OF FLAT COLLECTOR OPTIMIZATION STRUCTURE FOR WATER HEATING WITH COMBINED SOLAR AND BIENERAGE

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Abstract. *The paper presents a method for solving the differential equation of heat and mass exchange processes of two contour flat solar and bioenergy water and air heating collectors of a new parameter - reduced to a unit area for optimal parameters of the design of the front surface of their bodies of the heat exchange panel and its internal heat-removing channel and as a result of obtaining the corresponding numerical values in the "MATLAB" program.*

Keywords: *modern technologies, energy, collector, two-circuit, heat mass, mathematician model, structural elements*

It is important to increase its efficiency by improving the hot water-air extraction technology using combined two-contour solar and bioenergy.Today's experts need to solve the problem of achieving quality efficiency and energy savings by developing the optimal device of solar and bioenergy-heated water-air system collector and equipping it on the basis of modern technologies [1,2].The optimal variant of the collector using two-circuit solar and bioenergy collectors for water heating for farms in the study of thermal-physical processes, its optimization was determined by numerical methods of the system of equations.Water heating using solar and bioenergy was calculated by solving a system of differential equations of heat exchange and heat-mass transfer in a flat two-contour collector.To do this, we developed a mathematical model of a flat collector. In Figure 1, he developed a mathematical model of the flat two-contour helio collector by dividing it into elementary parts and expressing it in special multiplicative differential equations, in which the heat exchange in the flat heliocollector, the structural elements of the device: in particular, 1 flat black light absorbing metal sheet flow systems, 4- heat-insulating coating, 5- flat heliocollector glass-coated transparent surface, we express the system of special differential equations as follows:

$$\delta_n \rho_n C_n \frac{\partial T_n}{\partial t} = KE + \lambda_n \delta_n \frac{\partial T_n}{\partial x^2} - U_{n.,c}(T_n - T_c) - U_{n,ж}(T_n - T_ж) \quad (1)$$

$$\delta_ж \rho_ж C_ж \frac{\partial T_ж}{\partial t} = U_{n.,ж}(T_n - T_ж) - U_{ж,g}(T_ж - T_g) - C_ж G_{gd} L_n \frac{\partial T_ж}{\partial x} \quad (2)$$

$$\delta_g \rho_g C_g \frac{\partial T_g}{\partial t} = \lambda_g \delta_g \frac{\partial^2 T_n}{\partial x^2} - U_{n.,c}(T_n - T_c) - U_{n,ж}(T_n - T_ж) \quad (3)$$

$$\delta_u \rho_u C_u \frac{\partial T_u}{\partial t} = U_{g.,u}(T_g - T_u) - U_{u,ac}(T_u - T_{a,c}) \quad (4)$$

$$\delta_c \rho_c C_c \frac{\partial T_u}{\partial t} = U_{n.,c}(T_n - T_c) - \alpha_{c,ac}(T_c - T_{o,c}) - \alpha_{c,neb}(T_u - T_{neb}) \quad (5)$$

The initial and boundary conditions for solving this system of differential equations are expressed as follows:

$$T(o,x) = T_{0,c}(o) \quad (6)$$

$$\frac{\partial T_n(t,o)}{\partial x} = 0, \qquad \frac{\partial T_n(t,L_k)}{\partial x} = 0 \quad (7)$$

$$\frac{\partial T_g(t,o)}{\partial x} = 0, \qquad \frac{\partial T_g(t,L_k)}{\partial x} = 0 \quad (8)$$

$$T_ж(t,o) = T_{ж,bx}(t) \quad (9)$$

The coefficient of heat transfer associated with the absorption of black light passing through the flat surface of the flat heliocollector and the absorption of black paint on the coated sheets and pipes and the flow in the water pipes is determined by the following formula:

$$U_{n,ж} = \left(\frac{\delta_n}{2\lambda_n} + \frac{1}{\alpha_{n,ж}}\right)^{-1} \quad (10)$$

The default dimension here: $\alpha_{n,ж} = \frac{\lambda_ж \cdot \overline{Nu}_{n,ж}}{l_0}$ $l_o = 2\delta_ж$ –

The flow of water through flat parallel sheets for heat exchange in the laminar mode was studied by the academic M.A. We use Mikheev'sNusselt equation [3]:

$$\overline{N}u_{n,ж} = 1{,}4(\mathrm{Re}_{ж}\cdot\frac{l_0}{L_{уч}})^{0,4}\,\rho r_{ж}^{0,33}\cdot(\frac{\rho r_{ж}}{\rho r_n})^{0,25} \quad (11)$$

Here we separate the part of the flat heliocollector pipe to determine the average temperature of the water. The coefficient of heat exchange between a black painted flat metal sheet and a stream of water

$$U_{ж,g} = (\frac{\delta_g}{2\lambda_g} + \frac{l_0}{\lambda_{ж}\cdot Nu_{gж}})^{-1} \quad (12)$$

determined from the formula.

