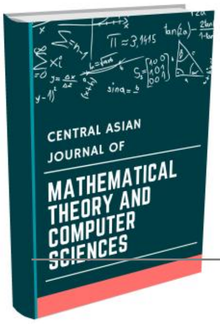


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# OPTIMIZATION OF OPERATING PARAMETERS OF NEW SOLAR AIR HEATERS USING SOLAR ENERGY

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***Annotation***

*This article focuses on the necessity and relevance of using solar energy. Recommendations for increasing the efficiency of solar air collectors with a flat surface are also given. The working methods of a newly developed solar air collector have been studied. The problems of accelerating the heat exchange processes by giving convective motion to the air flow in the working chamber of the solar air collector were considered.*

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## I. Introduction

Currently, the problems of energy conservation in the use of fuel and energy resources remain especially relevant due to the decrease in the reserves of traditional fuel and energy resources and the increasing negative environmental impact on the environment. Currently, 20% of the energy consumed in the world comes from non-conventional energy sources and 30% from fossil fuel sources.

Therefore, the implementation of complex measures to solve the problems of energy conservation and the development of the use of non-traditional renewable energy sources is very urgent. Agricultural processing systems account for 49.6% of total annual energy consumption in harsh continental climates. More than 50% of primary energy is consumed annually in agriculture [1].

Currently, a number of important national economic problems in the Republic of Uzbekistan include problems related to the development of the fuel and energy complex and solving environmental problems. In the implementation of these tasks, which require immediate resolution, it is required to increase the weight of the use of renewable energy sources. The use of solar energy in a rational combination with other energy sources helps to significantly save fuel and energy resources in many cases [2].

## II. Analysis of the literature on the research work under consideration

Today, many researchers and scientists use energy and fuel for the heat supply system. It is known that natural fuel used today on an industrial scale, fuel resources are rapidly decreasing, therefore, the use of renewable energy sources allows to preserve natural resources and the environmental situation at the current level [4-7] because in the 21st century, the world has faced two serious problems in the field of energy: it is the lack of reliable energy supply 'to ensure and fight climate change. The developing environmental problems, on the one hand, the extremely unstable market of energy sources, and on the other hand, the risks of the energy supply system, if it is built only on the basis of the use of fuel, if we take into account the resource of any type of resource, which will end in the end, this is the energy resource in the future. can cause serious problems related to Only two billionth of the energy emitted by the sun falls on the earth. This amount is not small, it is about $1{,}15\cdot 10^{19}$ J/min. Approximately 40% of the solar energy reaching the Earth's atmosphere is reflected back into space, 16% is absorbed by the atmosphere, and the remaining part passes through the atmosphere and reaches the Earth's surface. Usually, solar energy at the boundary of the Earth's atmosphere is characterized by its intensity, and this quantity is called the solar constant. The solar constant can be determined as follows: if we take the radius of the sun R and the distance from its center to the Earth with r, then we look at the sphere whose center coincides with the center of the sun.

The surface of such a sphere $4\pi r^2$ is equal to and within a unit of time

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

Amount of energy passes. In this case, I is the solar energy intensity at the boundary of the Earth's atmosphere. The amount of energy above (1), in turn, is the amount of energy radiated from the surface of the sun per unit of time

$$4\pi R^2 \cdot E \quad (2)$$

equating (1) and (2) equal to

$$4\pi r^2 I = 4\pi R^2 E \quad (3)$$

It will be

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

we get On the other hand, if we consider the sun as an absolute black body, according to the Stefan-Bolgtsman law

$$E = \sigma T^4 \quad (5)$$

will be. As a result, from (4) and (5).

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

Originates. The values of the quantities included in the formula (6) are as follows:

$$R = 6{,}95\cdot 10^8\, м \qquad r = 1{,}5\cdot 10^{11}\, м,$$

$$\sigma = 5{,}67\cdot 10^{-8}\, Bm/(м^2 K^4) \qquad T = 5800\, K.$$

If the values of these quantities are calculated using formula (6),

$$I_\perp = 1{,}4\, кBm/м^2$$

It follows that is equal to [4]

