International Journal of Applied Research

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2020; 6(6): 16-20
www.allresearchjournal.com
Received: 06-02-2020
Accepted: 08-03-2020

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Relevance of use of solar energy and optimization of operating parameters of new solar heaters for effective use of solar energy

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Abstract
Annotation: This article presents a contribution to the need and relevance of using solar energy. Furthermore, recommendations were made to improve the efficiency of the operation of solar collectors with a flat surface. The methods of operation of a new type of solar collectors are investigated. The issues of accelerating heat transfer processes due to the return of the upward movement of the air flow in the working chamber of the solar air collector are considered.

Keywords: Solar air collector, absorber, temperature, convective heat flux, hollow pipe, Reynolds number, laminar, turbulent

I. Introduction

At present, the problems of energy conservation in the use of fuel and energy resources remain especially relevant due to the reduction of traditional reserves of fuel and energy resources and increased environmental negative impact on the environment. Currently, 20% of the energy consumed in the world is extracted from on-conventional energy sources, and 30% from the fossil fuels.

Therefore, the implementation of comprehensive measures to solve the problems of energy conservation and the development of the use of non-traditional renewable energy sources is very relevant. In a sharply continental climate, 49.6% of the total annual energy consumption is accounted for by agricultural processing systems.

In agriculture, more than 50% of primary energy is consumed annually [1].

Currently, a number of important national economic problems of the Republic of Uzbekistan include issues related to the development of the fuel and energy complex and the solution of environmental problems.

To accomplish these tasks that require immediate solution, an increase in the share of renewable energy sources is required. The use of solar energy in reasonable harmony with other sources of energy in many cases helps to significantly save fuel and energy resources [2].

II. Reference review

Nowadays, many researchers and scientists are conducting research on the introduction of advanced technologies and equipment into the heat supply system that can efficiently and economically use energy, fuel and energy resources. It is known that at present, the reserves of natural fuels and energy resources used on an industry are declining sharply, so the use of renewable energy sources allows preserving natural resources and the ecological situation at the current level. Because in the XXI century the world faced two serious problems in the energy sector: ensuring a reliable energy supply and combating climate change. Developing environmental problems, on the one hand, are extremely unstable market of energy resources, on the other hand, the risks of the energy supply system, if it is to be built only on the basis of the use of fuel, given the resource depletion of any type of resources, this can lead to serious problems associated with energy reserves in the future.

Only one in two billion parts of the energy radiated by the Sun falls to the Earth. This amount is also not less, it is $1{,}15 \cdot 10^{19} J/min$.
Approximately 40% of the solar energy reaching the Earth's atmosphere is dissipated back into outer space as a result of returning to the atmosphere, 16% is absorbed by the atmosphere, and the rest passes through the atmosphere and reaches the Earth's surface.
As a rule, solar energy at the boundary of the Earth's atmosphere is characterized by its intensity, and this amount is called the solar constant. The solar constant can be determined as follows: if we take the radius of the Sun with R and the distance from its center to the Earth with r, then we consider a sphere whose center coincides with the center of the Sun.
The surface of such a sphere is equal to $4\pi r^2$, and the amount of energy.

$$4\pi r^2 \cdot I \qquad (1)$$

Pass from it per unit time. In this case, (I) is the intensity of solar energy at the boundary of the Earth's atmosphere. The amount of energy above, which in turn is equal to the amount of energy radiated from the surface of the sun per unit time.

$$4\pi r^2 \cdot E \qquad (2)$$

Equal to (1) and (2), becomes

$$4\pi r^2 \cdot \mathrm{I} = 4\pi r^2 \cdot \mathrm{E} \qquad (3)$$

From which we obtain

$$E = \frac{Ir^2}{R^2} \qquad (4)$$

On the other hand, if we consider the sun as an absolutely black body, it will be

$$\mathrm{E} = \sigma T^4 \qquad (5)$$

According to the Stefan–Boltzmann law. As a result

$$\mathrm{I} = \frac{R^2}{r^2}\,\sigma T^4 \qquad (6)$$

Is derived from (4) and (5). The values of the quantities included in the formula (6) are as follows:

$$R = 6{,}95 \cdot 10^8\, m \qquad r = 1{,}5 \cdot 10^{11}\, m,$$
$$\sigma = 5{,}67 \cdot 10^{-8}\, {Vt}/{(m^2K^4)} \qquad T = 5800\, K.$$

