HEATING FLOOR FOR POULTRY: THEORETICAL AND TECHNOLOGICAL INVESTIGATIONS

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ABSTRACT

Heating floor is the most profitable system of air heating at poultry houses. The tubes with heating elements inside are laid into the layer of concrete. To prevent losses of heat penetration deep into the ground the layer of isolation material is laid below the tubes. The depth of isolation laying in every point of the heating floor may be calculated according to the author's formula using the data of temperature on the floor surface and the tube, the distance between two nearest tubes, and the distance between the tube and the floor surface. Technological investigations allow to estimate the optimal density for geese and ducks when they are bred on the heating floor.

Key Words: Poultry, Heating system, Floor density

INTRODUCTION

Imperfection of the mechanism of bird's thermoregulation on the first days of life required to pay intensive attention to heating regimes. Despite of heating the whole poultry house a local heating system has to be used. Heating floor may be one of the ways to arrange the local heating system for poultry. Usually, the heating floor consists of the tubes with heating elements inside. The researches which were undertaken to determine the efficiency of the heating floor resulted in increasing birds safety of 3-9% in comparison with brooder system (Fortunatov, 1973; Sumkina, 1984; Nekrasov, 1989), decrease the coccidiosis accidents (Yermolayeva, 1969), improving climate conditions (Phelps, 1985; Reinhard et al., 1991). Regimes of heating with the heating floor need less of energy supply than the brooder system (Phelps, 1985; Stolliar and Grigoriev, 1988; Nekrasov, 1989). It is also very important that the litter expenditures should decrease when the heating floor is practicised (Lukianov and Mandazhi, 1993).

At the same time the heating floor system has one drawback: the unequality of the temperature on the floor surface. The temperature over the tube is higher than at the point between two nearest tubes. This fact leads to increasing the bird density in some places of the floor which temperature is most preferable for poultry (Narushin, unpublished). To prevent this it is possible to lay the tubes one near another but such solution increases costs for the heating system.

Technological aspects of breeding waterfowls on the heating floor are not available either at the literature.

To solve the problem on the equality of the temperature on the floor surface and to optimize the density of waterfowls during their breeding this research was undertaken.

THEORY

To prevent losses of heat deep in the ground the isolating material is laid below the sources of heating. In this case the problem of making the even temperature on the floor surface may be solved by changing the depth of laying the isolation layer at different points.

The scheme of the floor heating system is shown in Fig. 1. The distance between the tubes with the heating elements inside is l, and the depth of tubes laying is r. The temperature on the floor surface over the tube axes is maximum and equals to some value t_r. In accordance with Laplase's equation (Shorin, 1952) the temperature t_r is calculated by the formula:

$$t_r = a \ln r + b \ , \qquad (1)$$

in which a and b are experimental constants.

The minimal temperature on the floor surface is over the point located at half distance between two nearest tubes and equals to some value $t_{1/2}$. If to divide the distance between two nearest tubes into n equal parts, the temperature t_n at the point located on the distance l/n from the point with the temperature t_r is estimated according to Eq. (1):

$$t_n = a \ln r_n + b = a \ln(r^2 + l^2/n^2) + b \ , \qquad (2)$$

Then the difference between the temperatures t_r and t_n equals to:

$$t_r - t_n = a\ln r_n + b - a\ln(r^2 + l^2/n^2) - b = a\ln(r^2/(r^2 + l^2/n^2)/2. \qquad (3)$$

The value of heat Q at every point may be estimated using the Fourie equation (Shorin, 1952):

$$Q = \lambda F \tau (t_1 - t_2)/S, \qquad (4)$$

in which Q is the value of heat which is transfered through the layer which thickness is S; $(t_1 - t_2)$ is the difference between the temperatures on the layer borders; F is the square of the surface; τ is the time during which the heat is transfered; and λ is the coefficient of conductivity.

