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SELECTION OF SURFACES THAT FORM THE PHENOMENON OF NATURAL CONVECTION IN AN ADVANCED FRUIT DRYER

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Annotation: In this article, surfaces that form the phenomenon of natural convection in a fruit dryer are selected. It has been revealed that the efficiency of the dryer is higher when the first and upper windows are open, and the second and third windows are closed. Moreover, when the temperature difference reaches $\Delta T_{1',5'sr}$=2,4˚C, the flow of warm air begins to move in the dryer (natural convection). For an efficient drying process in a plant, natural convection must occur at low temperatures. The low temperature ($T_{4'sr}$=44.85˚C) in the first part of the installation where the product is located (point 4) did not affect the quality of the product.

Key words: the sun; dryer; housing; window; convection; product; natural; efficiency; experience.

For fruit dryers, various sources of energy are used (minerals, natural gas, the sun, etc.). Shortage of natural energy sources, rising prices for fossil fuels, environmental damage and other factors contribute to the widespread use of solar energy in drying plants [1]. In Uzbekistan,

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scientific studies were carried out on the kinetics of drying vegetable greens in the Sun [2], optimizing the dehydration of highly reduced materials [3], experimental testing of two-chamber drying devices [4], and experimental testing of the operation of an advanced greenhouse-type solar dryer for drying grapes [5] . The rural population of India dries agricultural products in the open air, which has a number of drawbacks, such as dust pollution, damage caused by local birds and animals, etc. Dryers using solar energy are used to prevent these drawbacks [6]. Drying fruits and vegetables in the sun is one of the methods of food storage in antiquity. Drying is a very important and necessary process in the storage of agricultural products. In addition, it is of great importance in such industries as light industry, tea production, wood processing, paper production, etc. [8.9]

Using environmentally friendly, free, alternative energy source - solar energy in drying devices having a number of advantages, in turn leads to some practical difficulties that must be overcome. During the day, the intensity of solar radiation is not constant, which requires maximum conservation of solar energy in the dryer. After sunset and in bad weather conditions, an additional artificial source of energy is needed. In addition, solar energy is too low, which requires the use of collectors to increase the collection area of solar radiation. For this reason, investment in this industry is very small. [10.11]

World population growth leads to a natural increase in food demand. The role of solar dryers in the continuous provision and supply of quality food to the population is undeniably not appreciable. As mentioned above, a lot of work has been done in this direction, and even now, many scientists of the world are engaged in these issues. Today, as in many developed countries, solar energy is widely used in the sun in plentiful Uzbekistan. To prevent the above drawbacks during the drying process, the following solar dryer has been created and introduced.

In order to efficiently use solar energy, a greenhouse-type fruit dryer has been manufactured. The dimensions of the installation are h=0,15м, l=0,78м, $h / l = 0,2$, $m=45^\circ$, $n = 52^\circ$. This installation can be used by every family in their home. The design of the fruit dryer includes such components as side walls, three light-transmitting surfaces, limited parts of the body and the collector (Fig. 1). The body is made of wood frame. Inside the case, shelves were placed in two floors, on which fruit pallets are laid out, and a collector is located under the lowest shelf.

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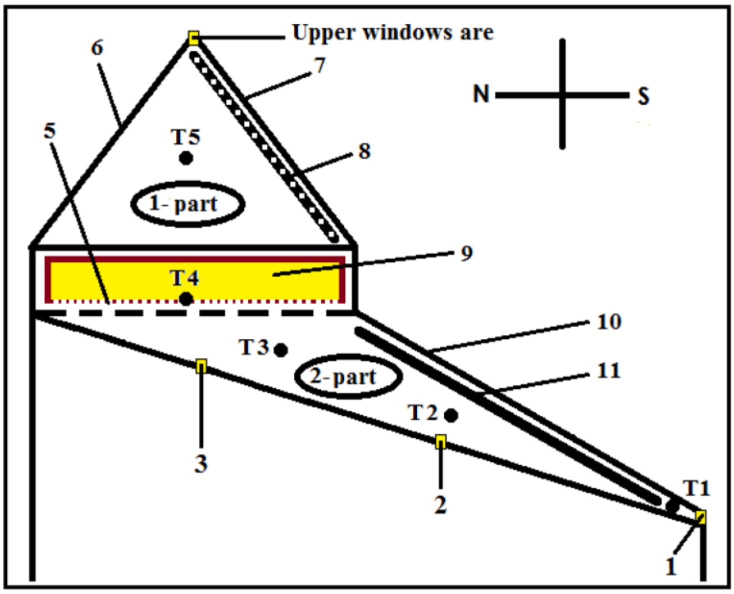