When the values of these quantities are calculated by the formula (6), it follows that [3] they are equal to

$$\mathrm{I} = 1{,}4\ \mathrm{kVt}/m^2$$

Collectors have factors affecting the acceleration of heat transfer processes, one of the main types of which is the requirement to install special hollow pipes on the absorption surface of the solar heater. Solar air heaters have low heat transfer properties due to the low thermal conductivity when air passes over a flat surface. The main problem of using air as a heat carrier is its low heat capacity and thermal conductivity, as well as the low cost of the thermal conductivity coefficient between the absorber and air. When using air as a heat carrier, the main task is to increase the heat transfer coefficient. Therefore, using a suitable method of increasing thermal conductivity, they increase the thermal efficiency of solar air purifiers. The heat transfer efficiency of these types of solar air heaters with a flat surface is 14-18% higher than that of collectors with a flat surface [4].
From the results of a study of the literature, it can be noted that the convective heat transfer rate can be increased by increasing the heat transfer surface, which is affected by the air flow, or by increasing the convective heat conductivity coefficient from the heated surface. It is necessary to establish the optimal turbulent flow regime to increase thermal conductivity and, accordingly, reduce the size of the solar radiation heater, its mass or increase its heat capacity in previous measurements and increase heat transfer through the air stream from the surface of the absorbing radiation. (Fig. 1) This task is carried out using an artificial canopy, profiles the surface of the sunlight receiver, recesses or gaps are placed on the surface of the light receiver [5].

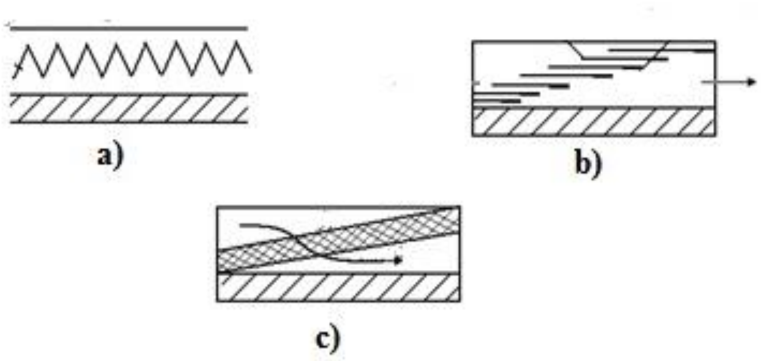

Fig 1: Types of solar air collector with high efficiency

a – surface with a triangular channel; b – surface with a hole; c – net

III. Device characteristic

A model of a flat solar air heater with a tubular winding was developed, the length of the device l = 800 mm, width a = 400 mm, height h = 62 mm. The working chamber of this solar heater has metal channels of a triangular shape. The length of each channel is l = 150 mm. The distance between the two bases of the duct l = 60 mm, the height of the base of the channel h = 60 mm. Two rows of internal convex geometric figures are given on each side of the base of the

ducts, the depth of which is h = 2 mm and the width l = 15 mm. The geometric shape given to the air ducts of the collector is opposite to the inner surface of the duct in the case of an internal convex position relative to the outer surface of the duct. The solar air heater has inlet and outlet pipes with d = 15 mm when used by blowing air.
The device works in two different ways.

- Blowing air
- Absorbing air

When blowing air according to the scheme of the device, inlet and outlet pipes are used.
When absorbing air, each channel is used in a separate order from the ducts.
The arrangement of the channels takes place in a checkerboard form, covering the collector until the complete return of the entire air flow passing through the common working surface of the chamber.

