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Determination Of Thermal Parameters Of Solar Water Heating Collectors Using The "Dark" Testing Method

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ABSTRACT

In the production of flat solar water heating collectors, thermal testing occupies a special place, the purpose of which is to determine their thermal characteristics experimentally. The corresponding approximation expressions are proposed for determining the coefficient of heat loss, inclined to the horizon at an angle of 300 for the average conditions of their operation in the hot water supply system.

KEYWORDS

Flat solar collector, radiant heat exchange panel, hot water supply system.

INTRODUCTION

Currently, serial production of flat solar water heating collectors (SWHC) is organized in many countries around the world. The organization of medium production of SWHC and the expansion of the scale of their use in hot water supply systems (HWSS) of objects for various purposes in the Republic of Uzbekistan sets the task of their certification and certification, the solution of which includes the development of a whole system of tests (tests) aimed at determining their thermal efficiency, reliability and manufacturing quality control. A special place in it is occupied by thermal testing, the

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purpose of which is to determine their thermal characteristics experimentally.

THE MAIN FINDINGS AND RESULTS

Typical SWHC consist of a blackened radiation absorbing heat exchange panel (BRAP) with built-in heat transfer channels (HRC), laid in a shallow flat box (body), with a translucent cover (TC), a thermally insulated bottom and side walls (Fig. 1-a).

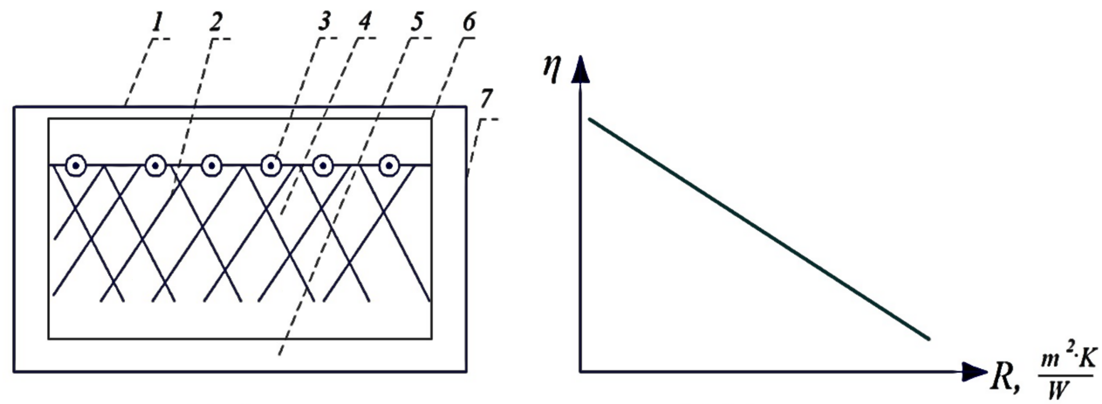

Fig.1-a *Fig.1-b*

Figure: 1-a. Schematic diagram of the cross-section of the SWHC with sheet-tube BRAP: 1 - TC; 2 - blackened BRAP; 3 - HRC; 4 - bottom insulation; 5 - from the bottom of the wall; 6 - tank walls; 7 - case. Figure: 1-b. Addiction $\eta = f(\frac{t_b - t_0}{q^{\Sigma}_{\text{падс}}})$.

In the blackened BRAP, the energy of solar radiation (SR) is absorbed and converted into heat, which has passed through the TC of the SWHC building. The TC, passing short-wave SR through itself, practically transmits back the long-wave (thermal) radiation of the blackened surface of the BRAP and, thereby, creates a greenhouse effect, excludes through radiant losses from the front surface of BRAP. The thermally insulated bottom and side walls of the housing reduce the conductive-convective heat losses of the BRAP into the environment. Useful energy in the form of hot water with a temperature of 55-65° is discharged through the built-in HRC in BRAP [1].

The results of thermal testing of SWHC are necessary for designers and manufacturers to work on their further improvement, and for suppliers and consumers to determine their nomenclature, compare them with each other and select a design that is most suitable for specific purposes.

