Electrical energy saving analysis based on solar power collector's thermal system

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Abstract. This article analyzed the processes of new types of solar collector water heating systems designed to form solar collector thermal energy, air movement mode, including boundary layers of air flow, based on solar energy due to the abundance of sunny days in Uzbekistan. Additional parts in the interior, pipes, structures of the heating surface, methods for calculating basic physics were indicated. Also, the issues of forming the boundary layers of air flow, determining the elongation of the boundary layers and forming the air movement of the air flow, which occur under conditions of laminar or turbulent flow, are determined by changes in the patterns of air flow movement. A mathematical and immersion model was developed based on the results obtained directly in Reynolds number (Re) in the range 1000-5000 of these thermal and hydrodynamic processes. In the research work, the concave dimensions of the air pipe, including the length of the concave step, were determined taking into account the relationship between t and the concave height h, the formation of air flow movements and the breakpoints of the boundary points. Based on this system, traditional fuel resources were saved as well as energy saving problems in the electric power system.

1. Introduction

Since the territory of our republic has many sunny days, the easiest way to convert sunlight into thermal energy is to use solar air heaters. Heaters of this type are cheaper than other types of heaters, and solar heaters are widely used due to the simplicity of the structural structure of the devices, and the amount of exhaust gases exiting the atmosphere is reduced. Solar air heaters are widely used mainly for air heating of buildings and drying agricultural products. In an air heating system, solar air heater devices are a device that converts direct and diffused sunlight into a form of heat and directs thermal energy to the desired environment [1].

When analyzing the literature, it is necessary to establish an optimal turbulent flow regime to increase the thermal conductivity and, accordingly, to reduce the dimensions of Air, solar air heaters from the surface absorbing radiation, its mass, or increase the thermal power in previous measurements and increase the thermal efficiency through heat flow, as well as maintain heat for a long time. This task is carried out by applying an artificial collector system, profiling the surface of the sunlight receiver, placing recesses or cavities on the surface of the light receiver [2].

If the geometric dimensions of the solar collector air heater are known, and the airflow in this solar collector air heater and other general quantities are given, it will be possible to determine the hydrodynamic processes occurring in solar collector air heater devices. After the specified time has elapsed when the airflow is sent to the solar collector air heater at a certain speed, the airflow consumption at the water inlet and hot water outlet in the interior of the device is equalized. On the basis of this system, electricity consumption is reduced in the energy system and traditional fuel resources are saved.

In order to increase the efficiency of solar collector air heaters in the absorber, additional parts in the form of deflectors, ribs, wings, honeycombs and twisted tape, the use of which is one of the popular passive efficient methods of increasing the rate of heat transfer. The main purpose of using these additional components is to increase the rate of useful, efficient heat transfer with the lowest energy consumption costs. The use of additional recesses and parts inside leads to convective heat exchange. This creates additional turbulence and secondary flow adjacent to the heated plate and

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improves heat transfer. However, since their additional elements act as turbulence amplifiers, their presence leads to additional friction losses, which leads to an increase in the power consumption of the heat-rotating pump. Consequently, the geometric parameters of the partitions or additional wings are one of the most important in the configuration of the heat exchanger, and in order to obtain high temperature transfer speed and low friction losses, the channel and the solar collector must be carefully performed on the parts of the elements of the air heater. [3-6].

According to the result of the analysis carried out heat flow, it can be divided into a boundary layer on the channel surface and an external flow. The boundary layer occupies a fundamental role in the dynamic and heat exchange processes of flow with the flow body. Because collecting heat and storing it is an important issue. Loss of energy is determined by interruption events in motion and failures caused by them [3]. From a theoretical perspective, mathematical models have been developed to analyze the performance of the ribbed collector. When the air flow rate in a ribbed solar air collector is 19 m3/h, the thermal conductivity coefficient of a ribbed absorber can be tripled compared to a flat absorber collector, but the main disadvantage of the study is that the heat dissipation processes in solar air heater Collector are insufficiently illuminated in research work, as a disadvantage of V-shaped ribs, the interaction [4-6].

