRODUCTION

Providing the necessary microclimate in the premises of agricultural complexes, and in particular poultry houses, requires significant energy expenditure.
All deviations from the normative parameters of the air environment negatively affect on the productivity of poultry meat breeds and the efficiency of production [1]. That is why there is a need for using an energy efficient infrared heating system in places where poultry are placed.
Infrared heating systems, unlike other systems of providing microclimate in poultry houses, carry out local heating. In addition, infrared radiation positively affects on the body of the bird, especially on young animals. Due to the ever-increasing price of energy in the whole world, alternative energy is intensively developing: wind, solar, biogas, geothermal, etc., which indicates the relevance of developments in this direction.
The article presents the developed system of heat supply for the poultry house with the integrated application of a soil heat exchanger for heating the tidal air and an infra-red heater for local heating of the bird's stay. The results of research of rational structural sizes of the module for poultry growing are obtained.

2. EXPERIMENTAL STUDIES

On the basis of the analysis of existing systems of heat supply in the zone of birds stay modular poultry farming has been offered and substantiated as an alternative to traditional growing poultry in cages. With this method of cultivation there is an opportunity to keep multi-year-old bird species and to carry out the temperature regime as it grows.
The use of modular poultry farming is possible both in the entire poultry house and in the farms as a separate unit [2, 3].
When developing a physical model of a bird breeding module, there is a need for choosing its rational design parameters. If the allowable variation of some module parameters, then from the whole set of possible, you need to choose the most attractive options. The attractiveness of the decision was determined by the presence of a binary relation to the choice of R, in which of the two alternatives was chosen the most attractive.
Denote by x the rational solution and through Ω the set of admissible solutions. Each solution x of Ω corresponds to one of n numerical indices X_1 (x), ..., X_n (x). When

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comparing two attractive options x_1, x_2 Ω, the condition $x_1 R x_2$ must be met [4].

The dimensions of the module were determined for the reasons of the technological process at the maximum output indicators in the poultry house, taking into account the normalized density of the birds' planting n_{norm} = 0.035 m^2 per head and the normalized intensity of the irradiation of the floor q_{norm} = 174 ... 290 W / m^2.

When heating the module with an infrared emitter, radiation heat transfer plays an important role in providing comfortable warmth of the bird.

With increasing air mobility in the module increases the intensity of convective heat transfer over the heated floor surface. As a result, the temperature of the surface of the floor and the body of the poultry decreases, which leads to rapid cooling of the body of the bird.

Therefore, the criterion for evaluating the rational dimensions of the module is the minimum speed of the inflow air flow in the module, v_{in}, m / s, which is within the range of $v_{\text{in}} = 0{,}2 \ldots 0{,}3$ m / s.

$$v_{\text{in}} = \frac{G_{\text{in}}}{3600 \cdot F_{\text{in}} \cdot \rho_{\text{in}}} \to \min \, , \qquad (1)$$

Where: G_{in} - mass flow of the inflow of air, kg / hour; F_{in} – area of the tidal air of the distributor, m^2; ρ_{in} – density of internal air, kg / m^3.

In this case, the binary relation of the choice of R can be represented as:

$$x_1 R x_2 = v_{\text{in}}(x_2) > v_{\text{in}}(x_1) \qquad (2)$$

In determining the rational dimensions of the module in the area, namely the length *a* and the width *b*, the restrictions on the number of birds in the module $n \le n_{norm}$ and the intensity of the irradiation of the floor $q \le q_{norm}$ are introduced.

Table 1 presents the results of the solution of the problem of choosing rational parameters of the poultry breeding module.

Table 1. Results of the decision of the problem of the choice of rational parameters of the module

The number of the evolutionary search branch	*a*	*b*	v_{in}, m / s
1	1.2	0.8	0.2
2	1.2	1.6	0.26
3	1.2	2.4	0.3

Taking into account the criterion condition, the rational parameters of the module are selected: length – 1.2 m and width – 0.8 m. In order to accommodate the maximum number of modules in the poultry house, the height of the module was taken equal to 1.5 m.

The engineering method for calculating the design dimensions of an infra-red heater is to determine the area of the irradiation surface of the module with known its rational parameters, namely, the area of the module and the height of the heater installation (Fig. 1).