In our case to make the temperature even on the floor surface the value Q_r of heat evolving through the layer of concrete over the tube and one Q_n over the random point located between two nearest tubes has to be equal. Basing on the Eq. (4)

$$Q_r = \lambda F \tau (t_T - t_r)/r, \qquad (5)$$

$$Q_n = \lambda F \tau (t_i - t_n)/S, \qquad (6)$$

in which t_T is the temperature of the tube and t_i is the temperature of the random point on the surface of isolation material. If to equate Eq. (5) and Eq. (6)

$$(t_T - t_r)/r = (t_i - t_n)/S\ , \qquad (7)$$

whence

$$S = r(t_i - t_n)/(t_T - t_r). \qquad (8)$$

The temperature t_i depends on the distance from the nearest tube and may be calculated by Eq. (1):

$$t_i = a\ln r_i + b\ , \qquad (9)$$

in which r_i is the distance between the random point on the surface of isolation material and the floor surface.

For the arbitrary curve of isolation layer (Fig. 2) the distance r_i is estimated according to the cosinus theoreme (Bronstein and Semendiayev, 1986) by the formula:

$$r_i^2 = S^2 + r_n^2 - 2Sr_n\cos\alpha. \qquad (10)$$

At the same time

$$\cos\alpha = r/r_n. \qquad (11)$$

Then

$$r_i^2 = S^2 + r_n^2 - 2Sr = S^2 + r^2 + l^2/n^2 - 2Sr, \qquad (12)$$

and the temperature t_i equals to

$$t_1=\frac{a}{2}ln(S^2+r^2+l^2/n^2-2Sr)+b. \qquad (13)$$

Considering Eq. (13) the formula (8) is rewritten as

$$S=\frac{\frac{a}{2}ln(S^2+r^2+l^2/n^2-2Sr)+b\ -\ \frac{a}{2}ln(r^2+l^2/n^2)-b}{t_{\text{т}}-t_{\text{r}}}\cdot r \qquad (14)$$

or after reformation

$$S=\frac{\frac{2}{ar}(l^2/n^2+r^2)(t_{\text{т}}-t_{\text{r}})+2r}{1-\frac{2}{a^2r^2}(l^2/n^2+r^2)(t_{\text{т}}-t_{\text{r}})^2}\ . \qquad (15)$$

The equation (15) shows the depth of isolation layer at every point of the floor heating system and may be expressed as the function $S(n)$. This function is a saddle curve. In practice the distance between the floor surface and the point of the curve extremum is a fixed value. Usually it is limited with the depth of concrete layer which must provide the safety of the floor surface under a moving tractor. As the extremum of the saddle curve $S(n)$ is located at the distance r_t from the axis of the tube which corresponds to the radius of the tube, its coordinate n equals to the value r_t.

Then, the maximum possible distance between two nearest tubes is defined from Eq. (15):

$$l=r_t\cdot\left[\frac{S_{min}-2r}{\frac{2S_{min}}{a^2r^2}(t_{\text{т}}-t_{\text{r}})^2+\frac{2}{ar}(t_{\text{т}}-t_{\text{r}})}-r^2\right]^{0.5}, \qquad (16)$$

in which S_{min} is the necessary depth of the layer of concrete.

PRACTICAL APPLICATION

Using the results of the theoretical investigations the maximum possible distance between two nearest tubes and the curve of isolation layer were defined by the following initial data: S_{min}=37 mm, r=125 mm, t_T=100°C, t_r=40°C. The heating elements are closed into the tubes which diameters equal to 50 mm.

To define the coefficient a Eq. (1) for the tube surface is rewritten as

$$100=a\ln 25+b \qquad (17)$$

and for the floor surface as

$$40=a\ln 125+b, \qquad (18)$$

whence a=-37.3.

According to Eq. (16) l=450 mm. Substituting the data into Eq. (15) we obtain:

$$S=(5211.8+152n^2)/(67+4.2n^2). \qquad (19)$$

Substituting in Eq. (19) the data of n the curve of isolation layer laid into the concrete was plotted in Fig. 3.

The reliability of the theoretical preconditions and the thechnological regimes of waterfowls breeding on the heating floor were defined experimentally.

MATERIALS AND METHODS

The floor heating system was devised in the poultry house. Two experiments with breeding of Pekin ducks and Obroshinsky geese were undertaken. During the first week 8 groups of ducks and 8 ones of geese were kept on the heating floor with different densities: from 43 to 68 ducks/m^2 and from 20 to 30 geese/m^2. During the second week the birds were kept both on the heated parts of the floor and unheated ones with densities from 24 to 34 ducks/m^2 and from 10 to 15 geese/m^2. The live weight of birds and their mortality were fixed. The temperature at different points on the floor surface was checked automatically.