A flat-surface absorber was also tested under the same conditions to compare the results. In each absorber, the Reynolds number (Re) was tested at different flow rates between values from 1000 to 5000. It has been concluded that in this type of roughened absorber, by changing the indicators of air flow, it is possible to increase the ability to give off heat in significant quantities. The Nusselt number as well as the friction coefficient indicators were developed on the basis of data from the results of experiments on various flow indicators in geometrically roughened absorbers. From the above, it can be seen that in such types of roughened absorber, an increase in the number of Nusselt and the coefficient of friction up to a maximum of six times compared with flat-surface absorbers is presented [7].

2. Methods

Based on the research work under consideration, the laminar boundary layer in the solar water heating collector system is expressed as follows [4].

$$\frac{\partial}{\partial x}(\rho V)+\frac{\partial}{\partial y}(\rho V)=0 \tag{1}$$

$$\partial U\frac{\partial U}{\partial x}+\rho V\frac{\rho U}{\partial y}=-\frac{\partial P}{\partial x}+\mu\frac{\partial^2 U}{\partial x^2} \tag{2}$$

$$\rho U s_\rho\frac{\partial T}{\partial x}+\rho V s_\rho\frac{\partial T}{\partial y}=\lambda\frac{\partial^2 T}{\partial y^2} \tag{3}$$

$$U_\omega=O_, T=T_\omega(y=0) \tag{4}$$

$$U=U_{\infty ,}T=T_\infty(y=\infty) \tag{5}$$

From these equations, the following signs are accepted : ρ is the density of the heat carrier (Air); U, V–the longitudinal and transverse organizers of the flow rate; U_ω, $U_{\infty ,}$ –channel flow yield on the wall and at a certain distance from it;

T – temperature of the flow; T_ω, T_∞– –the temperature of the flow in the channel wall and To take into account the effect of the pressure and friction gradient on heat transfer, we redefine the equation of the law of compression of the mass.

$$\rho U_{\infty ,}S=const \tag{6}$$

$$\rho\frac{\partial U_\infty}{\partial x}+U\frac{\partial s}{\partial y}=0 \tag{7}$$

$$\frac{\partial U_\infty}{U_\infty\partial x}+\frac{\partial s}{s\partial x} \tag{8}$$

$$S=(a-\delta^\circ)b \tag{9}$$

From these formulas A and b are the height and width of the profillngan channel. Taking into account the similarity of the air duct to the diffuser-comfort, and through it we will have the following ones, marking the angle of opening the Channel [8-10].

$$\frac{x\partial U_\infty}{U_\infty\partial x}=\frac{xdS}{SdS}=\frac{xd(a-b^*)b}{(a-b^*)bdx}=\frac{x}{(a-b^*)bdx}\left[\frac{da}{dx}-\frac{d\delta^*}{dx}\right] \tag{10}$$

$$a=a_0+xtg\gamma \tag{11}$$

$$\frac{x\partial U_\infty}{U_\infty\partial x}=\frac{x}{a-b^*}(tg\gamma-\frac{d\delta^*}{dx}) \tag{12}$$

$$\frac{x\partial U_{\infty}}{U_{\infty}\partial x}=\frac{x}{\partial x(a-b^{*})}=\frac{xtg\gamma}{a-\delta^{*}}) \quad (13)$$

