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Optimization of the Operating Parameters of New Solar Air Heaters with the Efficient Use of Solar Energy.

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ABSTRACT: This article presents a contribution to the necessity and relevance of the use of solar energy. Recommendations were also given to improve the efficiency of flat surface solar air collectors. The methods of operation of solar air collectors of a new type have been investigated. The issues of acceleration of heat exchange processes due to the recoil of the ascending air flow in the working chamber of the solar air collector are considered**.**

KEY WORDS: Solar air collector, absorber, temperature, convective heat transfer, sunken pipe, Reynolds number, laminar, turbulent.

I.INTRODUCTION

Currently, the problems of energy saving in the use of fuel and energy resources remain particularly relevant due to the depletion of traditional fuel and energy resources and the increasing negative impact on the environment. Currently, 20% of the energy consumed in the world is obtained from non-conventional energy sources, and 30% from extracted fuels.

Therefore, it is very important to implement comprehensive measures to solve the problems of energy conservation and the development of non-traditional renewable energy sources. In a sharply continental climate, 49.6% of total annual energy consumption comes from agricultural processing systems. Agriculture uses more than 50% of primary energy annually. [1]

Currently, problems related to the development of the fuel and energy complex and the solution of environmental problems are one of the important national economic problems in the Republic of Uzbekistan.

These challenges, which need to be addressed urgently, will require an increase in the share of renewable energy sources. Smart use of solar energy in combination with other energy sources can in many cases significantly save fuel and energy resources. [2]

II. SIGNIFICANCE OF THE SYSTEM

The article examines the technology of the device based on energy-saving and renewable energy sources for drying agricultural products. Nowadays relevance of the topic lies in the fact that saving any natural energy resources is one of the most important issues in the world.

III. LITERATURE SURVEY

Today, many researchers and scientists are conducting research on the introduction of advanced technologies and equipment that can efficiently and economically use energy, fuel and natural resources in the heating system. It is well known that the natural resources used in the industrial scale are decreasing sharply today, therefore, the use of renewable energy sources makes it possible to preserve natural resources and the ecological situation at the current level [3] because in the XXI century the world faced two serious problems in the energy sector: ensuring reliable energy supply and combating climate change.

Collectors have factors that affect the acceleration of heat exchange processes, one of the main types of which is the requirement to install special cotton tubes on the absorption surface of a solar heater. Solar air heaters have low heat-transfer properties due to 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 level of the coefficient of thermal conductivity between the absorber and air.When using air as a heat carrier, the main task is to increase the heat transfer coefficient. Therefore, by using a suitable method of increasing thermal conductivity, the thermal efficiency of solar air purifiers is increased. The heat transfer efficiency of this type of solar air heaters is about 14-18% higher than that of flat-surfaced solar air collectors.

From the results of studying the literature, it can be noted that the rate of convective heat transfer can be increased by increasing the heat transfer surfaces exposed to the air flow, or by increasing the coefficient of convective heat conductivity from the heating surface. It is necessary to establish the optimal turbulent flow regime to increase

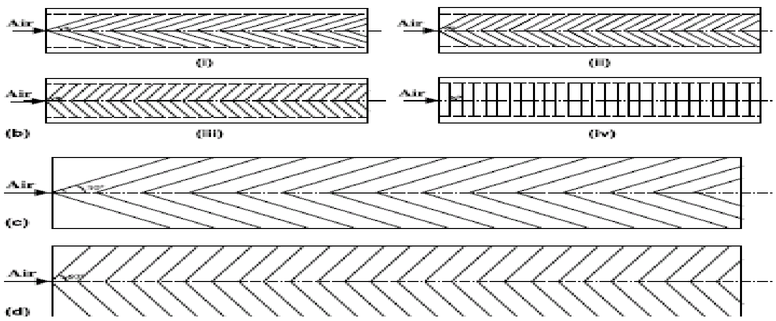

Fig. 1Scheme of high efficiency solar air collector

thermal conductivity and, accordingly, reduce the size of solar air cleaners, their mass or increase the heat capacity in previous measurements and increase heat transfer through the air flow from the surface of absorbing radiation. (Fig. 1) This task is performed using an artificial canopy, profiles the surface of the sun light receiver, grooves or gaps are placed on the surface of the light receiver.

