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CALCULATION OF TEMPERATURE CHANGES IN THE GREENHOUSE SOIL LAYER USING GEOTHERMAL ENERGY.

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Annotation. *The article presents the results of calculating the change in temperature in the soil layers of a greenhouse, in which a temperate climate is created using solar and geothermal energy. It is shown that the distribution, absorption and accumulation of heat in the soil layers depend on the incoming solar energy, the composition of the soil layer, humidity and on the inclination or smoothness of the soil surface.*

Key words: *heat accumulator, solar energy, greenhouse, temperate climate, fuel and energy resources, chemical and biological processes, thermophysical parameters, thermal free, temperature gradient.*

Introduction

It is known that the effective use of alternative energy sources (solar-geothermal) is one of the most pressing issues in solving the problems arising from the fact that the world's fuel resources are declining from year to year and rising demand is rising. President of the Republic of Uzbekistan Sh. M. According to the Resolution of Mirziyoyev dated November 20, 2018 "On measures to create additional conditions for the development of greenhouse complexes" -.... creation of modern greenhouse complexes using alternative energy sources, energy efficient and energy saving technologies, development of energy saving structures the need arose.

Scientists, doctors and masters of the Department of Agrochemistry and Soil Science and Physics of Karshi State University, engineers and technicians of Muborakneftegaz LLC jointly developed an experimental design of a greenhouse with a working area of $180\,м^2$ hectares for the creation of a temperate climate using solar and geothermal energy. Energy-saving combined modern greenhouse device by conducting research on the accumulation of excess heat generated by solar energy heating the air passing through the transparent surface of the greenhouse and its long-term storage of thermal energy for use at night or chronic cloudy days and the use of geothermal energy on chronic cold days development is a topical issue.

In recent years, in the activities of farms and businesses are used to cover greenhouses with thin transparent polymer films in the coating of engineering structures. In particular, the engineering structures of greenhouses are made of metal and the upper transparent surface is covered with polymer films with a thickness of 0.1-0.5 mm [1-3]. When studying the quantitative characteristics of sunlight transmission on the transparent surface of a greenhouse device, it is often important that the sunlight transmits infrared spectrum (heat) well, which is solved in engineering devices, especially using conventional methods of building physics in shaping the thermal regime of greenhouses. On this basis, it is important to study the problem of heat mass transfer in the indoor air-soil system under the influence of solar energy passing through the transparent surface of the greenhouse coverings [4-5]. Therefore, the heating of the air inside the greenhouse requires an experimental study of the processes of radiation and convective heat exchange. Also, in the study of this process, the optimal heat exchange can be solved by theoretical methods and compared with the results of experimental studies, the greenhouse is evaluated in accordance with the optimal accumulation of geothermal heat in the working soil layer, plants and surrounding devices. This article also presents a system for solving the problem of developing and researching a simplified and generalized physical model of the nonstationary heat exchange regime formed in the soil and air system of plants grown in greenhouses using solar energy and geothermal heat energy.

Normal development of the plant in the greenhouse The root layer In order to conduct theoretical and experimental studies of the soil temperature in the soil: special attention is paid to achieving energy savings by reducing the amount of heat lost to the environment through the introduction of new technologies in the process of heat exchange in the heat accumulator. To solve the problem, it is planned to apply the results in the process of compositional synthesis and design using a special methodology of technological and technical research in the greenhouse, which creates a temperate climate using solar and geothermal energy. Figure 1 shows a schematic of an experimental variant of an energy-saving greenhouse using solar and geothermal energy with a heat accumulator.