Here: $$\overline{N}u_{g,ж} = 1{,}4(\mathrm{Re}_{ж}\cdot\frac{l_0}{L_{уч}})^{0,4}\,\mathrm{Pr}_{ж}^{0,33}\cdot(\frac{\mathrm{Pr}_{ж}}{\mathrm{Pr}_g})^{0,25}$$

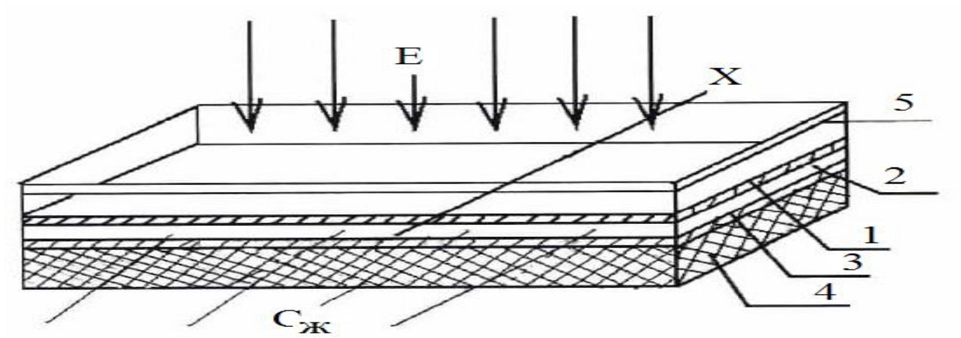

Figure 1. The model of the flat solar collector is divided into elementary volumes of the "list" type with a black bottom. 1- The bottom of the solar collector consists of a black sheet, which characterizes the process of light absorption; 2- heated water flow; 3- solar collector tubes; 4th heat-insulating layer; 5- light-reflecting transparent surface;

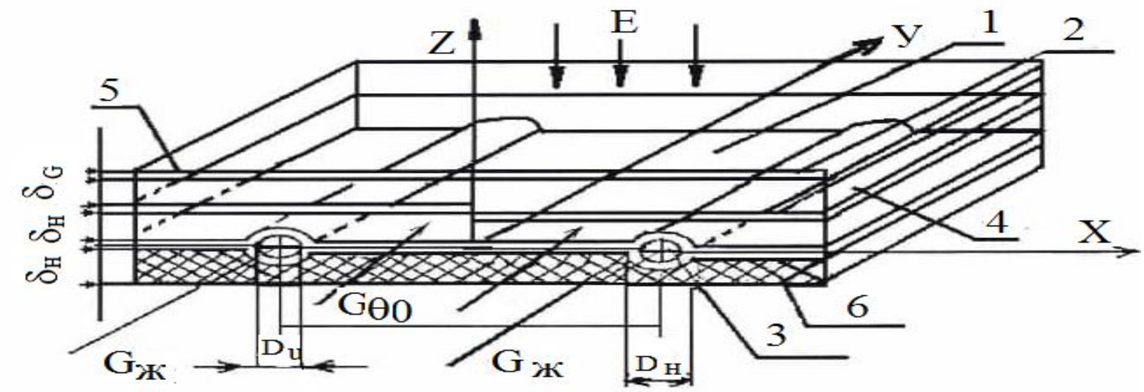

Figure 2. Elemental size of solar collector for flat hot water heating: 1-heat exchange surface; 2- trumpet; 3rd heat-insulating layer; 4; 5- clear surface transmitting internal and external sunlight; 6th heat-insulating layer;

Figure 2 shows a schematic diagram of the elemental volume of a hot water heating solar collector and is used for two purposes:

1) Helio air heater for air heating;

2) Water heater using solar and bioenergy for water heating;