There are factors influencing the acceleration of heat exchange processes in the collectors, one of the main types of which requires the installation of special concave pipes on the absorber surface of the solar air heater. Solar air heaters have low heat transfer properties due to low thermal conductivity as air passes over a flat surface. The main problem of using air as a heat carrier is the low value of its heat capacity and thermal conductivity, as well as the low value of the coefficient of heat transfer between the absorber and air. The main task in using air as a heat carrier is to increase the heat transfer coefficient. Therefore, the thermal efficiency of solar air heaters is increased by using a suitable method of increasing heat transfer. The efficiency of solar air heaters of this type is 14-18% higher than that of solar air collectors with a flat surface [8-14]

From the results of the literature review, it can be noted that the rate of convective heat transfer can be increased by increasing the heat transfer surfaces under the influence of air flow or by increasing the coefficient of convective heat transfer from the heated surface. In order to increase the thermal conductivity and, accordingly, reduce the size of the solar air heaters, its mass, or increase its heat capacity in previous measurements and increase the heat efficiency through the air flow from the radiation-absorbing surface, it is necessary to establish an optimal turbulent flow regime. (Fig. 1) This task is carried out by applying artificial roughness, profiling the surface of the solar receiver, placing dimples or cavities on the surface of the solar receiver.

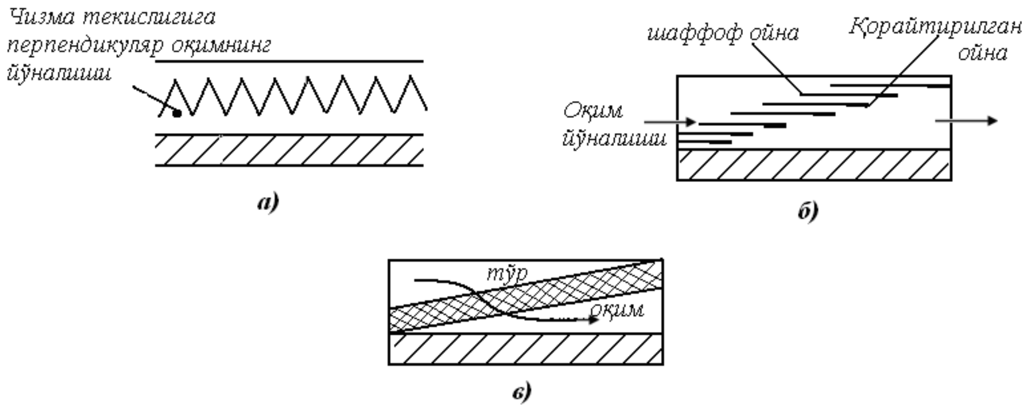



**Figure 1. High efficiency solar air collector types.**

A - Triangular channel surface; b – perforated surface; v - net. [6]

III. Device characteristics

A model of a flat solar air heater with a concave tube has been developed. The length of the device is l=800 mm, width a=400 mm, height h=62 mm. Triangular metal channels were installed in the working chamber of this solar air heater. The length of each channel is 150 mm. The distance between the two bases of the air channel is l=60 mm, the height of the channel bases is h=60 mm. . Two rows of inner convexities on each side of the base of the air ducts,the depth of this form is h=2 mm and width l=15 mm. Given to the air ducts of the collector

**The device works in two ways.**

- Air spray
- Inhaling air

In air spraying, inlet and outlet pipes are used along the diagonal of the device.

Air intake channels are used separately for each channel.

The arrangement of the channels is in the form of a checkerboard, and the collector completely covers all the air flow passing over the surface of the common working chamber.[15-20]