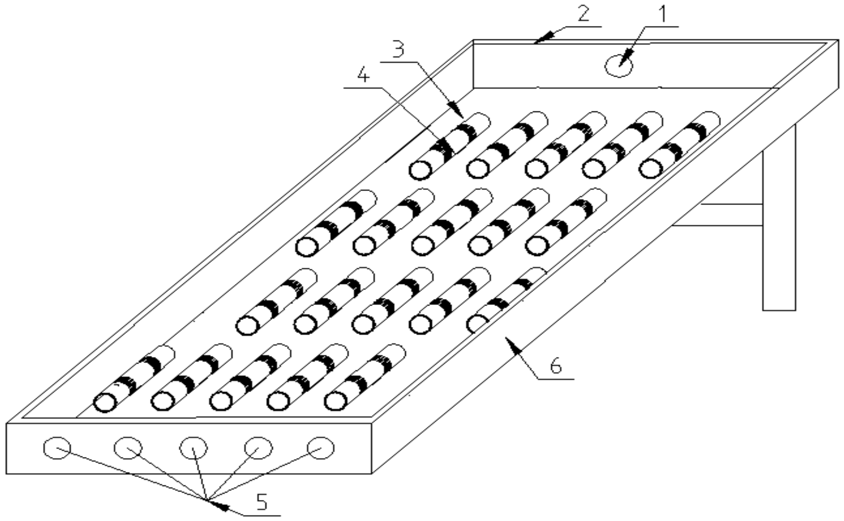

Fig 2: The scheme of the proposed flat solar air heater with a metal pipe

1-air outlet, 2-window, 3-darkened metal surface (absorber), 4-air duct, 5-air intake duct, 6-enclosur

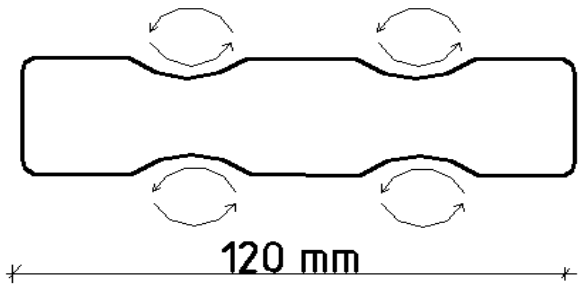

Fig 2a: Air duct

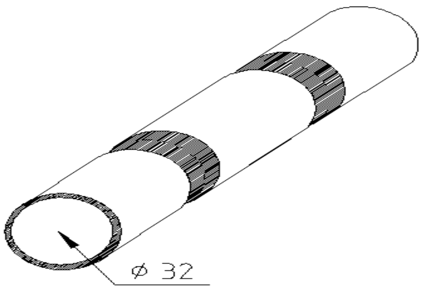

Fig 2b: Air duct

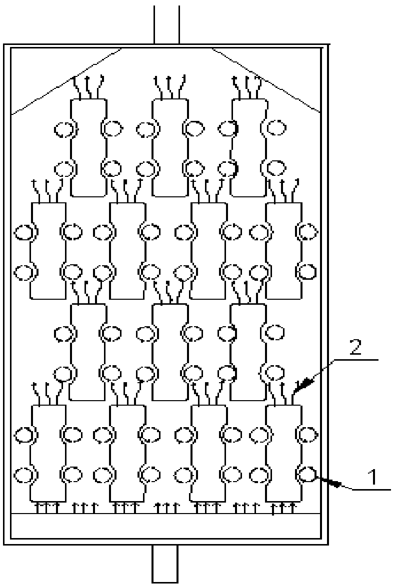

Fig 3: The movement of air flow in ducts in the air heater with pipelines

IV. Method of theoretical analysis

In solar air heaters with pipelines, the process of heat exchange mainly occurs over a wide range.

A boundary layer is formed on the opposite surface of the solar heater pipe, the thickness of which increases in the direction of flow. At some points, a breakdown of the boundary layer from the surface is observed, and two symmetric bends occur behind the pipe.