Water is circulated through the collector pipes. The air circulates through two metal sheets that absorb light with black paint and the bottom of a clear surface (glass). The mathematical model for determining the characteristics of heat transfer and technological processes in blackboard plates in the case where the solar air heater is designed for use as a double collector covered with double glazing is composed of the following system of differential equations. These equations are expressed as follows:

$$\delta_n \rho_n c_n \frac{\partial T_n}{\partial t} = \lambda_n \delta_n \left(\frac{\partial^2 T_n}{\partial x^2} + \frac{\partial^2 T_n}{\partial ó^2}\right) + KE - \alpha_{n,âo}(T_n - T_{âî}) - \alpha_{n-c1}\ (T_n - T_{c1}) - U_{n,u}(T_n - T_u); \quad (13)$$

Here for the trumpet:

$$\rho_T c_T \frac{\pi(D_k^2 - D_b^2)}{4D_н} \cdot \frac{\partial T_T}{\partial t} = \lambda_T \frac{\pi(D_н^2 - D_b^2\ )}{4D_n} \cdot \frac{\partial^2 T}{\partial y^2} - \frac{2\lambda_n \delta_n}{D_H} \cdot \frac{\partial T_n}{\partial x}\Big|_{x=\frac{w-D_H}{2}} + \quad (14)$$

$$KE \cdot U_{T,жс}(T_T - T_{жс}) - \alpha_{T,bo}(T_T - T_{bo})\ - \alpha_{T-c1}\ (T_T - T_{c1}) - U_{T,u}(T_T - T_u)$$

The heat storage layer of a water heater using solar and bioenergy, as well as the system of equations for air flows are described as follows.

$$\rho_{жс}c_{жс}\frac{\pi D_b^2}{4D_H}\cdot\frac{\partial T_{жс}}{\partial t}=U_{T,жс}(T_T-T_{жс})\ -\frac{c_{жс}G}{D_H}\cdot\frac{\partial T_{жс}}{\partial y}\quad(15)$$

$$\delta_u\rho_u c_u\frac{\partial T_u}{\partial t}=U_{n,u}(T_a-T_u)-U_{u,oc}(T_u-T_{a.c})\qquad(16)$$

For the inner layer of the two-layer transparent surface of the solar water heating and air heating solar collector:

$$\delta_{во}\rho_{во}c_{во}\frac{\partial T_{во}}{\partial t}=\alpha_{a,во}(T_a-T_{во})-\alpha_{во,c1}\ (T_{во}-T_{c1}\ )-c_{во}G_{возд}L_k\frac{\partial T_{во}}{\partial y}\qquad(17)$$

$$\delta_{c1}\rho_{c1}c_{c1}\frac{\partial T_{c1}}{\partial t}=\alpha_{a,c1}(T_a-T_{c1})-\alpha_{во,c1}\ (T_{во}-T_{c1}\ )-U_{c1,c2}(T_{c1}-T_{c2})\ (18)$$

For the outer layer of a light-transmitting transparent surface:

$$\delta_{c2}\rho_{c2}c_{c2}\frac{\partial T_{c2}}{\partial t}=\alpha_{c1,c2}(T_{c1}-T_{c2})-\alpha_{c2,ac}\ (T_{c2}-T_{ac}\ )-\alpha_{c2,Heb}(T_{c2}-T_{Heb})\,(19)$$

For the system of equations (13) - (19), the initial and boundary conditions in the characterization of the heat exchange processes in the solar air heating solar collector are expressed as follows:

$$T(0,x,y)=T_{o.c.(o)};\qquad\frac{\partial T_T(t,x,o)}{\partial y}=0,\qquad\frac{\partial T_T(t,x,L_k)}{\partial y}=0;\quad(20)$$

$$-\lambda_n\delta_n\frac{\partial T_n(t_1\frac{w-D_H}{2},y)}{\partial x}=\frac{4\lambda_T(D_H-D_b)}{\pi(D_H+D_b)}\left[T_n(t,\frac{w-D_H}{2},y)-T_T(t,y)\right]\qquad(21)$$

$$\frac{\partial T_n(t,o,y)}{\partial x}=0,\qquad\frac{\partial T_n(t,x,o)}{\partial y}=0;\qquad\frac{\partial T_n(t,x,L_k)}{\partial y}=0$$

$$T_{жс}(t,o)=T_{жс,bx}(t);\qquad T_{bo}(t,o)=T_{bo,bx}(t)\qquad(22)$$

This mathematical model, designed for a list-type solar collector, was originally calculated by a numerical method based on the computer programming system "MATLAB" for a special case in which the air flow is not circulating, hot water is circulating, and the experimental results are compared in Figure 3.