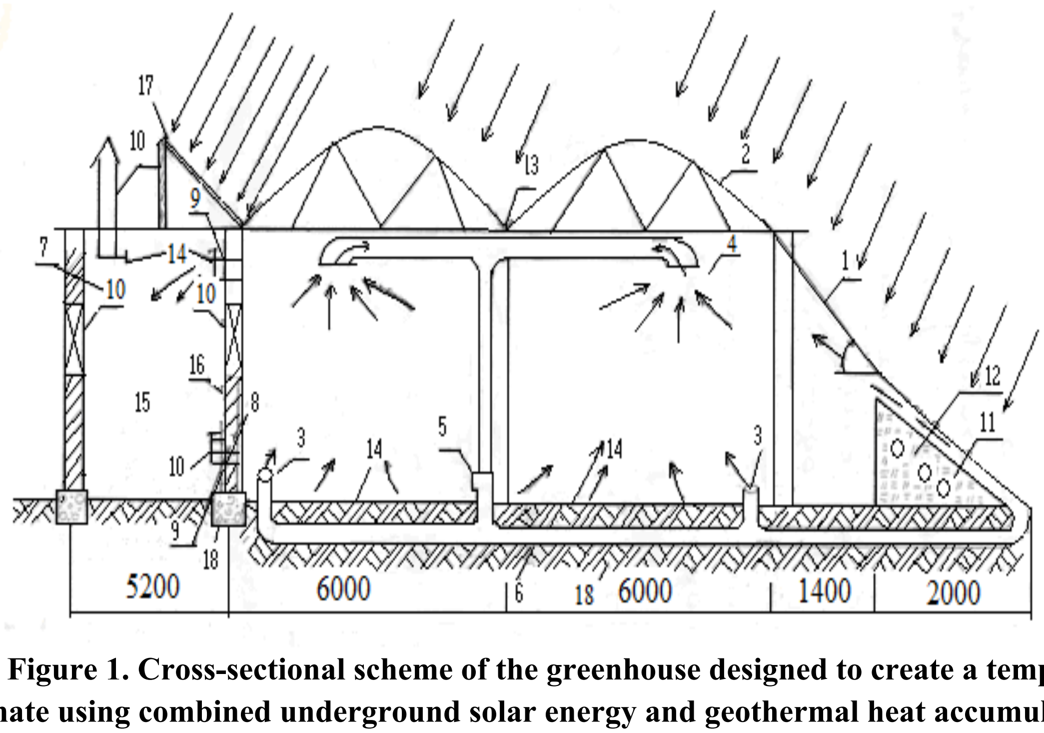

Figure 1. Cross-sectional scheme of the greenhouse designed to create a temperate climate using combined underground solar energy and geothermal heat accumulator energy, built and commissioned at the subsidiary farm of Muborakneftegaz LLC

Here:

1-is the main clear surface through which sunlight passes;

2 extra transparent surface through which sunlight passes;

3 air pipe coming out of the underground heat accumulator;

4- Pipe for suction of air inside the greenhouse;
5 Air suction drive pump device;
6 pipe with a diameter of 0.20 m made of underground composite material;
7- Poultry house;
8- Fan for automatic control of air circulation from the greenhouse to the building where the poultry is kept;
9- a ventilation window that provides moderate airflow to the building where the birds are reared;
10 upper and lower ventilation window;
11- geothermal-hot water circulating pipe located in the underground heat accumulator of the greenhouse;
12- soil layer with geothermal hot water circulation pipe; 13-tarnov; 14th greenhouse working area;
15-volume air heating collector (greenhouse);
16 - flat barrier wall separating the poultry house from the greenhouse;
17 solar solar and complex automatic control device for heating in winter and early spring using solar-geothermal energy, ventilation in summer and autumn, year-round lighting, power supply of water supply devices;
18 Substrate layer for heat accumulation around the underground heat pipe; (16 - 18^0 C)

In the analysis of the technical solution of the greenhouse, an experimental version of the device was designed and tested at the subsidiary farm of Muborakneftegaz LLC. The results of the experiment show that reducing the consumption of metal in the construction of the greenhouse, reducing the amount of heat consumed in the environment, to achieve the optimal efficiency of the criterion of the amount of heat accumulated in the heat accumulator, The temperature in the soil in the root layer of the plant in winter (16-18^0 C) and due to the fact that the moisture regime is not less than 60%, the yield (in the process of growing tomatoes) was 10-12 kg per 1$м^2$ of working area. The study took into account the effects of solar light energy and underground geothermal hot water temperature. This is important for the plant-fed root layer of the soil. This is because as a result of solar light energy being heated from above and below the ground by geothermal hot water pipes during the day, the temperature of the soil in the root layer where the plant develops in the affected area can be negative. Therefore, in order to normalize the temperature in the soil layer for the normal development of the plant in the greenhouse, it is necessary to study the effectiveness of the use of geothermal hot water energy on days when solar energy is insufficient.