The compression thickness of the boundary layer δ is expressed through the variables automodele η:

$$\delta^{*}=\eta\frac{x}{\sqrt{Re}} \quad (14)$$

$$\eta\frac{x\sqrt{Re}}{x}\int_{0}^{y}(1-\frac{\rho U}{(\rho U)_{\infty}})dy \quad (15)$$

$$d\delta^{*}=\eta\frac{1}{2}\frac{1}{\sqrt{Re}} \quad (16)$$

$$\frac{dP}{dx}=-(\frac{xdU_{\infty}}{U_{\infty}dx})=\frac{x\eta\frac{1}{2}\frac{1}{\sqrt{Re}}}{a-\eta\frac{x}{\sqrt{Re}}}=\frac{xtg\gamma}{(a-\eta)\frac{x}{\sqrt{Re}}}\frac{\frac{1}{2}\eta}{\frac{a\sqrt{Re}}{x}-\eta}\frac{tg\gamma}{\frac{a\sqrt{Re}}{x}-\eta} \quad (17)$$

In the solar water heating collector, the convenience of heat exchange and heat-directing friction masses to move in the internal channels will also depend on the internal pressure in the channels [11, 12].

According to the studied research work, the heat carrier in the receiving devices can be divided into three types of behavior. Continuous, pre-discontinuous and discontinuous. The flow can be laminar and turbulent. The following method can be used to solve the problem of the boundary layer. We accept the following deviations;

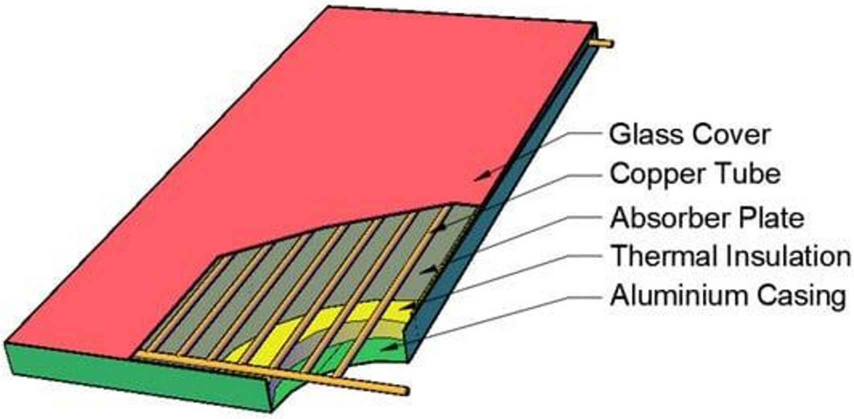


Fig.1. The structure of the inner lattices of the flat plate collector [13]

As seen in Figure 1, the FPSC is made up of a number of important components that can affect how well it performs in terms of heat. These consist of an insulation substance, riser tube, absorber plate, glass cover, and casing [14]. Heat is trapped inside the collector by the glass, which covers the riser tube from the top. The absorber plate expands the system's heat-transfer surface while the riser tube serves as a heat exchanger. The FPSC's efficiency is increased by insulating the side and bottom sections with insulation material to stop heat loss to the environment through conduction and radiation. According to [15], overheating from stagnant temperature is another frequent reliability concern in FPSCs. Dust settlement is a major problem that lowers FPSC performance over time and necessitates routine cleaning to maintain its function. The degradation of materials due to overheating can result in leaks and disrupted system functioning, ultimately diminishing the reliability of FPSC.

The distribution of air flow along the surface of the surface of the solar air heater absorber, as well as the change of longitudinal and transverse velocity, and the hydrodynamic processes occurring directly affect the heat exchange processes (Figure 2). The methods of structural solution of boundary layer problems in a given free-form profile without a two-dimensional heat exchange of the current stable and air-incompressible are based on the solution of the equation of pulses.

$$\frac{d\delta^{**}}{\partial x}+\frac{dV_{0}}{\partial x}\frac{\delta^{**}}{V_{0}}(2+H)=\frac{\tau_{\omega}}{\rho_{0}V_{0}^{2}} \quad (18)$$

Where δ * * - loss thickness of the impulse ; δ* - compression thickness; v_0, ρ_0 - the speed and density of the outer boundary of the boundary layer; N= δ*/ δ**; τω–friction tension in the wall. The compression thickness of the boundary layer at the point where the profile and speed are accurate is determined by the expressions below.