Fig. 1 Diagram of a solar dryer for greenhouse fruits. 1, 2, 3, upper vents - vents for the formation of natural convection; 5, 9- fruit pallets made of stainless steel and wood; 6, 7, 10 — dryer walls (light-transmitting surfaces); 8, 11 - collectors.

The unit is conditionally divided into two parts: in the upper part, fruits are placed, in the lower-collector. Solar energy penetrates the walls of the structure (6,7,10), which transmit light. Energy heats the ferrous metal with holes (8) located above the fruit pallets, as well as a second collector (11) in the lower part of the dryer. The metal with holes (8), painted black, protects the fruit from direct sunlight, which in turn can harm the minerals in the fruit. After the heat energy is transferred to the product, the water in the composition of the feed begins to evaporate. In this case, the resulting steam-water mixture disappears through the upper window (1). This process is facilitated by the temperature difference in the drying chamber, formed between points 2,3 and 5 (on average, $\Delta T = T_{2,3} - T_5 = 4.1^\circ C$). Due to this, the phenomenon of natural convection occurs. To dry the loaded product, a high temperature is not required, it is enough that a stream of warm air passes inside the chamber. The temperature at points 2 and 3 due to the additionally installed collector is much higher than in the others, thereby creating a noticeable temperature difference between the lower and upper parts. The high temperature in the lower part of the air, moving up, lowers. The products located in the upper part of the installation (9) receive thermal energy from air, and therefore, in the first part of the dryer, the temperature decreases sharply.

The collector and air vents installed in the lower part of the device accelerate the process of natural convection and increase the overall efficiency of the installation. The dryer with additional links is made compactly, cheaply and from local materials. It is important to determine the location of the lower window, intended for the convection process. In total there are three of them, and the installation efficiency and the speed of the drying process depend on their position. To study the modes of the dryer and check the influence of the position of the window leaves on the performance, work was carried out under the following conditions:

1. the first and upper windows are open, the second and third are closed;

2. the second and upper windows are open, the first and third are closed;

3. the third and upper windows are open, the first and second are closed.

The results of the experiments when choosing surfaces, forming the phenomenon of natural convection in a fruit dryer, and more specifically, provided that the first and upper windows are open, the second and third are closed, are given in table1.

Table 1. The temperature inside the dryer under the first condition of the experiment.

Measured points	**Temperature (˚C)**	**Measured points**	**Temperature (˚C)**	**Measured points**	**Average temperature (˚C)**
1	46,1	**6**	46,9	**1'**	46,5
2	46,5	**7**	48,6	**2'**	47,55
3	49,6	**8**	48,2	**3'**	48,9
4	43,8	**9**	45,9	**4'**	44,85
5	42,7	**10**	45,5	**5'**	44,1
Solar radiation (W/m^2)			836	**Outdoor temperature (˚C)**	40,5

