The Relationship between Temperature and Performance of Solar Desalination Plants

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Abstract: This article considers the analysis of studies on increasing the productivity of solar desalination plants through the rational use of falling solar energy on the surface of installations, as well as the dependence of the efficiency of solar desalination plants on the parameters of external thermal effects and determining the temperature regime of these installations. To determine the temperature regime of the desalter, a calculation method was applied based on finding the temperature functions in the form of Fourier series. It has been established that the heat transferred by radiation from the surface of the water to the surface of the transparent coating can be reduced by installing additional transparent screens between the evaporating zone of the desalter and its roof. This technical solution made it possible to increase the productivity of sloped-stepped type installations by 1.5 times in comparison with single-layer glazing.

1 INTRODUCTION

According to the annual addresses of the Founder of Peace and National Unity – Leader of the Nation, President of the Republic of Tajikistan Emomali Rahmon to the Majlisi Oli of the Republic of Tajikistan, hydropower comprises for 98% of electricity production in Tajikistan. This has become the basis for Tajikistan to be on the 135th place in terms of greenhouse gas emissions into the atmosphere on a global scale, which is assessed as a valuable contribution of the Republic of Tajikistan to the solution of global problems of mankind.

The value of this indicator shows that on a regional scale, the specific quantitative characteristics of greenhouse gas emissions in Tajikistan is the smallest indicator for each person, which is considered Tajikistan's contribution to improvement and enhancement of the ecological situation in the region and, particularly, the planet. This helps to achieve widespread use of renewable energy sources (RES), first of all, hydropower. It was also noted that the vast use of renewable energy sources, especially water resources, may explore one of the main sources of "green energy" generation and the development of a "green economy".

In connection with the statements made above and according to the main actions, in order to achieve the set strategic goals of the National Development Strategy of the Republic of Tajikistan for the period up to 2030 and its initial stage. The initial stage is included in the Medium-Term Development Program of the Republic of Tajikistan for 2016-2020, which indicated that to ensure energy security, as well as efficient use of electricity, it is necessary to diversify generating energy sources with the development of hydropower resources, both large and small rivers, the development of existing capacities in the oil and gas and coal sector, the exploration and development of new fossil fuel deposits, the creation and provision of technical capabilities with the purpose of using non-traditional (renewable) energy sources (solar, wind, biological, geothermal), modernization and rehabilitation of existing ones, as well as the construction of new hydroelectric power plants (HPPs) and thermal power plants (TPPs).

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The above-mentioned statement will serve as the reason to consider the research topic relevant and timely. The aim of the research is the rational use of solar energy through the development of theoretical and applied models and the improvement of low-potential solar installations in the climatic conditions of the Republic of Tajikistan.

To achieve the goal, the following tasks were set and solved:

- Assessment of the state and development of the use of non-traditional energy sources in Central Asia, including in Tajikistan.
- Analysis of existing methods for determining the formation of the process of heat exchange of constructions, under the influence of solar thermal effects and their improvement;
- Technical and economic justification and practical implementation of low-grade solar installations and developed models for the use of renewable energy sources in the conditions of the Republic of Tajikistan.

The scientific novelty of the obtained results consists of determining the temperature regime of closed volumes and channels with a coolant under periodic fluctuations in the parameters of the thermal effect and a developed model for regulating the temperature regime of a homogeneous structure under periodic fluctuations in the temperature of the medium on its lateral surface, on the basis of which the calculated parameters of the thermal characteristics of the coolant in duct exposed to the thermal effect of the environment with periodically changing temperature.

The practical significance lies in the fact that the thermal state of structures in a closed volume is determined in the absence and presence of sources and sinks of heat and filtration of outdoor air, as well as an algorithm for calculating and controlling the parameters of the temperature state of structures of solar desalination plants has been developed.