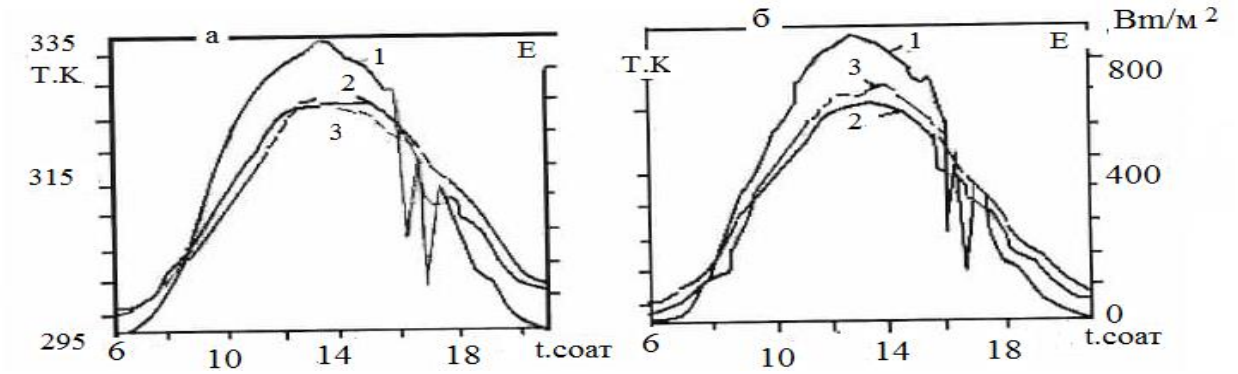

Figure 3. The results of experimental and theoretical research on solar water heating solar collectors of the combined list pipe (a), "list" (b) types are compared. (November 21-22, 2020) 1- Total solar radiation falling on the transparent surface of the solar collector, W / m2; 2- On the basis of theoretical research; 3- Experimental results of the temperature of water entering and leaving the solar collector.

Figures 4-7 show the results of theoretical research on a two-circuit solar collector tested as a water heater using solar energy of the "list" type.

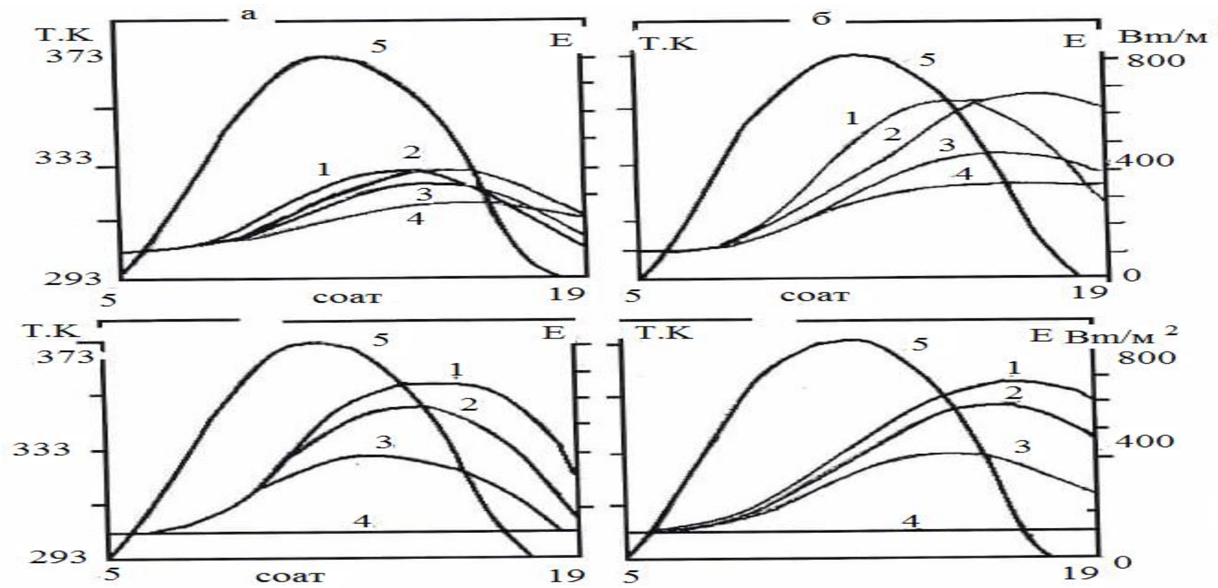

Figure 4. The thickness of the water layer in a water heater using two-circuit solar and bioenergy type "List" is $\delta_{ж} = 0{,}01(1),\ 0{,}02(2),\ 0{,}05(3),\ 0{,}1(4)$ *m and the specific water consumption* $G_{ж.уд} = 0{,}0042\,(a)$ *and*