The main indicators of the degree of thermal engineering quality of SWHC directly affecting their useful heat output ($q_{\text{пол}}$) and thermal efficiency (η) are reduced to a unit area of the frontal (front) surface of their body. The coefficient of total heat losses to the environment ($K_{\text{пр}_{р-о}}$) and the coefficient of thermal efficiency of the BRAP of the considered SWHC ($\eta_{\text{тп}}$), characterizing the efficiency of heat transfer from the elements of the BRAP to the water circulating inside the HRC ($\eta_{\text{тп}}$) and reduced to a unit area of the front surface of the collector body, the effective absorption capacity of the total SR, which characterizes the optical efficiency of the system "TC-BRAP" of the collector (η_0) under consideration, which is determined by the product of the effective integral absorption capacity of the total SR of the blackened surface of BRAP ($\alpha_{\text{рэфф}}$) by the effective throughput of the total SR TC ($\tau_{\text{сп}_{\text{эфф}}}$) reduced to a unit area of the front surface of the collector body, $\eta_0 = (\alpha_{\text{р}}\tau_{\text{сп}})_{\text{эфф}}$..

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To determine the values of these indicators of SWHC, a wide range of different methods of thermal testing has been proposed to date: full-scale, laboratory, quasi-stationary, non-stationary [1].

The basis of the ASHRAE SWHC quasi-stationary thermal testing method is a thermal model of the Hottel-Wheeler-Bliss collector with zero heat capacity, in which the influence of transient processes during heating (in the afternoon hours) of the collector on its thermal performance is neglected. In order to ensure the conditions of quasi-stationarity, thermal testing of the collector is carried out in the midday hours of clear days with the values of the surface flux density of the total (direct and diffuse) SR falling on the surface of TC ($q^{\Sigma}_{\text{пад}}$) not less than 630 $\frac{\text{Вт}}{\text{м}^2}$ and the angle of incidence of direct SR on the surface of TC ($i_{\text{пр}}$) not more than 30⁰ [2].

In the process of thermal testing of the SWHC, the flow rate of water through the collector $G_{\text{в}}\left(\frac{\text{кг}}{\text{с}}\right)$,, the temperature of water at the entrance to the collector $t_{\text{в}_{\text{вх}}}$(°C) and at the outlet of it $t_{\text{в}_{\text{вх}}}$(°C), the temperature of the outside air t_0(°C), and the surface flux density of the total SR falling on the surface plane of the translucent cover of the collector $q^{\Sigma}_{\text{пад}}$ $(\frac{\text{Вт}}{\text{м}^2})$ are measured.

The instantaneous values of the specific heat output $q_{\text{пол}}\left(\frac{\text{Вт}}{\text{м}^2}\right)$and thermal efficiency ($\eta$) of the tested collector are determined from expressions

$$q_{\text{пол}} = \left(mC_{\text{р}_{\text{в}}}\right)\left(t_{\text{в}_{\text{вых}}} - t_{\text{в}_{\text{вх}}}\right) \quad (1)$$

and

$$\eta = \frac{(mC_{\text{рв}})}{q^{\Sigma}_{\text{падс}}}\left(t_{\text{в}_{\text{вых}}} - t_{\text{в}}\right), \quad (2)$$

where

$$m_{\text{в}} = \frac{G_{\text{в}}}{F_{\text{фр}}} \quad (3)$$

$m_{\text{в}}$ - is the specific water consumption through the collector with the frontal surface area of the body $F_{\text{фр}}$, $C_{\text{р}_{\text{в}}}$- is the specific heat capacity of water, $C_{\text{р}_{\text{в}}} = 4186{,}8$ Дж/(кг°С).
The experimental results are processed in the form of dependence

$$\eta = f\left(\frac{t_{\text{в}} - t_0}{q^{\Sigma}_{\text{падс}}}\right). \quad (4)$$

The least regression method uses expression

$$\eta = \eta_m\left[\left(\alpha_{\text{р}}\tau_{\text{сп}}\right) - \frac{К_{\text{ппр}-0}}{q^{\Sigma}_{\text{пад}}}\left(t_{\text{в}} - t_0\right)\right], \quad (5)$$

proposed in the Hottel-Wheeler-Bliss model [1].

In (4) and (5) $t_{\text{в}}$ -, the temperature of the heated water averaged over the length of the heat-removing channel of the radiation-absorbing heat-exchange panel.