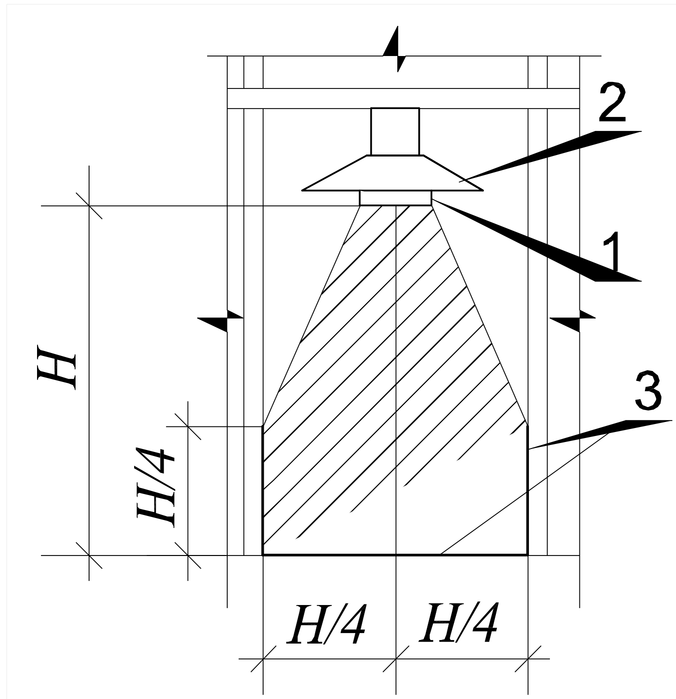

Fig. 1. Irradiation of the surface of the module with an infra-red heater:
1 – infra-red heater;
2 – exhaust hood;
3 –irradiation surface;

The dependence of the area of irradiation in the module F_{irrad}, m^2 on the size of the heater a_{heat}xb_{heat}, m and the height of the installation of the radiator *H*, m will be written as:

$$F_{irrad} = (a_{\text{heat}} + H) \cdot (b_{\text{heat}} + H) \text{ , m}^2, \qquad (3)$$

where the size of the emitter is determined.

Here a_{heat} - the length of the heater, m; b_{heat} - width of the heater, m.

With known structural dimensions of the module and the height of the installation of the radiator, obtained from the binary selection of the ratio, the size of the infra-red heater will be equal to 0.54x0.1 m.

The modules are located in two tiers with technological services provided in the poultry house (fig. 2).

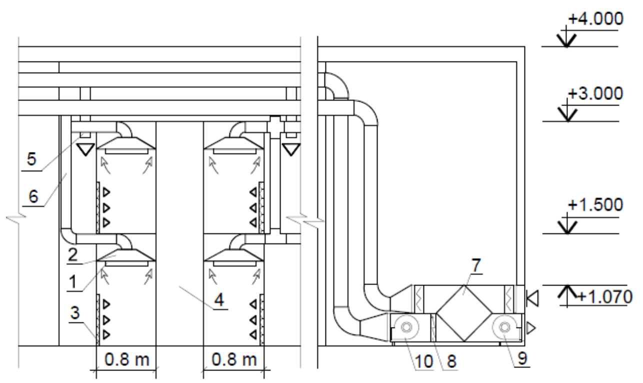

Fig. 2. The location of the modules in the poultry house with heat recovery:
1 – infra-red heater;
2 – exhaust hood;
3 - perforated air distributor;
4 – technological service area;
5 – supply air duct;
6 – exhaust air duct;
7 – heat recuperator;
8 – air heater;
9 – exhaust fan;
10 – supply fan

The heating element in the module is the infrared emitter 1, which serves to heat the surfaces. The air is heated due to convective heat transfer. Through perforated air distributor 5 fresh air is supplied to assimilate heat and moisture excess throughout the technological process. Removal of contaminated air occurs with exhaust hood 2. In the future, this air is used to heat the outside air in the recuperator 6.

Connection of the module to the inflow and exhaust system with a plate recuperator allows reducing energy costs, associated with the heating of the exhaust air. Air heater 8 is used for heating the supply air to the required parameters after the section of recuperator.

In order to save energy on heating the air in the air heater there is a need for application a ground heat exchanger.

Soil of the Earth's surface layers is a natural thermal battery. The main source of thermal energy entering the upper layers of the Earth is solar radiation.

At a depth of 3 m or more (below the freezing point), the soil temperature during the year practically does not change and is approximately equal to the average annual temperature of the outside air. At a depth of 1.5 - 3.2 m in the winter, the temperature ranges from +5 °C to + 7 °C, and in the summer from +10 °C to + 12 °C [5, 6].

Under the ground, below the level of freezing of soil, the system of air ducts is installed, which perform the function of the heat exchanger between the ground and air passing through these ducts. In winter, the entrance cold air entering the house and passing through the soil heat exchanger - heats up, and in the summer - cools. At a rational distribution of air ducts it is possible to remove from the soil a significant amount of thermal energy with low energy consumptions.

Figure 3 gives a schematic diagram of the system of geothermal ventilation with the use of a soil heat exchanger with a ventilation installation with heat recovery.