$$\delta^{*}\int_{0}^{\delta}(1-\frac{\rho v}{(\rho_{0}v_{0})})dy \quad (19)$$

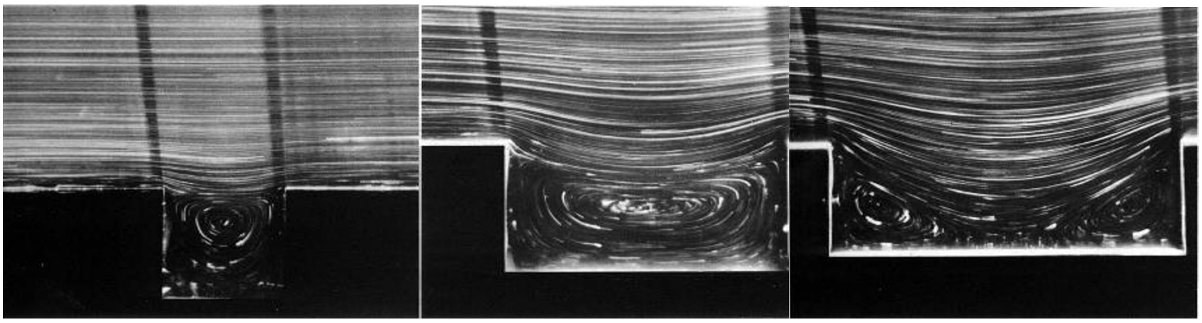
- pulse loss thickness.

$$\delta^{**} \int_0^{\delta} \frac{\rho v}{(\rho_0 v_0)} \left(1 - \frac{v}{v_0}\right) dy \tag{20}$$

Due to the fact that there are three indefinite parameters to the impulis equation - δ**, δ* and τ ω, according to the method of approximate solution of the problem, one parameter to an unknown equation depends on a number of profiles and speeds through. In place of such a parameter, the amount φ, which is called the form parameter, is proposed, and as a result of this, it makes it possible to develop structural methods for boundary layers according to theoretical foundations on the existence of internal scales of turbulence. Of particular importance is also the method of contribution of the Turbulent boundary layer with a disappearing viscosity [16-20].

3. Results

In the interior of the solar water heating collector, heat in turbulent motion near the limits of water movement is regularly added to the main airflow. Also, high-speed gradients at the upper limit of air at the heat output are caused by turbulent voltage [21-24].

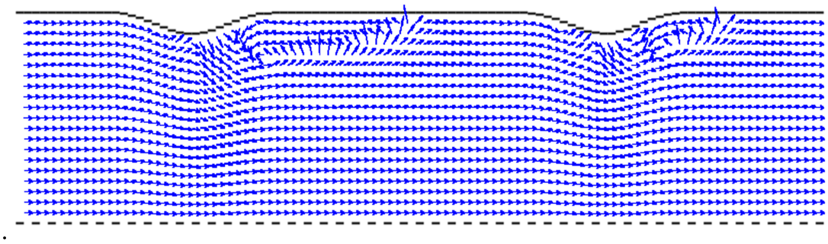


a) b) c)

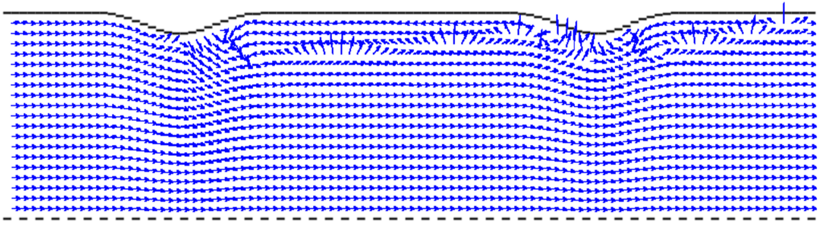
a) the formation of hanging piles, b) a shame that joins the air flow; c) uneven air flow with hanging groove.