$$0{,}0014\,(б)\,кг./(м^2 \cdot c);\ \ G_{ж,уд} = 0{,}0014\,(1),\ 0{,}0021\,(2),\ \ 0{,}0042\,(3)$$

the temperature of the water entering the heliocollector, $T_{ж.вх} = T_{ar.m} = 343k$ *(23) and the ambient temperature, the thickness of the water* $\delta_{ж} = 0,01(в)\ 0,02(r)м;$ *5-change depending on the intensity of the flow of solar radiation falling on the transparent surface of the heliocollector (28-29 November 2020).*

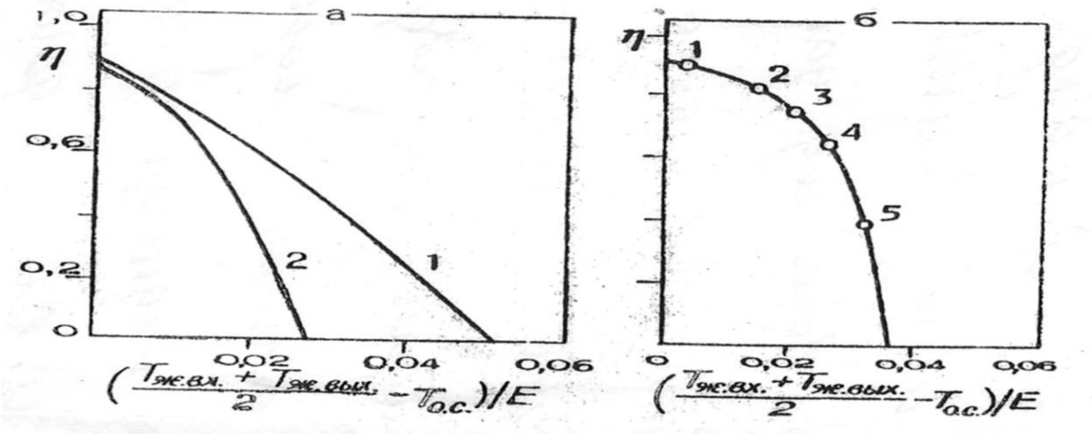

Figure 5. The water (a) and the consumption of heated water (b) in the two-contour solar water heating solar collector " list" have an effect on increasing the efficiency of the device:

$T_{ж bx} = 278k(1),\ \ 293k(2);\ E = 400Bm/м^2,\ T_{а.Tммy.} = T_{ж.вх};\ G_{ж.уд} = 0,02(1),\ 0,0056(2),$
$0,0042(3), 0,0028(4),\ 0,0014(5)\ кг/(м^2 \cdot c)$

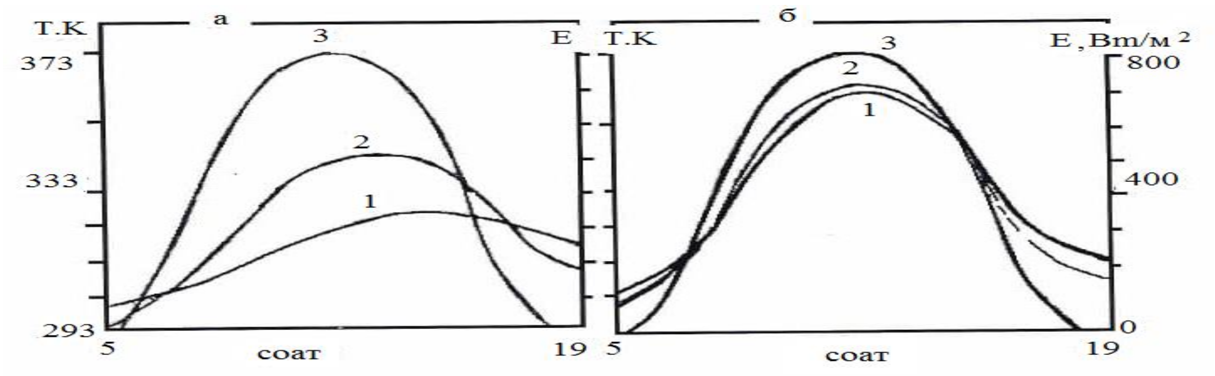

Figure 6. On a sunny day on December 3-5, 2020, the water temperature in the water heating collector (1) and air temperature (2) using two-contour "list" type solar-bioenergy with thermophysical parameters such as the density of solar radiation flux (3):