The role of the break point of the boundary layer will depend on the amount of Re. If the number Re is small and the level of turbulence of the flow entering the pipe is small, then a boundary layer break of 82–84o is observed. As the number Re increases, the motion of the boundary layer becomes turbulent. As a result of this, due to an increase in kinetic energy, the boundary layer break relay moves downstream (φ≈120÷140°), which leads to a decrease in the bending zone behind the pipe and an improvement in coating.

This kind of pipe coating affects the heat transfer between the air flow and the pipe surface.

Figure 4 (b) shows that the local heat transfer coefficient αφ depends on the angle φ on the average heat transfer coefficient α.As can be seen from the figure, the heat is released intensively on the pipe ((φ=0°), the minimum at φ=90°÷100°, the highest at φ=120°, and then decreases again at φ=140°. At the φ=0÷100°part of the pipe, a decrease in heat transfer occurs on account of an increase in the thickness of the laminar boundary layer [7].

The first lowest point on the curveαφ/ $\bar{\alpha}$=f(φ) corresponds to the transition from laminar flow to turbulent flow (Re_{kr}= 1·105÷4·105) in the boundary layer.

After that, the heat supply increases sharply. The second lowest point corresponds to a break in the turbulent boundary layer. The calculation of the average heat transfer in case the liquid or gas is washed with a cylinder in the cross section is determined by the formula:

$$\bar{N}u = (0{,}43 + C \cdot Re^{m} \cdot Pr^{0{,}38}) \cdot \varepsilon \qquad (7)$$

The temperature of the stream entering the pipe as a determinant of temperature, and the diameter of the cylinder will be the determining size. The coefficient ε of the correction takes into account the degree of turbulence of the incoming current (ε =1.0÷1.6).

The coefficient C and the index m have the following values depending on the number of Re:

$$Re = 1 \div 4 \cdot 10^3, C = 0{,}35, m = 0{,}5;$$
$$Re = 4 \cdot 10^3 \div 4 \cdot 10^4, C = 0{,}20, m = 0{,}62;$$
$$Re = 4 \cdot 10^4 \div 4 \cdot 10^5, C = 0{,}027, m = 0{,}80.$$

If the flow covers the cylinder at an angle ψ< 90°, then α calculated according to the equation (7) should be multiplied by εφ≈1–0.54 $\cos^2\psi$. If in the cross section, there is not one but a whole bundle of pipes, then the heat transfer process becomes more complicated. The heat supply in this case depends on the location of the pipes in the kit and the number of rows in which the pipe is located. Figure 4 shows a description of the fluid movement when the pipe is located in the corridor and shaft.

The first row of pipes in the set is washed with a stream of crude liquid, and therefore the α is the smallest. In later series, the heat supply is much faster, and the α is almost the same for the third and subsequent rows. Heat transfer at 103 <Re <105 and 0.7 <Pr<500 for a set of pipes is determined from the following equation.

$$\bar{N}u = CRe^{m} P_r^{1/3} \left(\frac{Pr_c}{Pr_g}\right)^{.1/3} \cdot \varepsilon_s \cdot \varepsilon_i \qquad (8)$$

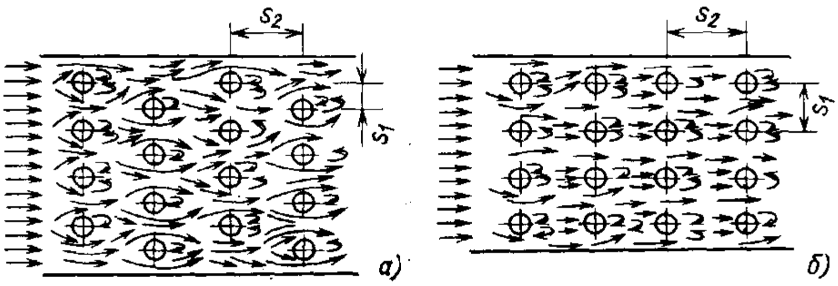

Fig 4: Description of air flow in a set of pipes

a – checkerboard-shaped layout; b - corridor layout

When the pipe is staggered, c = 0,41, m = 0,65; when located in the corridor c = 0,26, m = 0,65. The outer diameter of the pipe is taken to determine the linear size. The number Re is calculated through the average velocity of a liquid or gas in the narrowest section of the set. The correction factor takes into account εs, transverse S1 and the longitudinal pitch of the set:

In $\varepsilon_s = (S_1/S_2)^{1/6}$, $S_1/S_2 < 2$ for a checkerboard-shaped set.
In ε_s = 1, 12, $S_1/S_2 \geq 2$ for a paving set.