(a– t/h=3/2; b– t/h=4/2; c– t/h=5/2)

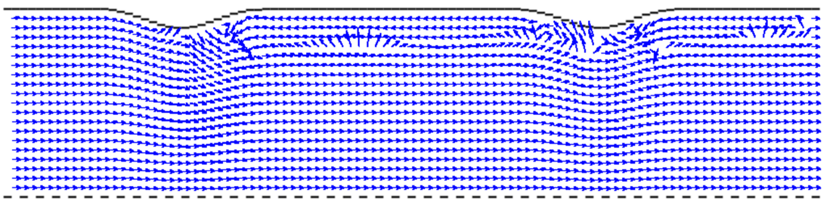
Fig. 3. Visual representation of air currents



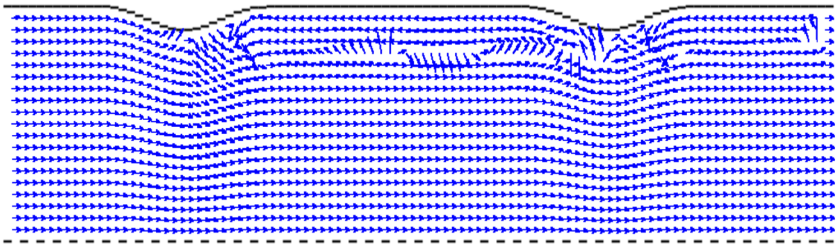
a) Re=1000



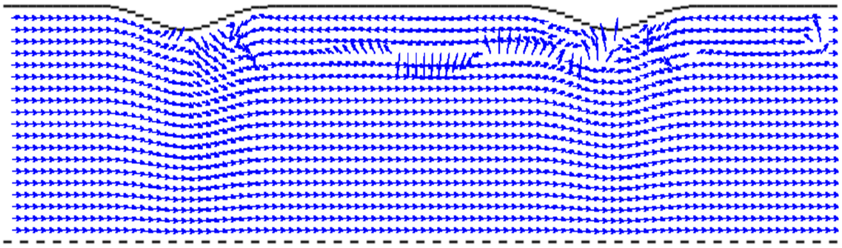
b) Re=2000



c) Re=3000



d) Re=4000



e) Re=5000

Fig. 4. Dependence of air flow boundary layers discontinuity on Reynolds number

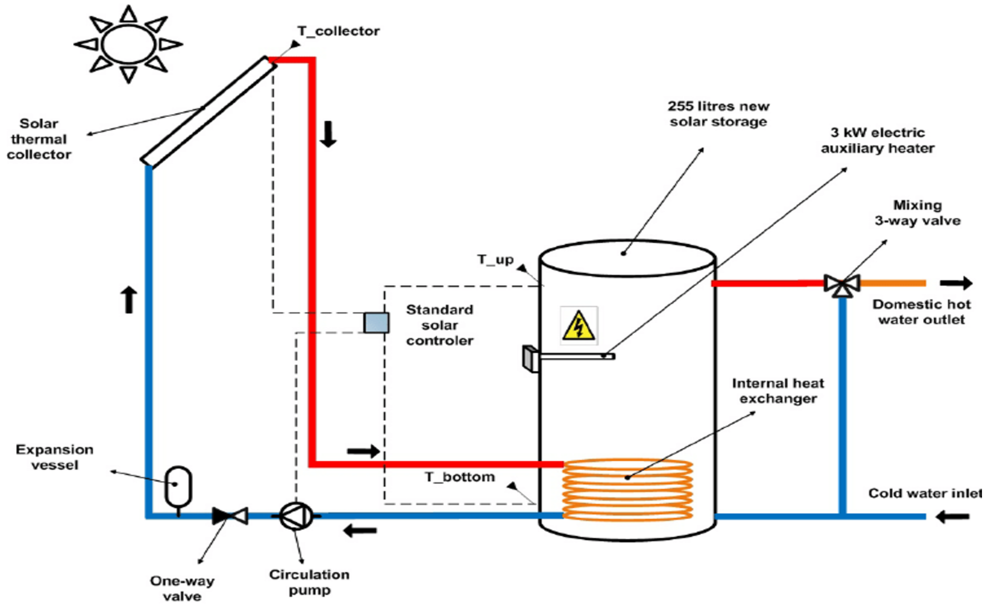


Fig. 5. Scheme of dependence of pressure loss in the heater on the Reynolds number in the solar water heating system