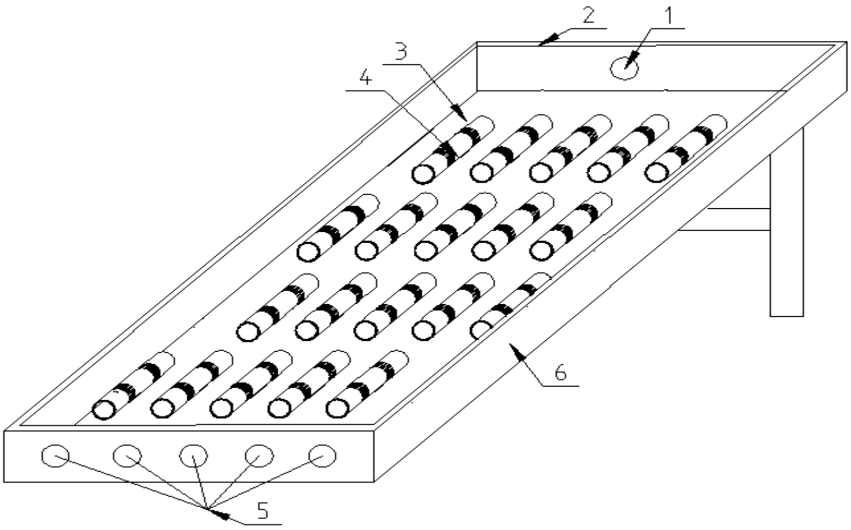



**Figure 2. Schematic diagram of the proposed metal tube flat solar air heater.**

1-air outlet, 2-mirror, 3-blackened metal surface (absorber), 4-air pipe, 5-air inlet channels, 6-case

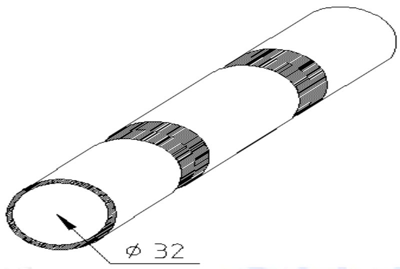



**Figure 2. Air pipe. IV. Theoretical analysis of air flow**

Convective heat exchange process mainly takes place in tubular solar air heaters. A boundary layer is formed on the surface of the opposite part of the pipe of the solar air heater, and its thickness increases along the flow direction. At some points, the boundary layer breaks from the surface, and two symmetrical piles appear behind the pipe. The location of the breakpoint of the boundary layer depends on the number of Re. If the Re number is not very large and the turbulence level of the flow coming to the pipe is small, the boundary layer breaks at 82-84. As the number of Re increases, the movement in the boundary layer becomes turbulent. As a result, such a unique covering of the pipe affects the heat exchange between the air flow and the surface of the pipe. Figure 4 (b) shows the angle dependence of the ratio of the local heat transfer coefficient to the average heat transfer coefficient. It can be seen from the figure that the heat transfer occurs rapidly around the pipe (=0), is the minimum at =90100, is the lowest at =120, and then decreases again at =140. The decrease in heat transfer in the part of the pipe with =0100 is due to the increase in the thickness of the laminar boundary layer.

The first lowest point on the f() curve corresponds to the transition from laminar flow to turbulent flow ($R_{erk}$= $1{\cdot}10^{5}$ $4{\cdot}10^{5}$) in the boundary layer.

After that, the heat output increases dramatically. The second lowest point corresponds to the disruption of the turbulent boundary layer. The calculation of the average heat transfer for the case of a liquid or gas flowing across the cylinder is determined by the following formula:

$Nu=(0{,}43+C\,Re^{m}Pr^{0{,}38})$ (7)

As the temperature of the flow coming to the pipe, and the defining size is the cylinder. The correction coefficient takes into account the degree of turbulence of the incoming flow ( =1.01.6).

The coefficient C and the indicator m take the following values depending on the number of Re:

$Re=1□4□10^{3}$, C=0,35, m=0,5;

$Re=4□10^{3}□4□10^{4}$, C=0,20, m=0,62;

$Re=4□10^{4}□4□10^{5}$, C=0,027, m=0,80.

If the current covers the cylinder at an angle of 90, then calculated according to equation (7) should be multiplied by 1-0.54 cos2. If there is not one, but a whole set of pipes in the transverse flow, the process of heat exchange becomes more complicated. In this case, the heat supply depends on the location of the pipes in the set and the row number of the pipe. Figure 4 shows the description of the fluid movement when the pipes are arranged in a strip and checkerboard [21-31].

The first row of tubes in the set is flushed with the still fluid flow and is therefore the smallest in the row. In the next rows, the heating is much faster, and in the third and third

$$\overline{Nu} = C\,\mathrm{Re}^{m}\,P_r^{1/3}\left(\frac{\mathrm{Pr}_c}{\mathrm{Pr}_g}\right)^{1/3}\varepsilon_S\cdot\varepsilon_i \qquad (8)$$