The study investigated the effect of a V-shaped recessed air duct solar air heater on thermal conductivity and flow rate.A fan was used to regulate the intensity of the air flow. Fourteen different cases were considered with different mass flows, corresponding to the Reynolds number range from 2500 to 18000.For comparison, the experiment results were repeated with flat absorber surfaces under similar flow conditions.The Nusselt number and friction correlations were determined by analyzing the experimental results.

It was concluded that with an increase in the Reynolds number, the Nusselt number increases with a decrease in the friction coefficient.The concave channels served to increase the Nusselt number and the coefficient of friction.The number of detected Nusselts and the coefficient of friction determined for concave canals at an angle of 60 ° increased by about 2.30 and 2.83 times, respectively, compared with a flat absorbing canal.The thermo-hydraulic processing process has improved with an increase in the lowering angle. [4]It was also found that experimental results and results obtained from correlations differed from each other by a maximum deviation of ± 10%.

IV.DEVICE CHARACTERISTICS.

A model of flat tube solar air heater was developed. The length of the device is l = 800 mm, the width is a = 400 mm, and the height is h = 62 mm. The working chamber of this solar heater has triangular metal channels. The length of each channel is l = 150 mm. The distance between the two bases of the air duct is l = 60 mm, the height of the channel base is h = 60 mm. On each base side of the air ducts, two rows of internal convex are defined, the depth of which is h = 2 mm, and the width is l = 15 mm. The shape given to the collector air ducts is opposite to the inner surface of the air duct in the case of an internal bulge relative to the outer surface of the air duct. In a solar air heater, when air spraying is used, the inlet and outlet pipes are arranged so that d = 15 mm.
The device works in two different ways.

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- Spraying air
- Absorbing air

Inlet and outlet pipes are used along the diagonal of the device for air spraying.

As for the absorption of air, each channel is used in its own separate order from the incoming air channels.

The location of the channels is in the form of chess and completely covers the entire air flow passing through the common working chamber surface [5].

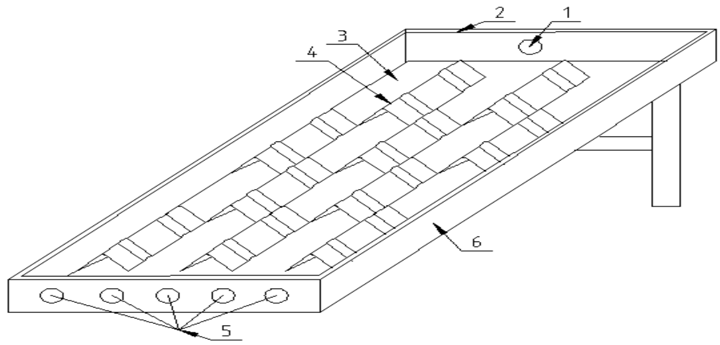

Fig. 2The scheme of the proposed metal triangular flat solar air heater.
1-air outlet, **2**-windows, **3**-darkened metal surface (absorber), **4**-air ducts, **5**-air intakes, **6**-corpus

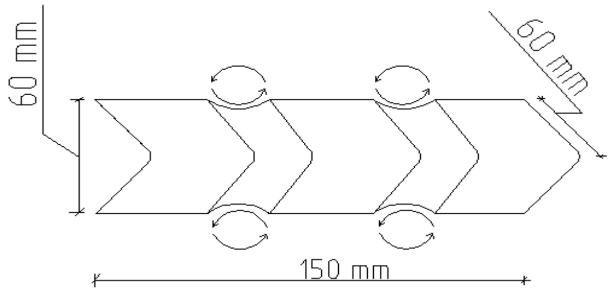

Fig. 3 Schematic representation of a concave duct through which air moves.

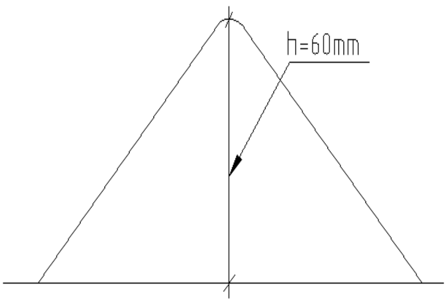

Fig. 4 Longitudinal view of a concave duct through which air moves.