The researches were conducted and completed using the current regulatory methods for studying the physicochemical and biotechnological properties of low-grade solar installations (Sokolov and Hershgal, 1990; Le Pierrèset et al., 2003; Ma et al., 2018; Zhu et al., 2019). In the processing stage, a mathematical and statistical technique was used to process experimental data. For the theoretical part, there were used analytical and numerical methods to solve the problem of heat and mass transfer, regarding the research objects (Safarov et al., 2003).

The authors contribution in this study is to conduct joint research, starting with the formulation of the research objectives, methodological support for their solutions and the analysis of the results of monitoring the water interrogation process obtained by the authors. The research mainly relies on the results of researches conducted by the authors over the last years on the problems of rational use of water resources.

The 21st century will be characterized by a further exacerbation of the shortage of fresh water on a global scale. At the same time, it is noted that two-thirds of drinking water is consumed for the implementation of agro-technical activities (for example, for irrigation and growing crops). The problem of desalination of sea and ocean water is aggravated by the fact that the world's population is growing rapidly (more than 80 million people per year) and by 2025 at least 2 billion people on the planet will systematically face an acute shortage of fresh water (Ruy et al., 2007).

It is also necessary to note that fresh water is used in different ways by the population of different countries. So, the water consumption in the homes of US residents is on average about 380 liters per person per day, while millions of people on the planet (especially in underdeveloped countries) use about 19 liters of water per day, and 46% of the world's inhabitants do not access to the supplied running water. All this indicates that there is a problem with fresh water, the demand for water will only start to grow. Therefore, people need to take care not only of water supplies, but also learn to rationally use precious moisture with care (Ruy et al., 2007).

In recent years, the problem of the shortage of fresh water has become more and more urgent for many regions of the world. As a result of desertification of large areas, pollution of water bodies and an increase in water consumption, there is already a shortage of drinking water for 1.2 billion people. It becomes obvious that in the future humanity will face a global catastrophe of lack of drinking water. In such conditions, it is important to develop not only methods for the efficient use of water resources, but also projects for the purification and desalination of sea water.

2 EXTERNAL THERMAL INFLUENCE PARAMETERS

The external thermal impact on constructions located in the open area is manifested in the form of convective heat fluxes during heat exchange with the outside air, radiant heat fluxes during heat exchange with the atmosphere, the surface of the Earth and the surrounding objects, as well as solar irradiation.

It is known that the outside air temperature changes over time in all regions of the Earth, and the temperature changes have a periodic oscillatory nature. Like any oscillatory process, temperature changes are characterized by periods and amplitude of fluctuations. The period of temperature fluctuations outside the air is the time interval during which there is one complete oscillation. In hydrometeorology it is accepted to distinguish annual, monthly and daily fluctuations of outdoor air temperature with a period of change of one year, one month and one day, respectively. The amplitude of temperature fluctuations is the largest deviation from the average value for the period of fluctuations. The amplitude of outside air temperature fluctuations, as well as its average values for the period of fluctuations, depends on the geographical location of the area on the earth's surface.

Numerous observations of changes in outdoor air temperature (Gidrometeoizdat, 1966) show that the daily amplitude of temperature fluctuations in summertime for almost all localities is significantly greater than the amplitude of temperature fluctuations in wintertime. Maximum air temperatures are observed in July and minimum air temperatures in January. Temperature fluctuations of recurring pattern in summer and winter can be repeated for 5-10 days, i.e. repeatedly. It is important because the temperature fluctuations of environment repeatedly repeat the temperature state of bodies in it gets the established periodical character (Lykov, 1967) that allows to consider a heat transfer in elements of constructions exposed to external thermal influence as quasi-stationary process with the established periodical character of temperature and heat flows changes.

Constructions located in open areas, in addition to heat exchange with the outside air, are exposed to solar radiation. The total impact of solar radiation on the surfaces of constructions consists of direct irradiation (direct solar radiation) and irradiation by the atmosphere scattering the sun's rays (scattered radiation).

Thermal influence of solar rays on surfaces of constructions is characterized by solar radiation intensity which is the quantity of heat referred to unit of time and unit of the irradiated surface area, and changes in the same units as heat flux density (W/m2).