The amount of geothermal hot water supplied to the greenhouse through underground pipes depends on the solar light energy passing through the clear surface, meteorological factors, and the setting of boundary conditions in the study of the temperature field of the soil layer in which the plant develops. To do this, we first consider the following thermal physical problem. ва

The soil layer is homogeneous and its boundary is M_3M_a, the density of the periodic solar light energy flux is equal to q and q_n. We determine the temperature change in the soil layer D and the area D_1 of the soil layer over time τ (day).

1. Reliability characteristic of the developed mathematical model.

The air temperature and humidity control system in greenhouses is one of the most important systems, and to develop this process on the basis of modeling requires the study of all thermal-energy and physicochemical characteristics in two perfect states by analysis and synthesis methods.

To solve the problem, the following simplification factors were used: We define the process of thermal radiation associated with the passage of solar energy through a clear surface meteorological, thermal characteristics, structural and thermal characteristics, convective air circulation system, geothermal heat flow, soil heat, melerative characteristics. Based on the results of the experiment, the average value of the thermophysical parameters in the soil layer in accordance with the determined soil temperature and humidity is taken into account.[11]. According to the isotropic characteristics of the soil layer, the greenhouse length (axis) temperature change gradient is zero, and therefore in this case the chemical and biological processes in the two-dimensional system do not affect the heat transfer in the soil layer. (Figure 2).

The complex factors listed above are taken into account to solve a large-scale engineering problem with the system of a simplified mathematical model of the process of heat exchange in the greenhouse.

We express the heat transfer equation for the soil layer where plant growth is ensured as follows.

$$\frac{\partial t}{\partial \tau} = a\left(\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2}\right) \tag{1}$$

$M_3 M_a$ - boundary condition in the field

$$-\lambda \left.\frac{\partial t}{\partial y}\right|_{y=0} = \alpha(t_x - t) + A_s BJ \tag{2}$$

OM_3 and $M_a M_r$

$$\lambda \left.\frac{\partial t}{\partial y}\right|_{y=ON=M_r M} = 0 \tag{3}$$

$$-\lambda \left.\frac{\partial t}{\partial y}\right|_{y=0} = \alpha_H (t_x - t) + A_s J \tag{4}$$

ON and $M_r N$ in the direction of

$$\left.\frac{\partial t}{\partial x}\right|_{x=0} = 0; \quad \left.\frac{\partial t}{\partial x}\right|_{x=OM_r} = 0; \tag{5}$$

$$\left.\frac{\partial t}{\partial x}\right|_{x=0} = a\frac{\partial^2 t}{\partial y^2} \tag{6}$$

$$\left.\frac{\partial t}{\partial x}\right|_{x=OM_r} = a\frac{\partial^2 t}{\partial y^2} \tag{7}$$

$$\left.\frac{\partial t}{\partial y}\right|_{y=ON} = \left.\frac{\partial t}{\partial y}\right|_{y=M_r M} = 0 \tag{8}$$

D and D_1 in the field

$$t_{D,D_1} = \begin{cases} T, DO\tau \le \tau_1 \\ t,\ \tau > \tau_1 \end{cases} \quad \text{when} \tag{9}$$

initial condition $t = t_0(0, x, y)$ (10)