$a : G_{ж.уд} = 0,0007\, кг/(м^2 \cdot c),\ \ G_{x.уд} = 0,0042\, кг/(м^2 \cdot c);\ б - G_{ж\cdot уд} = 0,0007\, кг/(м^2 \cdot c),$

the temperature of the water entering the heliocollector, $T_{жс.вх} = T_{ar.m} = 303k$ *and the ambient temperature, the thickness of the water* $\delta_{ж} = 0,01(в)\ 0,02(г) м;$ *5- change depending on the intensity of the flow of solar radiation falling on the transparent surface of the heliocollector (28-29 November 2020).*

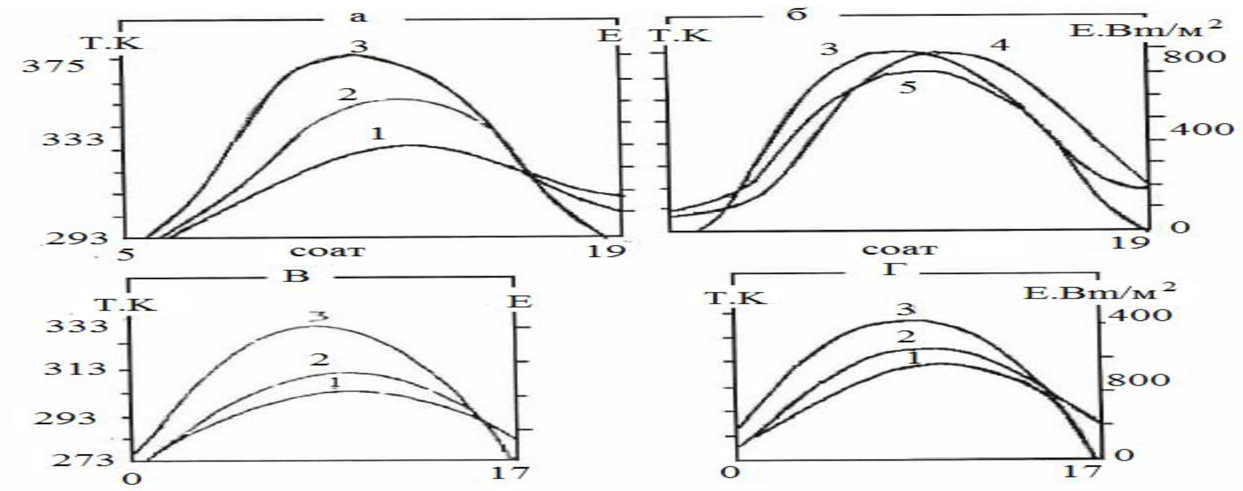

Figure 7 The amount of solar energy (a, b) falling on the transparent surface of the two-contour flat air water heater solar collector on a sunny day on December 9-12, 2020 and the amount of solar energy falling on a clear surface on December 12-14, 2020 (v, g) are given. Thermophysical parameters

$a: G_{жс.уд} = 0,0007 кг/(м^2 \cdot c),\quad G_{x.уд} = 0,0042 кг/(м^2 \cdot c);\ б - G_{жс \cdot уд} = 0,0007 кг/(м^2 \cdot c), в:$
$w = 0,15 м (1)\ w = 0,30 м (5)$

the distance between the pipes

$в: G_{жс.уд} = 0,0007 кг/(м^2 \cdot c),\quad G_{x.уд} = 0,0042 кг/(м^2 \cdot c);\ Г - G_{жс \cdot уд} = 0,0007 кг/(м^2 \cdot c), в:$

3,4,5-The amount of solar energy falling on a clear surface, Wt/m^2

Heat balance of solar and bioenergy water heaters based on experiments conducted at Muborakneftegaz LLC [4]

$$Q\frac{dT}{dt} = \varepsilon A \eta - \xi_1 C_p (T_k - T_r) - \xi_2 C_p (T_{дк} - T_{дг}) \qquad (23)$$

determined using the formula. Combined additional heating process takes place at the expense of energy received from the biogas plant.

A new parameter from the heat calculation practice and testing of a flat collector for water heating using combined solar and bioenergy is the collector light absorber panel. an expression was proposed to determine the transfer of heat from the absorbing panel to the heat carrier in the inner channel. As a result, it was found that the value of the light-absorbing panels of this collector decreased by 11.8% depending on the heat transfer coefficient.

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