The path the sun's rays take in the atmosphere increases as the Sun approaches the horizon line. The intensity of solar radiation reaching the Earth's surface decreases sharply. When the height of the Sun above the horizon h is less than 5°, the thermal impact of solar radiation can be ignored.

For values h more than 5° the intensity of direct solar radiation on the surface, perpendicular to the direction of the rays, is approximated by the simplified formula of Kastrov-Savinov (Kiteyev, 1962).

$$I_{\text{пр}} = 1360 \frac{\sin h}{\sin h + \dfrac{1-p}{p}} \text{ Вт/м}^2 \qquad (1)$$

where h is the height of the Sun, deg;

p - atmospheric transparency coefficient, varying from 0.7 to 0.8.

The height of the Sun h is calculated by the formula

$$h = arc\ sin\ (sin\ \varphi\ sin\delta + cos\ \varphi\ cos\ \delta\ \cos\gamma) \qquad (2)$$

where φ - geographic latitude, deg;

δ - declination of the Sun (deg.) depending on the time of the year (from -23.4° in December to 23.4° in June);

γ - hour angle in degrees, determined by the ratio

$$\gamma = 15(\tau 1\text{-}12), \qquad (3)$$

where τ1 - local time, h.

Due to the refraction of light in the atmosphere, the apparent height of the Sun slightly differs from the actual height, especially at sunrise and sunset. However, this phenomenon is neglected when calculating the thermal effects of solar radiation.

Intensity of direct solar radiation on flat horizontal and vertical surfaces of constructions is defined by dependences

$$I_{\text{пр.г}} = I_{\text{пр}} \sin h; \qquad (4)$$

$$I_{\text{прв}} = I_{\text{пр}} \cos h \sin|\alpha - x| \qquad (5)$$

where x is the angle determining the position of the vertical surface relative to the meridian;

α is the azimuth of the Sun, calculated by the ratio

$$\cos\alpha = \sin\varphi \cos m - \cos\varphi \sin m \cos A_0 \qquad (6)$$

The intensity of total solar radiation is defined as the sum of direct and scattered radiation. The dependence of the intensity of scattered solar radiation affecting the horizontal surface under a cloudless sky as a function of angle h is as follows:

h^0	10	20	30	40	50	60	70
I_{pr}	31,4	43,1	52,4	60,5	65,2	67,5	68,6

The intensity of scattered solar radiation for vertical surfaces is determined by the approximate dependence

$$I_{\text{пр}} = 0{,}5\, I_{\text{pr}} \qquad (7)$$

The scattering that the sun's rays pass through the atmosphere varies depending on the position of the Sun in relation to the horizon line, which is the reason for the periodic change in the intensity of solar radiation reaching the Earth and affecting the surfaces of various constructions.

More complete data on measurements of solar radiation intensity for different times of the year and any regions of the USSR are given in the reference book on the climate of the USSR (Gidrometeoizdat, 1966), which summarizes the results of observations of changes in the outside air temperature in the territory of the Tajik SSR.

3 METHODOLOGIES

The main method of obtaining fresh water is based on the heating and evaporation of salt water, its subsequent condensation on the surface of the heat exchanger and removal of the brine, which remains after heating the mixture with a high salt content. Any heat carrier that produces a sufficient amount of energy can serve as a source of heat for the desalination plant. There are installations based on fossil fuels, chemical sources and fuel cells, with electric heating and even on the basis of nuclear fuel.

Due to the fact that the greatest shortage of fresh water is observed in regions of the world with increased solar radiation, solar desalination plants are of particular interest. Solar collector desalination - plant for desalination of water by the method of thermal distillation. The main advantages of solar desalination plants are due to the energy source, namely the absence of the need for fuel supplies, environmental friendliness, and affordability.

There are two main technologies for desalination of water, widely used in the world: a method based on a change in the phase state of a substance (thermal method), and membrane, which can be provided by several methods.