RESULTS

The temperature at different points on the floor surface was within the interval 40±0.5°C. Such overfalls of the temperature garanteed the even distribution of the birds on the floor surface.

The differences in live weight during the first week between different groups both ducks and geese were not true. Therefore, the optimization was done by the data of birds mortality. The results of the experiment are shown in Table 1. The data show that both low and high densities are not available for waterfowls. High mortality in the groups with low density is apparently explained by the fact of the environmental temperature decrease through decreasing of heat evolving of the birds' bodies. The obtained data were approximated by the formulae:

$$M_d=0.00614D_d^2-0.616D_d+21.527 \qquad (20)$$

$$M_g=50.759-3.897D_g+0.083D_g^2 \ , \qquad (21)$$

in which M_d and M_g are the mortality in per cents of ducks and geese respectively, and D_d and D_g are the densities of ducks and geeses respectively.

The differences in live weights during second week between different groups both ducks and geese were not true and optimization was also done by the data of birds mortality. The results of the experiment are shown in Table 2. The obtained data were approximated by the formulae:

$$M_d=24.714-1324.2/D_d+18530/D_d^2 \qquad (22)$$

$$M_g=1/(0.241+0.0556D_g-0.00297D_g^2) \ . \qquad (23)$$

The extremums of Eq. (20)-(23) were found after the derivatives of the formulae had been equated to 0. The results showed the optimum densities: during the 1st week D_d=50 ducks/m^2, D_g=23.5 geese/m^2; during the 2nd week D_d=28 ducks/m^2, D_g=9.4 geese/m^2.

DISCUSSION

The obtained results may be of great importance when the floor heating system is projected in a poultry house. If the poultry house is intended for breeding of 12,000 ducks the necessary square of heating floor is calculated as a ratio 12,000 ducks:50 ducks/m^2= =240 m^2. In the case of arranging the heating floor along the house which length is 90 m the breadth of the floor heating system is defined as 240 m^2:90 m=2.7 m. Similarly it is possible to determine the dimensions of the floor heating system for geese. For the poultry house which length is 90 m and breeding stock of geese contents 6,000 birds the breadth of the heating floor is 2.8 m. During the second week the birds are kept as on the heating floor as on the unheated one. The optimal temperature during this period helps to determine the distance between the heating floor border and a feeding trough. During the first week the birds are fed from small feed boards which are filled in and mounted on the heating floor surface by an operator. During the second week the birds are fed from the feeding trough which is filled in by feeds mechanically, usually by a tractor. To prevent the birds' stress under the noise of the tractor the feed trough is located along the extreme line of live surface for breeding poultry. To calculate the distance between the border of the heating floor and the feed trough when 12,000 ducks are kept in the poultry house it is necessary firstly to determine their live square: 12,000 ducks:28 ducks/m^2=429 m^2. For the house which length is 90 m the breadth of live square is defined as 429 m^2:90 m=4.8 m. Considering the breadth of the heating floor to be equal to 2.7 m the distance between the heating floor and the feed trough is 2.1 m. Similarly for the poultry house with 6,000 geese the distance to the feed trough is 4.3 m.

CONCLUSIONS

The theoretical and technological investigations may be used when the poultry houses for breeding waterfowls are projected. Using the obtained data the isolation has to be laid according to the deduced formula which garantees the even temperature on the floor surface and minimum number of the tubes with heating elements inside. The results of the theoretical investigations were confirmed by the expirements. The optimal densities for ducks and geese allow to determine the dimensions of the heating floor and the coordinates of the technological equipment inside the poultry house.