For a solar heating collector system, the t/h height-to-length ratio stabilizes the movement of the air volume with an increase in heat transfer by 4 times. The volume of the direction of heat transfer through the air increases (Figure 3).

In this method of solar heating collector system, it was shown that the dimensions for viscosity can be reduced faster than the dimensions in the entire boundary layer (Figure 4).

In the upper edge part of the nebulizer, a not too large separation air flow appears, with an increase in the t/h ratio up to 8...96 times, as a result of the movement of the hub formed in the initial part of the air flow in the pipe, which forms a stream opposite to the hub formed in the next boundary (Figure 5)

Figure 6 shows the pressure losses in the duct at different Reynolds numbers. Remarkably, in the case of semi-hexadecagonal profiles, the flow velocity increases gradually until it reaches its maximum and then remains reasonably flat until the flow exits the splitters-occupied region of the duct. On the other hand, when rectangular profiles are taken into account, the first interaction between the flow and the silencer produces a bigger peak, which accounts for the higher-pressure loss in this arrangement [24].

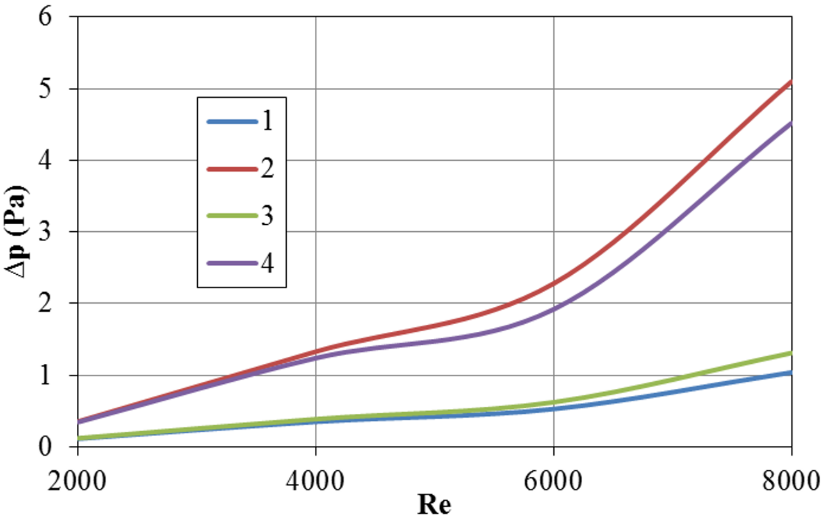


Fig. 6. Pressure losses in the duct at different Reynolds numbers: 1) t/h=5/2; 2) t/h=4/2; 3) t/h=3/2; 4) t/h=1

4. Conclusion

This article carried out mathematical modeling of the processes of the solar collector heating system operating on the basis of solar energy, the dependence of the geometric arrangement of the concave-tube-shaped compartment installed in the working Chamber of the heater on the process of operation of the Collector. As a result of the simulation, the issues of concave-tube placement on the absorber surface were calculated in a staggered order perpendicular to the airflow, parallel to the airflow. As a result, the stepped geometric Reynolds number (Re) with the lowest pressure losses was chosen at a value of 2000, which became the optimal geometric placement indicator. By applying this system, electricity that could be spent on the heating system was saved, as well as exhaust gases from conventional fuels that were released into the atmosphere..

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