Phase change technology includes:

- multistage distillation;
- highly efficient distillation;
- steam pressure: thermal and mechanical compression of steam;
- other processes including distillation, humidification, dehumidification using solar installations.

Membrane technologies, in addition to membrane distillation, include two main processes: reverse osmosis and electrodialysis. These two technologies use membranes to remove salts from water.

Both processes require a lot of energy to overcome the existing osmotic pressure between fresh and salt water. Electrodialysis technologies, as a rule, are used only for brackish waters, in which salts from the water stream are attracted by membranes and pass through them under the action of an electric current.

Despite significant advances in the use of solar energy for desalination of salt water, the problem of creating optimal methods for desalination of water and the theory of their calculation is still unresolved. (Achilov, 1976; Kolodin, 1981; SNiP, 1983; Baum, 1985)

To measure the impact of the climatic parameters of the outside air and solar radiation, we can use the reference data of the place of the experiment. (Gidrometeo-Izdat, 1990; Dorvlo and Ampratwum, 1998; Stathopoulos and Zacharias, 2004; Hasni et al., 2012; Smirnov, 2013; Adeala et al., 2015). The solar desalination process generally proceeds as follows.

Before starting work, the solar water-maker, which is a "hot box" in design, is filled with salt water. Solar energy passes through the transparent coating of the desalter almost completely (up to 90%) and is absorbed by the surface of the salt water, which heats up and evaporates.

Next, the saturated steam-air mixture comes into contact with the colder transparent wall of the desalter, and water vapor condenses on its surface. As it accumulates, fresh water condensate is discharged from the installation, and the desalter is replenished with a new portion of salt water. The desalination process is carried out continuously until the end of the effect of solar radiation on the design of the desalination plant.

The performance of solar plants is a function of the salt water and condensation surface temperatures, which in turn depend on the outside temperature and the intensity of solar radiation. Since the parameters of the external thermal effect, to which the desalter is exposed, change during the daylight hours over a fairly wide range, the temperature regime and productivity of the installation are impermanent.

To measure the temperature regime of the desalter, let us consider a calculation method based on finding the temperature functions in the form of Fourier series.

Assuming that the water temperature has insignificant volume fluctuations, and the thermal resistance of the transparent wall, through which the heat flux from solar radiation enters the desalination tank, it is possible to record the heat balance equations for water and the transparent wall of the desalination tank (Kutateladze, 1979; Brdlik, 1983; Baum, 1985; Timakova, 2006; Nokali, 2007; Temerov, 2008; Usmanov, 2019):

$$C_в\rho_в\delta_в\frac{dt_в}{d\tau} = \varepsilon_в\beta_с I_с - K_{тс}(t_в - t_{ус}) - K_{ти}(t_в - t_{уи}), \quad (1)$$

$$C_в\rho_в\delta_в\frac{dt_с}{d\tau} = A_в I_с - K_п(t_в - t_с) - \alpha_н(t_с - -t_н), \quad (2)$$

here Cc, ρc, δc - specific heat, density and thickness of the transparent wall of the desalter; Cв, ρв, δв - specific heat, density and thickness of the water layer; Ac, βc - absorption and throughput capacity of the transparent wall of the desalter; Кп - heat transfer coefficient from water to transparent wall; Ктс, Кти - heat transfer coefficients of the transparent wall and insulation of the desalter; α_н- total heat transfer coefficient of the desalter; Ic - the intensity of solar radiation on the surface of the transparent wall; tc, tв, tн – respectively, the temperatures of the transparent wall, water and outside air; τ - time.