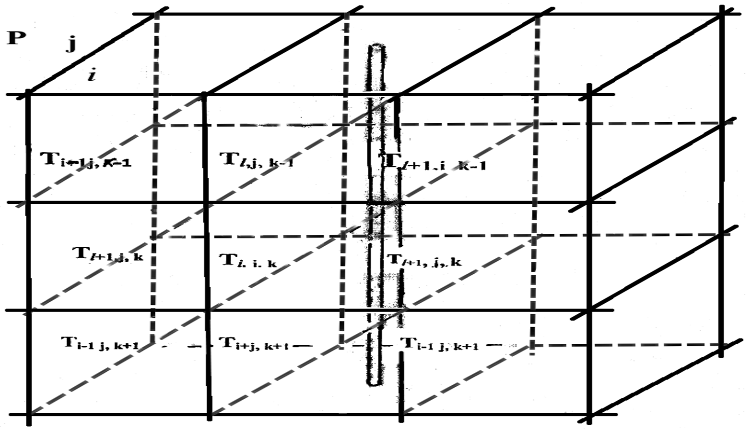

Figure 2. Scheme of the model for calculating the temperature change in the soil layer of the greenhouse, which creates a temperate climate regime using solar geothermal energy.

Hence, a mathematical model of the problem based on equations (1-10) is formed.

The heat transfer equation for the soil layer and the vertical boundary of the greenhouse is one-dimensional and is expressed in equations (6) and (2), the temperature gradient in the horizontal direction characterized by equation (5) is assumed to be zero.

When equations (1) - (10) are solved using the method of boundary differences [5-9], the temperature change over time in the area of the soil layer up to the plant root layer takes the following form.

$$\frac{t_{i,j}^{n+1}-t_{i,j}^{n}}{h_\tau} = a\left[\frac{t^{n}_{i+1},_{j} -2t^{n}_{t,j} + 2t^{n}_{i-1,j}}{h_x^2} + \frac{t^{n}_{i,j+1} - 2t^{n}_{i,j} + t^{n}_{i},_{j+1}}{h'_y}\right] \qquad (11)$$

$$-\lambda \frac{t_{i,1}^{n+1}-t_{i,0}^{n+1}}{h_y} = \lambda\left(t_x^{n+1} - t_{i,o}^{n+1}\right) + A_s B J_1 \qquad (12)$$

$$\lambda\frac{t^{n+1}_{i,N+1}-t^{n+1}_{i,N}}{h_y}=0 \qquad (13)$$

$$-\lambda \frac{t_{i,1}^{n+1}-t_{o,j}^{n+1}}{h_y} = \alpha_H\left(t_0^{n+1}-t_{i,o}^{n+1}\right)+A_s J \qquad (14)$$

$$\lambda\frac{t^{n+1}_{1,j}-t^{n+1}_{o,j}}{h_x}=0; \quad \frac{t^{n+1}_{M_r+1,j}-t^{n+1}_{M_r,j}}{h_x}=0; \qquad (15)$$

$$\frac{t^{n+1}_{o,t}-t^{n+1}_{o,j}}{h_\tau} = a\frac{t^{n}_{o,j+1}-2t^{n}_{o,j}-t^{n}_{o,j-1}}{h_y^2} \qquad (16)$$

$$\frac{t^{n+1}_{M_r,}-t^{n+1}_{o,j+1}}{h_\tau} = a\frac{t^{n}_{M_r,j+1}-2t^{n}_{M_r,j}+t^{n}_{M_r,j-1}}{h_y^2} \qquad (17)$$

$$\frac{t^{n+1}_{1,N+1}-t^{n+1}_{i,N}}{h_y} = \frac{t^{n+1}_{i,N+1}-t^{n+1}_{i,N}}{h_y}=0 \qquad (18)$$

$$t_{D,D_1}^{n+1} = \begin{cases} T & n = 0,1,2,\ldots\ldots 15, \quad \text{when} \\ t_{M_{3+1},N}^{n+1} = t_{M_{x+2},N}^{n+1} & 15 \leq 3b \quad \text{when} \end{cases} \qquad D, D_1 \text{ while in the field} \tag{19}$$

$$t_{D,D_1}^{n+1} = t_{M_{s-i,},N}^{n+1} = t_{M_{3,N}}^{n+1} = t_{M_{3+1}}^{n+1} = t_{M_{3,N-1}}^{n+1} = t_{M_{3,N}}^{n+1} = t_{M_{3,A+1}}^{n+1} =$$
$$= t_{M_{x-,N1}}^{n+1} = t_{M,A}^{n+1} = t_{M_{x+1,N}}^{n+1} = t_{M_{x,N-1}}^{n+1} = t_{M_{2,N+1}}^{n} \tag{20}$$