Note that for the developers and designers of solar water heating collectors, the values $\eta_{\text{тп}}$ and $К_{\text{ппро}}$, separately, are very important, and not $\eta_{\text{тп}}К_{\text{ппро}}$ and $\eta_{\text{тп}}(\alpha_{\text{р}}\tau_{\text{сп}})_{\text{эфф}}$. Due to the fact that the values of complexes $\eta_{\text{тп}}$ *and* $К_{\text{аппо}}$and $\eta_{\text{тп}}(\alpha_{\text{р}}\tau_{\text{сп}})_{\text{эфф}}$ were obtained at around noon, they can only be used for comparison with similar indicators of flat solar water heating collectors of various manufacturers. For this reason, these complexes can be used to determine the daily variation of the heat output of the tested collectors, as suggested in [3].

From the graph of dependence $\eta = f(\frac{t_b - t_0}{q^{\Sigma}_{\text{падс}}})$ in Fig. 1-b. the value of the sets, which are works, is determined $\eta_{\text{тп}} К_{\text{пр}_{\text{р}-0}}$ *and* $\eta_{\text{тп}}(\alpha_{\text{р}}\tau_{\text{сп}})_{\text{эфф}}$.

As follows from the graph in Fig. 1-*b*., The ordinate of the intersection point of the straight line with the ordinate axis, i.e. at $\frac{t_{\text{в}} - t_0}{q^{\Sigma}_{\text{пад}}} = 0$, is equal to the value of complex $\eta_{\text{тп}}(\alpha_{\text{р}}\tau_{\text{сп}})_{\text{эфф}}$, and the value of complex $\eta_m \cdot К_{\text{пр}_{\text{р}-0}}$ is equal to the negative value of the slope of the straight line [3].

By including "dark" experiments in the program of their tests, it is possible to significantly reduce the duration of the thermal testing of SWHC and significantly reduce the labor intensity [4, 5, 6].

The essence of carrying out "dark" experiments is as follows. At night, hot water is supplied to its BRAP with a temperature of $t_{b\text{вх}}$ at a constant flow rate of (G_b). As a result of heat losses of the BRAP through the enclosing elements of the collector body into the environment, the water temperature at the outlet from it drops to $t_{\text{в}_{\text{вых}}}$..

One of the main goals of the dark method for determining the thermal characteristics of SWHC is to determine the reduced coefficient of heat transfer from water in the HRC BRAP to the unit of the frontal surface area of its body $F_{\text{фр}}$ and to the environment $(К_{\text{пр}_{\text{р}-0}})$ according to the measurement results t_0, $t_{\text{в}_{\text{вх}}}$, $t_{\text{в}_{\text{вых}}}$, $G_{\text{в}}$ and $F_{\text{фр}}$.

Definition $К_{\text{пр}_{\text{р}-0}}$ in this case is based on the equality of heat fluxes given off by cooled water

$$Q_{\text{тп}} = (G_{cp})\,(t_{\text{в}_{\text{вх}}} - t_{\text{в}_{\text{вых}}}) \tag{6}$$

and lost into the environment through the enclosing elements of the SWHC

$$Q_{\text{тп}} = К_{\text{пр}_{\text{р}-0}} F_{\text{фр}}(t_{\text{в}} - t_0), \tag{7}$$

i.e.

$$К_{\text{пр}_{\text{р}0}} = (mc_{\text{р}})\frac{t_{\text{в}_{\text{вх}}} - t_{\text{в}_{\text{вых}}}}{t_b - t_0}. \tag{8}$$

case.

The value t_b in (7) and (8) can be determined from the expression

$$t_{\text{в}} = 0{,}5\,(t_{\text{в}_{\text{вх}}} + t_{\text{в}_{\text{вых}}}), \tag{9}$$

i.e. as a half-sum of $t_{b\text{вх}}$ and $t_{b\text{вых}}$ or from expression

$$t_{\text{в}} = t_0 + \frac{t_{\text{в}_{\text{вх}}} + t_{\text{в}_{\text{вых}}}}{\log\frac{t_{\text{в}_{\text{вх}}} - t_0}{t_{\text{в}_{\text{вых}}} - t_0}}, \tag{10}$$

Proposed in [2].