Since the daily changes in the temperature of the outside air and the intensity of solar radiation are periodic in nature, and the thermal capacity of the installation is relatively small, it seems possible to look for the dependences of the temperatures tc and tв on time in the form of harmonic Fourier:

$$t_с = t_{с0} + \sum_{k=1}^{\infty}\left(x_k cosk\frac{2\pi\tau}{z} + y_k sink\frac{2\pi\tau}{z}\right), \quad (3)$$

$$t_в = t_{в0} + \sum_{k=1}^{\infty}\left(\mu_k cosk\frac{2\pi\tau}{z} + \eta_k sink\frac{2\pi\tau}{z}\right), \quad (4)$$

where the average values of temperatures tc0, tв0 and the coefficients of the series xk, yk, μ_k, η_k should be determined during the solution; the value k = 1, 2, 3 ... is an integer variable; z - period of change, equal to 24 hours.

To find a solution to equations (1) and (2) in the form (3) and (4), series (3) and (4) are conveniently written using a complex number i:

$$t_c = t_{c0} + \sum_{k=1}^{\infty}\theta_{ck}e^{k\frac{2\pi\tau}{z}i}, \quad (5)$$

$$t_в = t_{в0} + \sum_{k=1}^{\infty}\theta_{вk}e^{k\frac{2\pi\tau}{z}i}, \quad (6)$$

where θ_ck, θ_vk are the amplitude-phase characteristics of the simple harmonic components of the temperatures of the transparent wall and water. The amplitude-phase characteristics are related to the coefficients of the series (5) and (6):

$$\theta_{ck} = x_k - iy_k, \quad (7)$$

$$\theta_{вk} = \mu_k - i\eta_k. \quad (8)$$

As already noted, the outside air temperature and the intensity of solar irradiation can also be represented in the form of Fourier series:

$$t_н = t_{н0} + \sum_{k=1}^{\infty}\left(\alpha_k cosk\frac{2\pi\tau}{z} + b_k sink\frac{2\pi\tau}{z}\right), \quad (9)$$

$$I = I_0 + \sum_{k=1}^{\infty}\left(C_k cosk\frac{2\pi\tau}{z} + d_k sink\frac{2\pi\tau}{z}\right); \quad (10)$$

where the average values of tн0, I0 and the coefficients of the series ak, bk, ck, dk are determined by harmonic analysis of daily fluctuations in the outside air temperature and the intensity of solar radiation. By analogy with relations (5) - (8), we have

$$t_н = t_{н0} + \sum_{k=1}^{\infty}\theta_{нk}e^{k\frac{2\pi\tau}{z}i}, \quad (11)$$

$$I = I_0 + \sum_{k=1}^{\infty}\theta_{I_k}e^{k\frac{2\pi\tau}{z}i}, \quad (12)$$

$$\theta_{нk} = a_k - ib_k, \quad (13)$$

$$\theta_{I_k} = c_k - id_k. \quad (14)$$

Let us determine the time derivatives of temperatures tc and tв from equations (5) and (6):

$$\frac{dt_c}{d\tau} = \sum_{k=1}^{\infty} k \frac{2\pi i}{z} \theta_{ck} e^{k^{\frac{2\pi\tau}{z} i}}, \quad (15)$$

$$\frac{dt_в}{d\tau} = \sum_{k=1}^{\infty} k \frac{2\pi i}{z} \theta_{вk} e^{k^{\frac{2\pi\tau}{z} i}}, \quad (16)$$

Substituting relations (5), (6), (11), (12), (15), (16) into equations (1) and (2), separating constant and variable components in them, we obtain equations for constant and variable components heat flows:

- for constant components

$$A_с T_0 + K_п (t_{в0} - t_{с0}) - \alpha_н (t_{с0} - t_{н0}) = 0; \quad (17)$$

$$\varepsilon_в I_c I_0 - (K_c + K_д)(t_{в0} - t_{н0}) = 0; \quad (18)$$

- for k-x simple harmonic components of heat flux densities

$$С_0 \rho_0 \delta_0 k \frac{2\pi i}{z} \theta_{ck} e^{k^{\frac{2\pi\tau}{z} i}} = A_c \theta_{I_k} e^{k^{\frac{2\pi\tau}{z} i}} + K_п (\theta_{вk} - \theta_{ck}) * * e^{\frac{2\pi i}{z}} + \alpha_н (\theta_{нk} - \theta_{ck}) e^{\frac{2\pi i}{z}}; \quad (19)$$