The coefficientεI of the correction takes into account the reduction in heat transfer of the first and second row of pipelines. Pipes for the first row ε_i=0.7 (a checkerboard-shaped set) and ε_i=0.9 (a paving set); for the third and next rows ε_i=1.

The average value of the heat transfer coefficient for the whole set of pipes is determined from the following equation:

$$\bar{a} = \frac{\sum_{i=1}^{Z} \bar{a_i} F_i}{\sum_{i=1}^{Z} F_i} \quad (9)$$

Here $\bar{\alpha}_i$ – the average heat transfer coefficient of the i row; F_i – the surface of the i row; Z – the number of pipes in the set.

V. Experimental Results

Experiments were carried out using a solar tube-tube heater. The efficiency of the solar air collector depends on the amount of Re, the Reynolds number can be found as follows [8].

$$Re = \frac{vd}{\nu} \quad (10)$$

Here v-speed, d –diameter, ν-kinematic viscosity of air. The dynamic viscosity of air is determined by the following formula.

Table 3: Reynolds number versus speed

Re	5111	6766	8271	9559	9993
V m/s	3.77	4.99	6.1	7.05	7.37

Table 4: Reynolds number versus temperature

Re	5111	6766	8271	9559	9993
t ℃	73	70	68	65	61

Table 5: Reynolds number versus temperature

Re	5111	6766	8271	9559	9993
t ℃	84	84	83	82	81

Table 5: Reynolds number versus temperature

Re	5111	6766	8271	9559	9993
t, ℃	82	81	81	80	79

VI. Expected efficiency

- Relative to a common full-channel solar air heater, the air duct consumption is halved.
- Through the geometric shape specified by the air channel, the rotational movement of air is transmitted and the possibility of maximum increase in air temperature is created.
- Relative to a common full-channel solar air heater, the local resistance coefficient of the device will be reduced.
- Due to the reduction of local resistance, the device works efficiently even at low speeds.

Conclusion and future work

With the help of a newly developed solar air heater, experiments are required in all periods of the year and based on the results obtained and a mathematical model of the device is developed.

References

1. Abdukarimov BA, Muminov OA, Utbosarov Sh. R. Optimization of the operating parameters of a flat solar air heater, Collection of scientific articles following the results of the second international scientific conference, 2020, 8-12.
2. Abbosov Yo S, Umurzakova MA, Abdukarimov BA. Methods for increasing the efficiency of thermal transfer of horizontal solar air heaters and their research Scientific – technical Journal of FerPI. 2019; 23(3):187.
3. N.M Safarov, A Kh Alinazarov. - "Use of clean energy sources", Tashkent, 2014, 11-16.
4. Uzbekov MO. Sunny air heating collectors with metal cheese absorber, the dissertation for the degree of Doctor of Philosophy (PhD) in technical sciences Tashkent, 2019, 14-17.
5. Umurzakova MA. Study of heat transfer and hydraulic resistance of solar air heaters with intensification of heat transfer: The dissertation on competition of a scientific degree of the candidate of technical sciences: special 05.14.05-Theoretical foundations of heat engineering Fergana, 2009, 116.
6. Abdukarimov BA, Abbosov Yo S, Mullayev II. Optimization of operating parameters of flat solar air heaters, Bulletin of science and education Part 2. 2019; 19(73):6-9.
7. Madaliyev EO'. Heat Engineering Fergana, 2012, 150-168.
8. Abbasov YS, Umurzakova MA, Abdukarimov BA, Sattorov AX. Issues of increasing the efficiency of solar air heaters and methods for calculating heat transfer on solar receivers with an intermittent boundary layer. Scientific – technical Journal of FerPI. 2018; 4:209-211.