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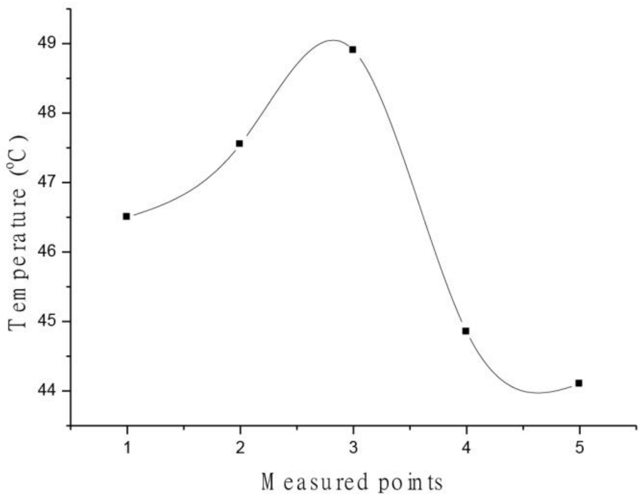

Fig. 2 Temperature distribution over the points under the first condition of the experiment

It can be seen from Fig. 2 that under the first condition (when the first and upper windows are open, and the second and third are closed), if the solar radiation is $Q=836W/m^2$, and the ambient temperature is T=40,5°C then in the dryer the average temperature at the first and fifth points is the lowest (46,5°C, 44,1°C), at the third point the highest (48,9°C). In this case, the temperature difference between the first and fifth points is quite high ($\Delta T_{1',5'sr} = T_{1'sr}-T_{5'sr}$ = 2,4°C), which leads to an increase in the speed of rotation of the warm air stream. This event accelerates the drying process of fruits, which favorably affects the efficiency of the installation. In other words, for the drying process, it is not necessary to maintain a high temperature in the chamber, a temperature difference ($\Delta T_{1',5'sp}$), which affects the occurrence of natural convection, is sufficient. The low temperature ($T_{4'sr}$=44.85°C) at point 4, located in the first part of the installation, does not affect the quality of the dried product.

The experimental results under the second condition, when the second and upper windows are open, and the first and third are closed, are shown in table 2.

Table 2. The temperature inside the dryer under the second condition of the experiment

Measured points	Temperature (°C)	Measured points	Temperature (°C)	Measured points	Average temperature

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					(°C)
1	51,1	**6**	54,3	**1'**	52,7
2	48,6	**7**	50,1	**2'**	49,35
3	49,7	**8**	49,0	**3'**	49,35
4	50,8	**9**	52,3	**4'**	51,55
5	53,3	**10**	59,2	**5'**	56,25
Solar radiation (W/m²)		812	**Outdoor temperature (°C)**		38,2

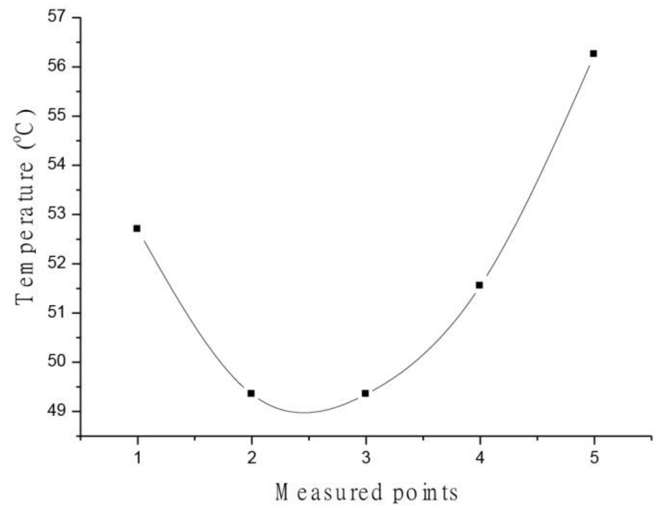

Fig. 2 Temperature distribution over the points under the second condition of the experiment

The graph in the second figure shows that during the experiment, under the second condition, when the second and upper vents are open, and the first and third are closed, then, given the solar radiation Q=812 W/m², the outside temperature is T = 38,2 °C , at the first point, the average temperature will be $T_{1'sr}$=52,7 °C. In this case, the temperature at the fifth point rises to the indicator $T_{5'sr}$=56,25 °C, thereby forming a low speed of rotation of the warm air stream. The temperature at the points located in the drying chamber ($T_{4'sr}$=51,55°C; $T_{5'sr}$=56.25°C), sharply increasing, had a negative impact on the quality of the product. It follows that convection is too small in the drying chamber, and this in turn reduces the efficiency of the installation and the quality of the product.