$$С_в \rho_в \delta_в k \frac{2\pi i}{z} i \theta_{ck} e^{k^{\frac{2\pi\tau}{z} i}} = \varepsilon_в T_c \theta_{I_k} e^{k^{\frac{2\pi\tau}{z} i}} + +(K_c + K_д)(\theta_{нk} - \theta_{вk}) e^{k^{\frac{2\pi\tau}{z} i}}; \quad (20)$$

From equations (17) and (18) we determine the constant components of the desired temperatures

$$t_{в0} = t_{н0} + \frac{\varepsilon_в T_в}{(K_c + K_д)} I_0; \quad (21)$$

$$t_{c0} = \frac{A_с I_0 + K_п t_{в0} + \alpha_н t_{н0}}{K_п + \alpha_н}. \quad (22)$$

Making a cancellation by e ^ (k ^ (2πτ / z i)) from equations (19) and (20), we determine the dependences for finding the amplitude-phase characteristics of the k-x components of the desired temperatures:

$$\theta_{вk} = \frac{\varepsilon_в T_в \theta_{I_k} + (K_c + K_д)\theta_{нk}}{С_в \rho_в \delta_в k \frac{2\pi}{z} i + (K_c + K_д)}; \quad (23)$$

$$\theta_{ck} = \frac{A_c \theta_{I_k} + K_п + \theta_{вk} + \alpha_н \theta_{нk}}{С_0 \rho_0 \delta_c k \frac{2\pi}{z} i + K_п + \alpha_н}. \quad (24)$$

The values θ_ink and θ_ck are generally complex numbers. Using relations (7) and (8), we obtain the dependences for determining the coefficients of the Fourier series:

$$x_k = Re(\theta_{ck}); \quad y_k = -I_m(\theta_{ck}), \quad (25)$$

$$\mu_k = Re(\theta_{вk}); \quad \eta_k = -I_m(\theta_{вk}), \quad (26)$$

where Re (θ_ck), Re (θ_vk) - real parts of complex numbers;

I_m (θ_ck), I_m (θ_vk) are the coefficients of the imaginary parts of the complex numbers θ_ck and θ_vk.

Correlations (23) and (24) are algebraic expressions and make it easy to determine the amplitude-phase characteristics, and hence the coefficients of the Fourier series. Rows (3) and (4) should have as many components as are contained in the external thermal effect. As already noted, the outside air temperature and the intensity of solar radiation are well described by the first three harmonic components, therefore, dependencies (23) and (24) will also contain three harmonic components.

The outlined method was used to determine the temperature regime of solar desalination plants of inclined-step type by analogy with previous studies (Garg, 1987; Hamed et al., 1993; Roca, 2008; Al-Othman, 2018; Zheng et al., 2021).

4 RESULTS AND DISCUSSION

The results of temperature calculations based on the obtained dependences and experimental data (see Figure), Coinciding with an error not exceeding 7-10%, allow us to assess the validity of the described method for calculating the temperature regimes of solar desalination plants and the possibility of its application to analyze the operation of various low-potential plants.

Note that the greatest difficulty in calculating the temperature regime of a solar desalter is the determination of the heat transfer coefficients in the inner volume of the desalter, since heat transfer occurs simultaneously when there is convection, radiation and phase transformations on the heat exchange surfaces.

It is important to describe the total coefficients of the fluxes using the method of successive approximations, since the convective and radiant components of heat fluxes are functions of the temperatures of the heat exchange surfaces, which are determined in the process of thermal engineering calculation of the desalter.

