RESEARCH OF ABSORBERS EFFICIENCY OF SOLAR AIR HEATERS

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Abstract: *solar collectors are transforming the installation of solar radiation into useful heat.An important way to increase the efficiency of solar air collectors is to intensify the process of heat exchange from the solar collector to the airflow, for example by artificially increasing the surface roughness or profiling the working surface. The article considers solar air collectors, the main ways to increase their efficiency, the materials used as a beam-absorbing surface. The results of the experimental and theoretic studies.*
Keywords: *energy, renewable energy sources, solar energy, solar collectors, solar air collectors, efficiency, absorbers.*

ИССЛЕДОВАНИЯ ЭФФЕКТИВНОСТИ АБСОРБЕРОВ СОЛНЕЧНЫХ ВОЗДУХОННАГРЕВАТЕЛЕЙ

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Аннотация: *солнечные коллекторы - преобразовательные установки солнечной радиации в полезное тепло. Важным способом повышения эффективности солнечных воздушных колекторов является интенсификация процесса теплообмена от гелиоприѐмника к воздушному потоку, например, путем искусственного повышения шероховатости поверхности или профилирования рабочей поверхности. В статье рассмотрены солнечные воздушные коллекторы, основные пути повышения их эффективности, используемые материалы в качестве лучепоглащаюшей поверхности. Результаты полученных эксперементальных и теоретических исследований.*
Ключевые слова: *энергия, возобновляемые источники энергии, солнечная энергетика, солнечные коллекторы, солнечные воздушные коллектры, эффективность, абсорберы.*

Simple solar air collectors considered in [1] with increasing speed, the efficiency decreases. For more effective heat removal from the surface of the beam of the absorbing surface by the airflow, it is necessary to organize a turbulent flow regime in a micro and macro scale - using materials with a rough roughness or profile instead of flat plates, which leads to ripening and twisting of the flow [2]. Intensification of heat transfer with the use of surface profiling in the general case occurs due to an earlier transition from laminar flow to turbulent flow in comparison with a smooth surface. Some contribution to the increase in heat transfer makes an increase in the surface area of heat exchange due to the presence of elements of profiling. One of the first proposed methods of heat transfer intensification is the use of profiled surfaces (Fig. 1.b, e, j, z). This is one of the simplest and most effective methods of heat transfer intensification today. The presence of surface profiling elements, contributes to the destruction or disturbance of the viscous sublayer of the turbulent boundary layer of the flow, which contributes to an increase in heat transfer. However, for laminar flows small-scale elements of profiling do not have a significant effect. The authors of [3] investigated the energy characteristics of four absorbent plates of different types (type I) flat surface, V-shaped (type II), wedge-shaped (type III) and undulating (type IV). The absorber of each type was made from both aluminum (Al) and copper (Cu). The results showed that the efficiency of the heater with the copper absorber plate is better than the aluminum plate, however, the obtained air temperature from the heater with the aluminum plate of the absorber is higher than the copper plate. The results of the experiment showed that type IV and type II achieved the highest energy efficiency, respectively. Experiments have shown that absorbers embedded from aluminum and copper sheets are of little efficiency. The study [4] showed that when the operating temperature of the SAK is 55°C above the outdoor temperature, the efficiency of the shown rays of the absorbing panels in Figure 1.3. 10 ... 15% higher compared to a flat plate, and when the temperature difference between the collector and the external environment is 15 ... 20ºC, the surface efficiency with V-shaped undulation or ribbed plate is the same as for a flat plate. The higher the temperature of the air collector, the more intensive the process of heat exchange, therefore, the value of efficiency increases.