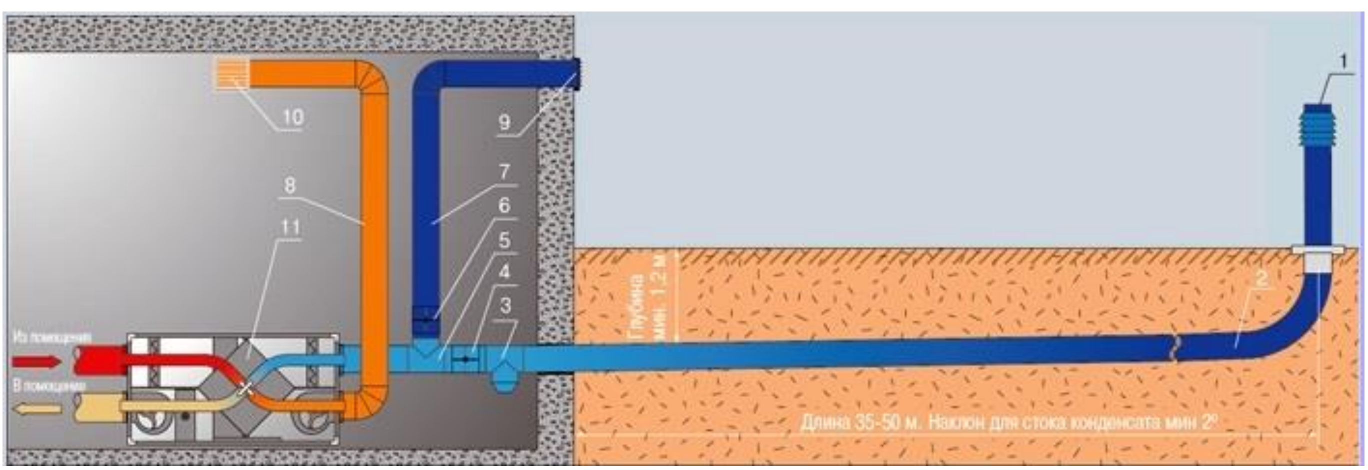

Fig. 3. Principal scheme of the system of geothermal ventilation:
1 – supply column; 2 – air duct of the soil heat exchanger; 3 – device for collecting and withdrawal condensate; 4 – automatic shutter valve; 5 – tee; 6 – automatic by-pass; 7 – by-pass supply channel; 8 – exhaust air duct; 9 – supply grid; 10 – exhaust grid; 11 – supply and exhaust system with heat recovery

The system is based on the use of heat of the earth. In the ground laid air ducts 2, in which winter air is heated due to low-temperature soil heat. Passing through the plant with heat recovery 11, air is heats to the required temperature and enters to the poultry house.
The air that is removed from the birds` placement zone enters to the heat recuperator and heats up the supply air.
Thus there is energy savings for additional heating of the air in the ventilation installation.
Since the soil temperature does not change much during the year, and the temperature outside changes, the recovery occurs due to temperature difference.
In the summer, the temperature of the outside air is quite high, when air passes through the air ducts underground, it gives off part of its warm soil and gets to the house already cool.

3. CONCLUSIONS

The article presents the developed system of heat supply for the poultry house with the integrated application of a soil heat exchanger for heating the tidal air and an infra-red heater for local heating of the bird's stay. The efficiency of the application of such a system is proved.
The results of research of rational structural sizes of the module for poultry growing are obtained. The dimensions of the infra-red heater are equal to 0.54x0.1 m. The modules are located in two tiers, with technological maintenance zones in the poultry house.

References

[1] Dolgikh D.O., Kovyazin O.S., Rensevich Ye.O., *Results of Experimental Studies of the Air Heat Exchanger*, Design, Manufacture and Operation of Agricultural Machinery 43 (1) 2013, 263-267
[2] Zhelykh V., Ulewicz M., Spodyniuk N., Shapoval S., Shepitchak V., *Analysis of the Processes of Heat Exchange on Infrared Heater Surface*, Diagnostyka 3(17) 2016, 81-85
[3] Yurkevich Yu., Spodyniuk N., *Energy-saving infrared heating systems in industrial premises*, Budownictwo o zoptymalizowanym potencjale energetycznym, 2(16) 2015, 140-144
[4] Voloshin O.F., Mashchenko S.O., *Models and methods of decision-making,* Publishing and Printing Center "Kyiv University", 2006, 336 p.
[5] Nakorchevsky A.I., Basok B.I. *Optimal design of ground heat exchangers,* Industrial Heat Engineering, 27(6), 2005, 27-31
[6] Nakorchevsky A.I., Basok A.I., Belyaeva T.G. *Problems of soil heat accumulation and methods of their solution,* Industrial Heat Engineering, 25(3), 2003, 42-50