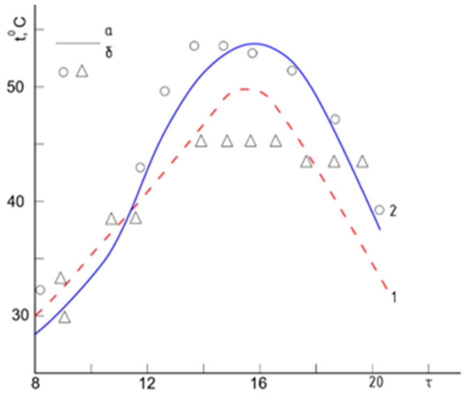

Figure 1: Temperature range of solar desalination plant: 1 - water temperature; 2 - temperature of the transparent coating; a - calculation; b - experiment.

Research analysis on increasing the productivity of solar desalination plants (Achilov, 1976; Baum, 1985) shows that the improvement of their designs is possible through the most rational use of incident solar energy while minimizing some energy losses. Thus, the heat transferred by radiation from the surface of the water to the surface of the transparent coating can be reduced by installing additional transparent screens between the evaporating zone of the desalter and its roof, by analogy with work (Timakova, 2006; Temerov, 2008; Prakash, 2019). This technical solution makes it possible to increase the productivity of inclined-step type installations by 1.5 times in comparison with single-layer glazing.

Solar absorption and reflection of energy from the transparent wall and the condensate layer, which make up to 20% of the incident energy (Baum, 1985), can be reduced by applying an interference layer to the roof material (Brdlik, 1983) and organizing film condensation, which eliminates reflection from condensate droplets. In this respect, clean degreased glass is a fairly acceptable structural material, but it is fragile.

As a material with acceptable optical and strength properties, it is possible to recommend a lavsan film coated with polyvinyl spirit, which increases its wettability. However, such a film is not strong enough and after some time is partially washed off, therefore, the problem of creating strong materials that are well wetted and sufficiently well to transmit solar energy remains one of the urgent problems at the present time.

A promising direction in increasing the productivity of solar desalination plants is the use of recuperation of the heat flux supplied to the condensation surface due to a phase transition, which is removed by convection and radiation into the environment and thus becomes the most significant loss of energy. Known technical solutions for the use of this heat flux for heating desalinated water (SNiP, 1983; Slesarenko, 1991; Smirnov, 2013), for example, adding to the design of the desalinator (Achilov, 1976) just one additional layer of the condenser-evaporator. At the same time, an increase in its productivity was established by almost 40%.

The heat flow, which is removed by the flowing hot distillate, also refers to significant heat loss and can be largely recovered. So, a heat exchanger can be connected to the distillate drain line, in which the water supplied to desalination will be preheated. Thus, an increase in the performance of solar desalination plants can be achieved by recovering heat and minimizing heat losses that cannot be recovered.

5 CONCLUSIONS

1. To determine the temperature regime of the desalter, a calculation method was applied based on finding the temperature functions in the form of Fourier series.

2. The outlined method is applied to determine the temperature regime of inclined-step type solar desalination plants. The results of temperature calculations based on the obtained dependences and experimental data, which coincided with an error not exceeding 7-10%, make it possible to assess the legality of the described method for calculating the temperature regimes of solar desalination plants and the possibility of its application to analyze the operation of various low-potential plants.

3. One of the promising areas for increasing the productivity of solar desalination plants is the use of recuperation of the heat flow supplied to the condensation surface due to the phase transition, which is removed by convection and radiation into the environment and thus becomes the most significant loss of energy. Known technical solutions for the use of this heat flux for heating desalinated water by adding one additional layer of the condenser-evaporator to the design of the desalinator, in which an increase in its productivity is established by almost 40%.

4. Analysis of studies on increasing the productivity of solar desalination plants shows that the improvement of their designs is possible through the most rational use of falling solar energy while minimizing some energy losses. Thus, the heat transferred by radiation from the surface of the water to the surface of the transparent coating can be reduced by installing additional transparent screens between the evaporating zone of the desalter and its roof. This technical solution made it possible to increase the productivity of the inclined-step type installations by 1.5 times in comparison with single-layer glazing.

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