The value $\eta_{\text{тп}}$ according to [3] can be determined from the ratio

$$\eta_{\text{тп}} = \frac{К_{\text{пр}_{\text{в}-0}}}{К_{\text{пр}_{\text{р}-0}}}. \tag{11}$$

The value $К_{\text{пр}_{\text{р}-0}}$ in this case can be determined from the approximation dependences

$К_{\text{пр}_{\text{р}-0}} = 2{,}3980 + 0{,}0044t_{\text{р}} - 0{,}0121t_0 - 1{,}1645\varphi_0 + 4{,}2025\varepsilon_p + 0{,}0512v + (182{,}9315 - 5095{,}8649\,\delta_{\text{впрс}})\delta_{\text{впрс}}(\frac{\text{Вт}}{\text{м}^2 K})$. (12)

in the range of ε_p from 0.10 to 0.25 and

$$К_{ap_{p-o}} = 4{,}7838 + 0{,}0119t_p - 0{,}0193t_0 - 1{,}6475\varphi_0 + 2{,}4879\varepsilon_p + 0{,}1554\vartheta + (82{,}6677 - 2054{,}3139\delta втр\delta втр,(Втм2К), \quad (13)$$

in the range of change ε_p from 0.80 to 0.9, obtained on the basis of [5] with the corresponding heat loss coefficients of BRAP through the bottom and side walls of the SWHC (1,5925 $\frac{Вт}{м^2K}$) body and the ratio of the areas of the front surfaces of the TC ($F_{сп}$) and the collector body ($F_{фр}$), i.e.

$$\frac{F_{сп}}{F_{фр}} = 0{,}93.$$

In approximation expressions (12) and (13) t_p – is the average operating temperature of BRAP; t_0 *and* φ_0 –, respectively, the temperature and relative humidity of the outside air; ε_p emissivity of the blackened surface of BRAP ; ϑ - wind speed, $\frac{м}{с}$; $\delta_{впр-с}$– the thickness of the closed air gap enclosed between the outer surface of the BRAP and the inner surface of the joint venture TC (c_1).

Expressions (12) and (13) obtained for the average operating conditions of the SWHC in the HWSS and the angle of inclination of the SWHC to the horizon (α) 30°.

CONCLUSIONS

1. In this work, the technique of the "dark" method for determining the main heat engineering characteristics of SWHC used in HWSS is developed. As a result of heat losses of BRAP through the enclosing elements of the collector body into the environment, the water temperature at the outlet from it decreases to 11.
2. By including "dark" experiments in the program of their tests, it is possible to significantly reduce the duration of the process of thermal testing of SWHC and significantly reduce the labor intensity.
3. Approximation expressions are proposed for determining the reduced coefficient of heat loss of BRAP collector 12 inclined to the horizon at an angle of 300 for the average conditions of their operation in the HWSS.

REFERENCES

1. Beckman W., Klein S., Duffy D.J. Calculation of solar heating systems. – Moscow. Energoizdat. 1982. – p. 80.
2. Avezov R.R., Avezova N.R. Development of a "dark" method for determining heat engineering collectors for heating a heat transfer fluid. Proceedings of the International Conference "*Fundamental and Applied Problems of Physics*" November 5-6, 2015. - pp. 343-345.
3. Avezov R.R., Vokhidov A.U., Usmonov N.O. Heat Transfer Coefficient from the Sheet-Piped Light-Absorbing Panels of the Flat-Plate Solar Water-Heating Collectors to the Heat Transfer Fluid in Their Heat-Removing Channels // *Applied solar energy*, 2018. №54. – pp. 168-172.
4. Usmonov N.O., Khazratov A.G. Influence of an internal heat source on the temperature field and heat transfer through the translucent coating of flat solar installations. Collection of articles based on the materials of the XLIX international scientific-practical conference "*Experimental and theoretical research in modern science*" 2020. - №1 (44) - pp. 70-76.
5. Usmonov N.O., Umarjanova F.Sh., Khashimova F.A. Flat solar water heating collectors are sources of thermal energy.

Collection of articles based on the materials of the LVIII International Scientific and Practical Conference "*Experimental and Theoretical Research in Modern Science*" November 2020. - No. 10 (52) - pp. 54-58.

6. Usmonov N.O., Isaxodjayev X.S. Influence of the internal heat source on the temperature field and transfer through light-translucent coating of flat solar plants // The American journal of engineering and technology. 30 july, 2020. Volume-II, Issue-VII. – 46-50 p. doi: 10.37547/tajet/volume02issue07-07