From equations (1-1) and (1-10), the magnitude representing the temperature change sought is determined

$$t_{i,j}^{n+1} = \frac{t_{i+1,j}^{n} + t_{i-1,j}^{n} + t_{i,j+1}^{n} + t_{i,j-1}^{n}}{4} \tag{21}$$

$$t_{i,o}^{n+1} = \frac{h_y \cdot t_{i,1}^{n+1} + \alpha \cdot \lambda \cdot t_x^{n+1} + BA_s \cdot J \cdot h_y}{\alpha\lambda + h_y} \tag{22}$$

$$t_{i,N+1}^{n+1} = t_{i,N}^{n+1} \tag{23}$$

$$t_{i',0}^{n+1} = \frac{h_y \cdot t_{i',1}^{n+1} + \alpha_H \cdot \lambda \cdot t_{BH}^{n+1} + A_s \cdot J \cdot h_y}{\alpha_H \lambda + h_y} \tag{24}$$

Here

$$\begin{gathered} i' = 0,1,2,\ldots\ldots M_3, M_x < i' < M_3 \\ i' = M_x, M_{x+1}, M_x + 2,\ldots\ldots M_r \\ t_{i,j}^{n+1} = t_{o,j}^{n+1}; \quad t_{M_{r+1}}^{n+1} = t_{M_{r,j}}^{n+1} \end{gathered} \tag{25}$$

$$t_{o,j}^{n+1} = \frac{t_{o,j+1}^{n} + t_{o,j'-1}^{n}}{2}, \quad j = 1,2,\ldots\ldots N \tag{26}$$

$$t_{M_r j}^{n+1} = \frac{t_{M_{r/j+1}}^{n} + t_{M_r,j-1}^{n}}{2}, \quad j = 1,2,\ldots\ldots\ldots N(N = 17) \tag{27}$$

$$t_{i,N+1}^{n+1} = t_{i,N}^{n+1} \tag{28}$$

In a greenhouse where a temperate climate is created using solar and geothermal energy, the temperature change in the soil layer in which the plant is grown (Fig. 3) is initially sequentially in a horizontal direction.

$t_{o,j}^{n+1}$, $t_{1,j}^{n+1}$; $t_{2.j}^{n+1},\ldots\ldots t_{M_{r.j}}^{n+1}$ then in the vertical direction

$t_{i,o}^{n+1}$, $t_{i,1,}^{n+1}\ldots t_{i,2}^{n+1},\ldots\ldots t_{i,N}^{n+1}$ is calculated.

In performing all the calculations, h_τ, h_x, h_y was determined on the basis of step-by-step shifts per unit time $\alpha, \alpha_H, t_x, B, J, A_s, \lambda$, and other quantities were determined on the computer according to the C^{++} programming program based on the experimental results (Figure 3). Also, the infiltration of the air temperature inside the greenhouse into the soil layer over a period of

$\Delta\tau = \dfrac{\Delta x^2}{2a}$ is determined by the following formula for the temperature change in each adjacent layer:

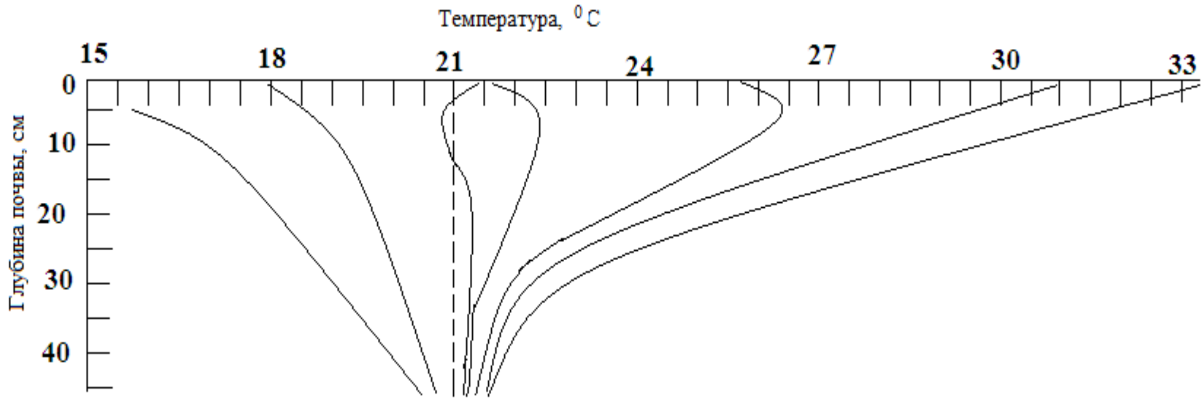

Figure 3. Periodic temperature distribution in depth per unit time in the greenhouse soil cover heated by solar and geothermal energy.

As can be seen from the graph, over time, the distribution of heat waves along the depth of the greenhouse soil layer periodically reaches a constant extinction state at 36 cm.

$$t_{(n+1)\Delta\tau, m\Delta x} = \frac{(m+1)\Delta x + t_{m\Delta\tau}(m-1)\Delta x}{2} \qquad (29)$$

here $n, \Delta\tau -$ time piece number, $m -$ layer number.

1. Thermal regime of a greenhouse soil layer heated using combined solar and geothermal energy

When using solar and geothermal energy, if the change in air temperature in the greenhouse is known, the boundary of the soil where heat is accumulated is not known, it is calculated from the following formula by convection heat transfer coefficient, amount of absorbed light energy and physical and chemical properties of the body:

$$t_{n\Delta\tau, o\Delta x} = \frac{\gamma\Delta x t_{xaво} \lambda t_n \Delta\tau, \Delta x + Q_o \cos i A_s \Delta x}{\lambda + \gamma\Delta x} \qquad (30)$$

Here: $\lambda -$ thermal conductivity of the soil; $c -$ the heat capacity of the soil; $\gamma -$ soil density; Q_0 – the amount of incident light energy; $i -$ the angle of incidence of light on the soil surface; A_s – the coefficient of absorption of incident light by the soil; $Q_0 A_s \cos i -$ the amount of light energy absorbed by the soil.

By studying the propagation of heat waves in the soil of the greenhouse by this method, it is possible to calculate the amount of energy accumulated in it during the day. Hence, the energy stored in the soil of the solar greenhouse [12]

$$Q_a^T = C\rho V_{nc} \Delta\bar{t}_1 \qquad (31)$$

using the formula.

Here $C -$ The average temperature is the appropriate soil capacity, $\rho -$ density, V_{nc} – the volume of the heated layer, Δt_1 – the average temperature of the heated layer.

The soil of a solar greenhouse is a specific regenerative structure, because heat exchange in this case is also divided into two periods: in the first period, heat is transferred to the soil and accumulated during heat radiation and convective heat exchange. In the second period, the soil begins to cool and heat is transferred to the air, creating a microclimate in the solar greenhouse [13-16].

Calculate the distribution of heat waves in the soil in the grooves. It is known that the accumulation of sunlight (energy) in the soil can be calculated according to Fure's law:

$$q_T(\tau) = -\lambda \frac{\partial t_\Pi}{\partial x}\bigg|_{x=0} \tag{32}$$

Here $\partial t_\Pi / \partial x -$ gradient of temperature change at the soil surface, $\lambda -$ thermal conductivity in the layer close to the soil surface.