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The results of the dryer experiments under the third condition, when the third and upper windows are open, and the first and second are closed, are shown in table 3.

Table 3. The temperature inside the dryer under the third condition of the experiment

Measured points	**Temperature (˚C)**	**Measured points**	**Temperature (˚C)**	**Measured points**	**Average temperature (˚C)**
1	51,4	**6**	52,7	**1'**	52,05
2	50,6	**7**	49,1	**2'**	49,85
3	48,4	**8**	48,1	**3'**	48,25
4	48,7	**9**	49,9	**4'**	49,3
5	53,2	**10**	52,3	**5'**	52,75
Solar radiation (W/m²)		891	**Outdoor temperature (˚C)**		40,2

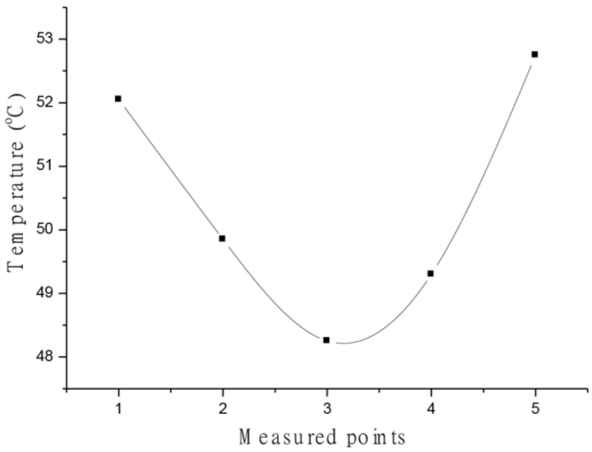

Fig. 3 Distribution of temperature over points under the third condition of the experiment

It can be seen from the graph in Fig. 3 that, subject to the third condition of the experiment, when the third and upper windows are open, and the first and second are closed, taking into account external radiation Q=891W/m^2, ambient temperature T=40,2°C, then the average temperature at the first point is $T_{1'av}$=52.05°C, at the fifth the highest indicator is $T_{5'av}$=52.75°C. Consequently, the difference between the extreme points is very insignificant ($\Delta T_{5',1'sr}=T_{5'sr}-T_{1'sr}$=0,7˚C), which negatively affected the process of natural convection. In this case, due to the slow speed of rotation of the warm air stream, a high temperature was observed inside the drying

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chamber, which led to spoilage of products, and, of course, to a decrease in the efficiency of this installation.

The modern world requires providing humanity with fruit and vegetable products all year round, and for this it is necessary to solve several problems in this area, including the use of cheap available energy sources and reducing the cost of manufactured products are very relevant. For this purpose, an improved combined solar plant for drying fruits was created. Studies were conducted on it to study the operating modes of the installation, the temperature inside the drying chamber was measured, the data obtained were analyzed, and based on them, surfaces were selected that contribute to the formation of natural convection.

From the work done, the following key aspects can be distinguished:

- the air temperature throughout the volume inside the installation is constantly changing;
- a change in temperature leads to the occurrence of natural convection;
- drying at low air flow temperature improves the quality of products;
- the results of experiments conducted on an advanced solar installation will subsequently lead to a reduction in the cost of production.

Summing up the data obtained, we can conclude: the efficiency of the dryer increases when the first and upper windows are open, and the second and third are closed. The low temperature in the first part of the installation does not affect the quality of the product. The proposed combined solar installation with selected surfaces, forming the process of natural convection, can be applied in practice in horticultural farms throughout Uzbekistan

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