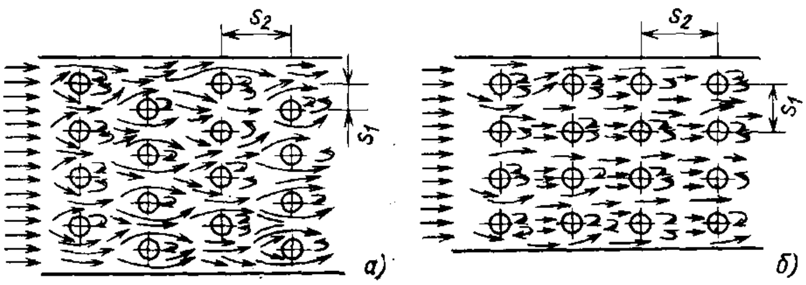



**Figure 4. Description of the movement of air flow in a set of pipes.**

a - checkerboard arrangement; b - lane location

When the pipes are arranged in a checkerboard pattern, c=0.41, m=0.65; c=0.26, m=0.65 when located in a corridor. The outer diameter of the pipe is taken as the determining linear dimension. The Re number is calculated by the average velocity of the liquid or gas in the narrowest section of the set. The correction factor s takes into account the transverse S1 and longitudinal step of the set:

For a chess set

$□_s=(S_1/S_2)^{1/6}$, $S_1/S_2 < 2$ at.

For the corridor set

$□_s=1,12$, $S_1/S_2□$ 2 at.

The correction coefficient I take into account the reduction of heat transfer in the first and second row of pipes. For the first row of pipes, $e_i=0.7$ (checkerboard set) and $e_i=0.9$ (striped set); $e_i=1$ for the third and subsequent rows.

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

$$\overline{\alpha} = \frac{\sum_{i=1}^{Z}\overline{\alpha_i}F_i}{\sum_{i=1}^{Z}F_i} \qquad (9)$$

where □$_i$ – i – inch is the average heat transfer coefficient of the row; $F_i$ – inchi row surface; Z is the number of pipes in the set. [9]

V. Experimental results

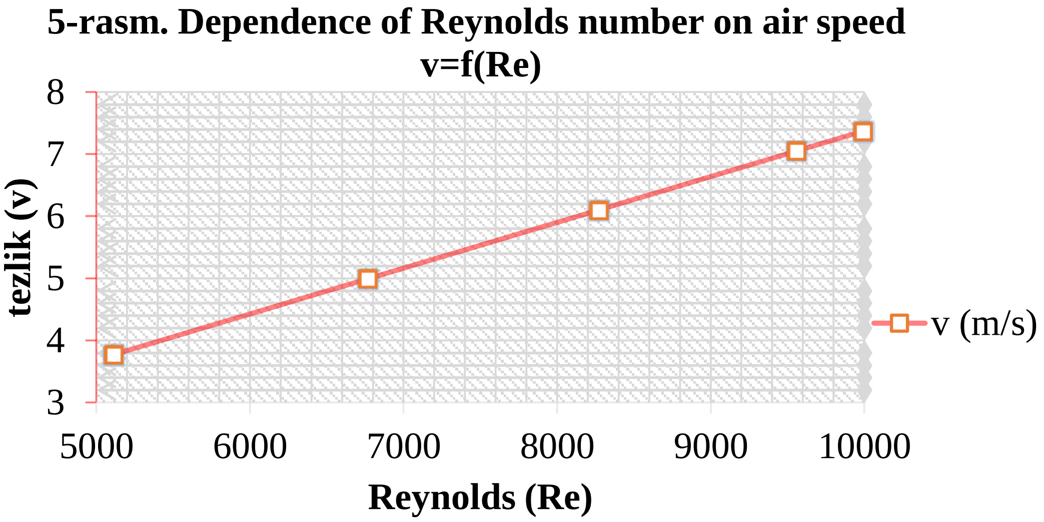
Experiments were conducted with the help of a sunken pipe solar air heater. The working efficiency of the solar air collector directly depends on the $R_e$ number, and the Reynolds number is found as follows.

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

Here:v - speed, d- diameter, - kinematic viscosity of air.

Table 1. Dependence of Reynolds number on air speed

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




- ➢ Compared to a general full-channel solar air heater, the consumption of air channels is reduced by two times
- ➢ Through the geometrical shape given to the air channel, the air is given a circular motion and the temperature of the air is increased to the maximum level.
- ➢ The local resistance coefficient of the device is reduced compared to the general full-channel solar air heater.
- ➢ As a result of reduced local resistance, the device works efficiently even at low speed. [32-34]

**Conclusion**: It is necessary to conduct experiments in all periods of the year with the help of a newly developed solar air cooler and to develop a mathematical model of the device based on the obtained results.

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