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Table 1. Mortality of birds during the 1st week of breeding

Birds density, birds/m^2	Mortality, %
Ducks	
43	6.2
47	7
51	4.2
52	4.6
54	7.6
60	6.8
65	7.7
68	7.3
Geese	
20	5.2
22	5.8
23	4
24	4.2
26	5
28	6.1
29	6.7
30	8

Table 2. Mortality of birds during the 2nd week of breeding

Birds density, birds/m^2	Mortality, %
Ducks	
24	1.6
27	0.6
29	1
31	1.4
34	1.5
Geese	
10	2.2
11	2.3
12	1.8
14	3
15	2.6

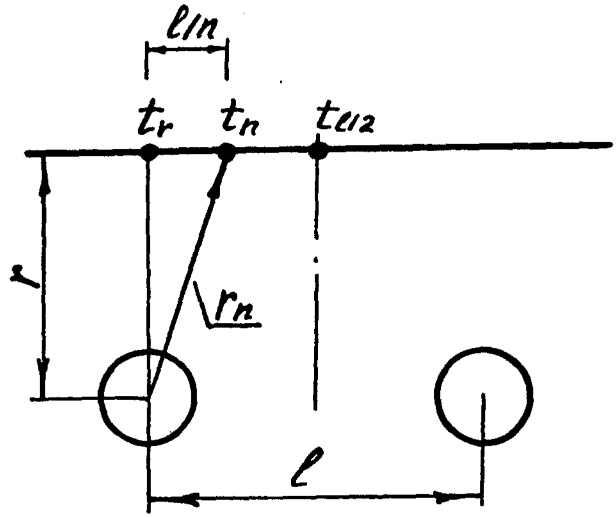

Fig. 1 Scheme of the floor heating system

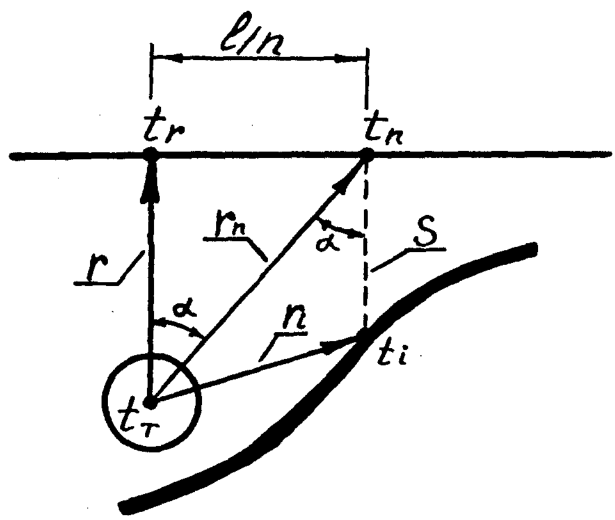

Fig. 2 Scheme of laying of isolation layer

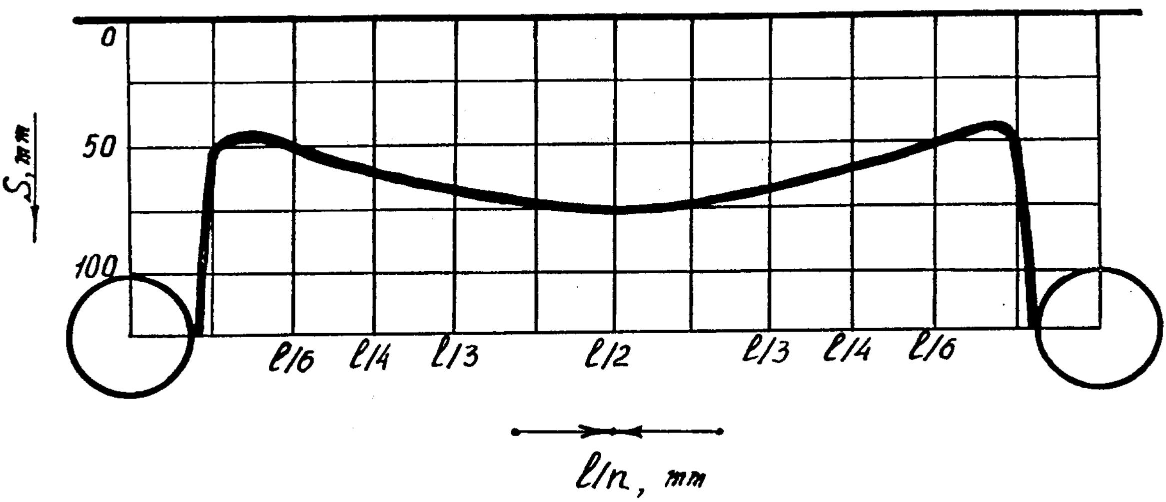

Fig. 3 The curve of laying of isolation layer