V. METHOD OF THEORETICAL ANALYSIS

In tubular solar air heaters, mainly convective heat exchange takes place. On the opposite surface of the solar heater tube, a boundary layer is formed, the thickness of which increases in the direction of flow. At some points, a separation of the boundary layer from the surface is observed, and two symmetric bends appear behind the pipe.

The role of the breakpoint of the boundary layer will depend on the amount of Re. If the number is small, and the level of turbulence of the flow entering the pipe is small, then a break in the boundary layer of 82-84°is observed. As the number of revs increases, the motion of the boundary layer transforms into a turbulent form. Due to this, by

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increasing theenergy, the boundary layer rupture switch slides downstream (φ≈120÷140°), which leads to a decrease in the bend zone behind the pipe and an improvement in coverage.

This specific coverage of the pipe and the air flow affect the heat exchange between the pipe surfaces.

Figure 5 (b) shows the **φ** angle dependence of the ratio of the local heat transfer coefficient α_φ to the average heat transfer coefficient**α**.

As can be seen from the figure, the heat transfer occurs rapidly about the pipe (φ=0°), is lowest at φ=90°÷100°, highest at φ=120°, and then decreases again at φ=140°. The decrease in heat transfer in the section φ=0÷100°is due to the increase in the thickness of the laminar boundary layer.

The first lowest point on the $\alpha_\varphi/\alpha=f(\varphi)$ curve corresponds to the transition of laminar flow in the boundary layer to turbulent flow ($Re_{kr}=1\cdot10^5\div4\cdot10^5$).

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

$$Nu = (0,43 + C \cdot Re^m \cdot Pr^{0,38}) \cdot \varepsilon \quad (1)$$

The determinantis the temperature of the flow to the pipe, and the determinant is the cylinder. The correction factor ε takes into account the degree of turbulence of the incoming current (ε =1,0÷1,6).

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

$Re=1\div4\cdot10^3$, C=0,35, m=0,5;

$Re=4\cdot10^3\div4\cdot10^4$, C=0,20, m=0,62;

$Re=4\cdot10^4\div4\cdot10^5$, C=0,027, m=0,80.

If the flow covers the cylinder at an angle ψ< 90°, then (7) calculated by the equation must be multiplied by α, $\varepsilon_\varphi\approx1-0,54\cos^2\psi$. If there is not one but a whole tube bundle in the cross section, then the heat transfer process becomes more complicated. The heat supply in this case depends on the location of the pipes in the set and the number of rows in which the pipe is located. Figure 5 shows a description of the movement of fluid when the pipe is located in the corridor and shaft.

The first row of tubes in the set is washed with a stationary liquid stream, so the **α** is the smallest in the row. The heat transfer in the next rows is much faster, and the α is almost the same for the third and 4eying rows. For a set of pipes, the heat transfer at $10^3<Re<10^5$ va $0,7< Pr < 500$ is determined from the following equation. [6]

$$\overline{Nu} = CRe^m P_r^{1/3} \left(\frac{Pr_c}{Pr_g}\right)^{1/3} \varepsilon_s \cdot \varepsilon_i \quad (2)$$

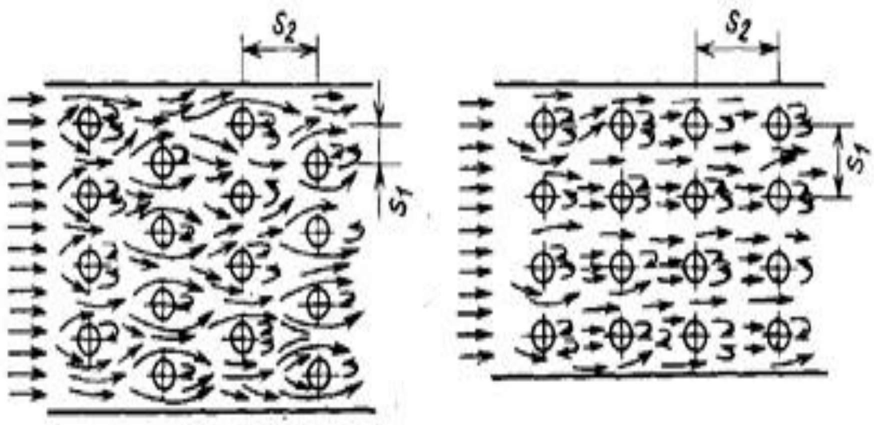

Fig. 6.Description of air flow in a set of pipes.
a – chess-shaped location; **b-** corridor location