Also for a coarse-grained sloping soil layer $t_\Pi(x,\tau) = const$ the differential equation related to the thermal conductivity in the boundary condition can be expressed and solved by the following form:

$$t_\Pi(x,\tau) = t_{\Pi_0} + e^{-x\sqrt{\frac{\omega}{2a}}}\left[t_{\Pi_1}\cos(\omega\tau - x)\sqrt{\frac{\omega}{2a}} + t_{\Pi_2}\sin(\sigma\tau - x\sqrt{\frac{\omega}{2a}})\right] \tag{33}$$

(33) formula $\frac{\partial t_\Pi}{\partial x}\bigg|_{x=0}$ we set the magnitude to (34):

$$q_F(\tau) = \lambda\sqrt{\frac{\omega}{2a}\left[(t_{\Pi_1} + t_{\Pi_2})cos(\omega\tau) - (t_{\Pi_1} - t_{\Pi_2})\sin(\omega\tau)\right]} \tag{34}$$

Based on this, the accumulation current of sunlight falling during the year can be calculated by the following formula due to the half-oscillation:

$$Q_{\frac{z}{z}} = \int_{\tau_1}^{\tau_2} q_F(\tau)\cdot\partial\tau \tag{35}$$

To do this, use formula (36)

$$q_F(\tau) = \lambda\sqrt{\frac{\omega}{2a}}\sqrt{t_{n_1}^2 + t_{n_2}^2}\left[\frac{t_{n_1} + t_{n_2}}{\sqrt{t_{n_1}^2 + t_{n_2}^2}}\cos(\omega\tau) - \frac{t_{n_1} + t_{n_2}}{t_{n_1}^2 + t_{n_2}^2}\sin(\omega\tau)\right] \tag{36}$$

we see.

Pour (35) into (36).

$$q_F(\tau) = \lambda\sqrt{\frac{\omega}{2a}}\sqrt{t_{n_1}^2 + t_{n_2}^2}\left[\cos(\omega\tau)\sin(\omega\tau)cos\varphi\right] = \lambda\sqrt{\frac{\omega}{2a}}\sqrt{t_{n_1}^2 + t_{n_2}^2}\int_{\tau_1}^{\tau_2}\sin(\omega\tau + \varphi)\partial\tau \tag{37}$$

we can Pour $q(\tau)$ into (36).

$$Q_{\frac{z}{z}} = \lambda\sqrt{\frac{\omega}{2a}}\sqrt{\frac{\omega}{a}\cdot\frac{2}{\omega}}\sqrt{t_{n_1}^2 + t_{n_2}^2} = 2c\rho\sqrt{\frac{a}{\omega}(t_{n_1}^2 + t_{n_2}^2)} \tag{38}$$

and we will be able to determine the amount of solar energy falling on the sloping cores. Here $\sqrt{t_{n_1}^2 + t_{n_2}^2}$ expression characterizes the maximum change in temperature amplitude in the soil layer on the slope of the ridge.

From calculations

$$c = 830\frac{J}{kg \cdot K}, \quad \rho = 1340\frac{kg}{m^3}, \quad \alpha = 0{,}0032\frac{m^2}{soat}, \quad t_{n_1} = 15{,}4 \quad va \quad t_{n_2} = -5{,}5$$

$$Q_z = 2 \cdot 8301340\sqrt{\frac{0{,}0032}{0{,}262}} \cdot (15{,}4^2 + 5{,}5^2) = 961{,}0\frac{Кэж}{m^2 \cdot s} \tag{39}$$

This amount is 36 percent of the solar energy absorbed by the flat soil surface. If the soil is sloping $t_{n_1} = 20{,}3$ and $t_{n_2} = 8{,}6$

$$Q_z = 2 \cdot 8301340\sqrt{\frac{0{,}0032}{0{,}262}} \cdot (20{,}3^2 + 8{,}6^2) = 630{,}0\frac{Кэж}{м^2 \cdot s} \tag{40}$$

This is 42.6 percent of the solar energy absorbed by the soil. It can be seen that the solar energy falling on the slopes, which are normally fed with local fertilizers, is absorbed and accumulated in a much higher amount than on the flat soil surface. Therefore, it can be concluded that in the cultivation of plants (tomatoes, cucumbers) in the greenhouse, taking into account the sunlight and geothermal heat energy that enters and absorbs into the soil during the use of solar light energy and geothermal heat energy, heat waves propagate in the soil. This allows the plant to provide sufficient temperature and light energy for growth.

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