CALCULATION OF A HEAT BATTER FOR MAINTAINING TEMPERATURE IN AGRICULTURAL BUILDINGS

K.Sh. Tursunov[1], Zh.D. Sadykov[2], M.Sh. Mirzayev[3], Zh.M. Shohimardonov[4]

[1]Doctor of pedagogical sciences, professor of the department of natural sciences,
[2]Senior lecturer of the department of thermal power engineering.
[3]Senior lecturer of the department of natural sciences,
[4]Lecturer of the department of natural sciences,
Karshi state technical university, Karshi, Republic of Uzbekistan, e-mail: sadikovjd57@inbox.ru

Annotation: В статье рассмотрены теплообменные процессы в сельскохозяйственных сооружениях с подпочвенным аккумулятором тепла и математическая модель с учётом температуры и влажности воздуха.

Key words: Математическая модель, сельскохозяйственное сооружение, теплообмен, аккумулятор тепла.

Introduction. During the winter period with low external temperatures, agricultural facilities must be equipped with combined energy-saving underground heliobiological heating systems [4].

Subject of research. In the work [1], the calculation of temperature regimes in rooms is carried out by modeling the heat exchange process by links (by dividing the room volume into zones). This leads to a sufficiently large discrepancy between the theoretical calculated data and the experimentally observed ones. Therefore, we are solving the problem of the relationship between the temperature in the volume of livestock and poultry buildings, the amount of heat accumulated by the accumulator, and the flow of warm air passing through the substrate layer surrounding the subsoil heat accumulator.

Goals. A mixture consisting of 30% husk (raw cotton processing waste), 30% dry manure, and 40% dry clay was chosen as the substrate material.

Let there be a series of parallel pipes with a diameter equal to the distance d, c between the axes S, immersed in a homogeneous mass h to a depth from its surface F. The temperature of the pipes t_{mp} and the surface of the massif t_F is known, distributed unevenly in the remaining substrate layers. It is required to determine the magnitude of the heat flow through the mass and substrate layers from a separate pipe located alongside other pipes.

Materials and methods. To solve the problem, we apply the source method and the superposition principle. Assuming that the heat flow inside each pipe has a capacity of Q , let's place it symmetrically from the surface of the massif h_0.

$$\theta' = Q\frac{1}{2\pi\lambda}\ln\frac{r_1''}{r_1'}, \qquad \theta'' = Q\frac{1}{2\pi\lambda}\ln\frac{r_2''}{r_2'} \qquad \theta''' = Q\frac{1}{2\pi\lambda}\ln\frac{r_3''}{r_3'}$$

where $r_1', r_1'', r_2', r_2'', r_3', r_3''$ - distances from the point of the pipe to individual moving heat flows of air. When all sources and drains act simultaneously, the total temperature difference at any point can be found by summing the differences:

$$\theta' + \theta'' + \theta''' + ... = \theta_{mp} = t_{mp} - t_F = Q\frac{1}{2\pi\lambda}(\ln\frac{r_1''}{r_1} + \ln\frac{r_2''}{r_2} + \ln\frac{r_3''}{r_3} + ...)$$

Furthermore, considering the boundary conditions of the substrate layer - the upper surface of the heat accumulator $T(0) = T_0$ and $T(L) = T_L$, we can write the following equation for the heat accumulator to release into the room's atmosphere:

$$\pi R^2 k\frac{d^2T}{d\bar{x}^2} + \pi R^2 \rho c_p U\frac{dT}{d\bar{x}} - 2\pi R h_c (T - T_0) = 0 \qquad (1)$$

Here are $f = \dfrac{T - T_0}{T_L - T_0}$ and $x = \bar{x}/R$. $\dfrac{UR}{\alpha} = k$. Taking into account our mathematical modeling, the heat balance equation can be written in the following form:

$$CG(t)\frac{\partial T}{\partial x} + C_V S\frac{\partial T}{\partial t} + KfT = KfT_x \qquad (2)$$

In particular, we write the equation (2) taking into account the initial and boundary conditions:

$$T(0,t) = \tau_P(t), \qquad T(x,0) = T_0(x);$$

For this, the underground heat accumulator with an air duct will be considered a semi-bounded space and from the solution of the direct and inverse Laplace equations we obtain [2]:

By entering a new variable

$$Z = X - S^{-1}\int_{\varphi}^{t} G(\theta)d\theta$$

if we do not take into account the highest temperature values at the "accumulator-atmosphere" boundary under initial conditions 9, then for the subsoil heat accumulator and its surrounding substrate layers, the equation will have the form:

$$T(x,t) = \left[Kf/C\int_0^x \exp\left(-\left(Kf/(CS)\right)\right)\right]\left(t - \varphi(z,x,t)\right) : G\left(\varphi(z,x,t)\right)dz +$$

$$+\exp\left(-\left(Kf/(CS)\right)\left(t - \varphi(0,x,t)\right)\right)\tau_1\left(\varphi(0,x,t)\right), \qquad (3)$$

Results.

By introducing into equation (3) the experimentally determined values of the heat flow rate of the underground heat accumulator G over time t, the heat transfer coefficient of the substrate material К, the amount of heat accumulated by the accumulator over time t (t = nh, h -step time) and the measured values of atmospheric temperature in the room based on a special modeling program, the distribution of heat flow flow along the air duct of the underground battery was established:

$$\varphi = nh - S(l - z)/G((n-1))h$$

and on their basis, expressions of the temperature of the warm air at the input and in the x layer were obtained:

$$T_x = (\frac{nh - S(l - z)}{G(n-1)}) \quad \text{и} \quad \tau_1(\frac{nh - Sl}{G(n-1)h}) \qquad (4)$$

Using the results obtained in the work [3] for the distribution of heat along the air duct and its surrounding substrate, we obtain:

$$T_x(n+1)h - T_T((n+1)h) - Q((n+1)h)/q_0V =$$
$$= \exp(-h/\beta)\left(T_x(nh) - T_T(nh) - Q((n-1)h)/(q_0V)\right), \qquad (6)$$

How easy is it to calculate the amount of heat that needs to be accumulated in the underground heat accumulator to maintain the required temperature in the farm's premises. In addition to the temperature field created by the heat flow from the heated pipe, the substrate soil also has a temperature field from the daily fluctuations in ambient temperature and the substrate's own heat flow. The superposition of these temperature fields complicates the search for the true distribution of temperatures in the substrate.

Conclusions. Thus, a mathematical model of system control has been developed, with theoretical calculations coinciding with the experimentally obtained data in the premises of livestock and poultry farms, where the temperature regime is normalized and optimized, which is maintained by solar bioenergy of the volumetric heating collector of the underground heat accumulator in the pipe and in the substrate around it of the accumulated heat flow flow.

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