When pipes are chess-shaped located, c=0.41, m=0.65; when it is corridor-shaped located, c=0.26, m=0.65. As a detectable linear dimension, the outer diameter of the pipe is obtained. The number of Re is calculated by the average speed of the liquid or gas in the narrowest part of the collection. The correction coefficient εs takes into account the cross-S_1 and longitudinal step of the bundle:

For the chess-shaped set

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at $\varepsilon_s=(S_1/S_2)^{1/6}$, $S_1/S_2<2$

For the corridor-shaped set

at $\varepsilon_s=1,12$, $S_1/S_2\geq 2$

The correction factor εI takes into account the reduction in heat transfer in the first and second rows of pipes. For the first row of pipes, $\varepsilon_i=0,7$ (chess-shaped set) and $\varepsilon_i=0,9$ (corridor-shaped set); $\varepsilon_i=1$ for the third and subsequent rows.

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

$$\bar{a} = \frac{\sum_{i=1}^{Z}\bar{a}_i F_i}{\sum_{i=1}^{Z} F_i} \qquad (3)$$

here α_i- the average heat transfer coefficient of the *I* row; F_i - the surface of the *I* row; Z - the number of tubes in the set. [7]

VI. EXPERIMENTAL RESULTS

Experiments have been carried out using a tubular solar heater. The efficiency of a solar air collector directly depends on the amount of Re, the Reynolds number can be found as follows.

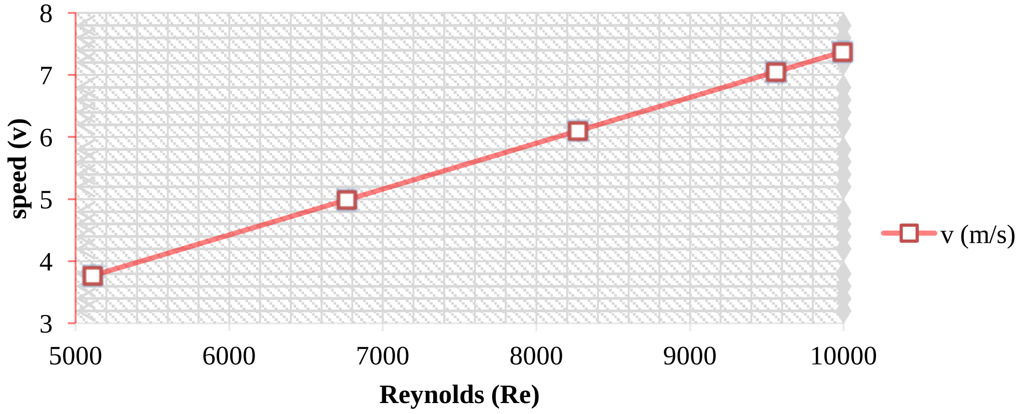
$$Re = \frac{vd}{\nu} \qquad (4)$$

Here **v** - the velocity, **d** - the diameter, and ν- the kinematic viscosity of the air.

Table 1. The dependence of the Reynolds number on air velocity

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

Fig. 6 The dependence of the Reynolds number on air velocity v=f(Re)



VII. EXPECTED EFFICIENCY

- Compared with a common full-channel solar air heater, the air duct consumption is halved.
- Through the geometric shape given by the air channel, the rotational movement of the air is transmitted and the possibility of a maximum increase in the air temperature is created.
- Compared with a common full-channel solar air heater, the local resistance coefficient of the device will be reduced.
- By reducing local resistance, the device works effectively even at low speeds.

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VIII. CONCLUSION AND FUTURE WORK

In solar heaters, developed in a new way, the efficiency of the device increased by 2.36 and 2.83 times, respectively, compared to collectors with a flat absorption surface. With the help of this solar heater, it is required to carry out experiments throughout the entire period of the year and, on the basis of the results obtained, to develop a mathematical model of the heat transfer coefficient and hydraulic stability of the device.

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