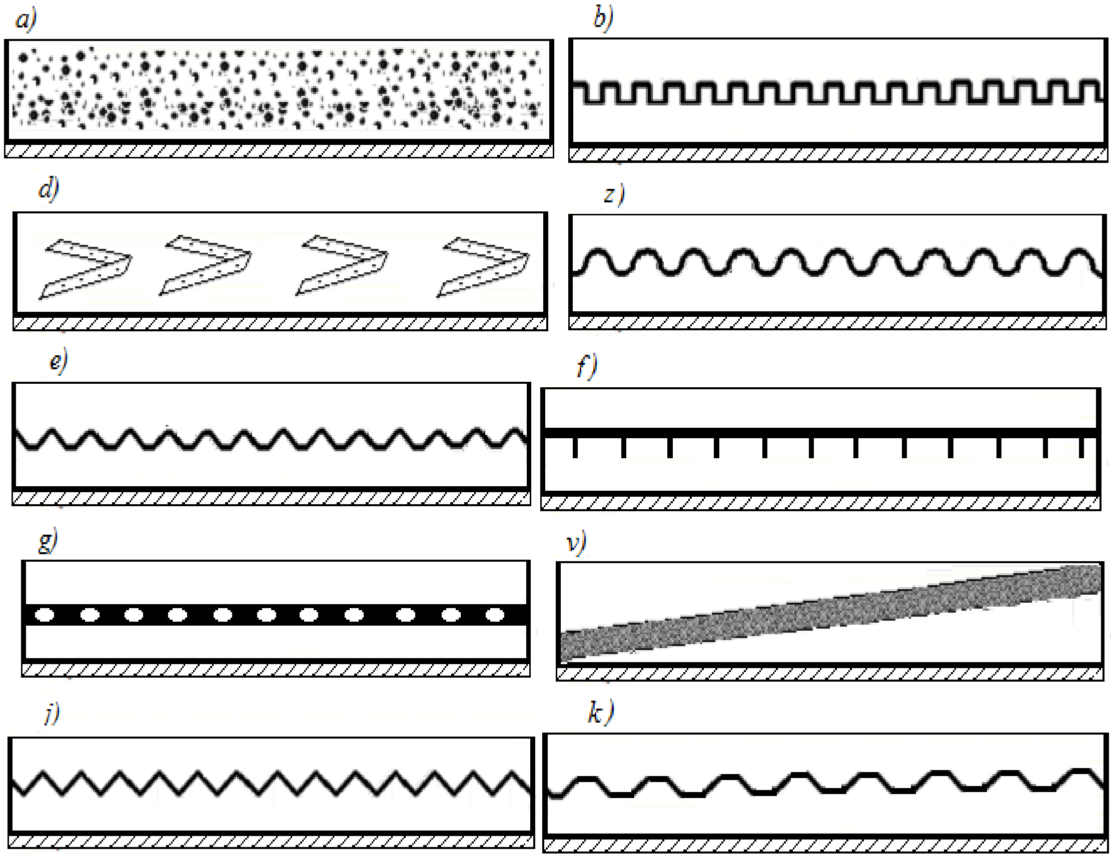

Fig. 1. The main types of beam absorbing panels of solar air heaters:
a - metallic particles, b - rectangular projections, v - grid, g - holes, d - horizontal V - shaped with holes, e - wavy, j - V-shaped, z - rectangular section, f - with projections, k - truncated V - shaped undulations

To reduce the area of heat exchange and, accordingly, to reduce the dimensions of SAK, its mass or to increase its thermal power with the same dimensions and mass, it is necessary to intensify the heat transfer from the solar receiver to the air flow. Improvement of heat transfer makes it possible to reduce the temperature drop, i.e. to increase the efficiency of utilization of low potential heat in SSMS. The heat transfer coefficients can be increased by: using artificial roughness, profiling the surface of the helio receiver, creating depressions or cavities on the helio receiver surface creating the effect of tornado intensification, etc. [5].

The results of an experimental study of the thermal efficiency of a single-channel air helio collector with five ribs installed behind the absorber are presented in [6] (Fig. 1.f). Thanks to the installed ribs it was possible to increase the contact surface between the absorber and the coolant, then the collector efficiency, heat-efficient, showed at a mass flow of 0.012 kg / s without ribs of 34.92%, with ribs 40.02%, without ribs 43.94, with ribs 51, 5% at a mass air flow rate of 0.016 kg / s. In [7] (Fig. 1.2f), they were investigated by an ultrasonic absorber with an absorber with fins and partitions, with double air channels. A significant improvement in the heat transfer efficiency achieved with the design of the partition and the rib due to the increased heat transfer zone. The experiments showed internal ribs provide higher turbulence and increase heat exchange, therefore, increase the efficiency of the SAK. In work [8], circular transverse ribs on the absorber plate were investigated. The authors noted the maximum Nusselt number was 2.05 times greater than that of the smooth channel. In work [9] a flat beam absorbed the panel compared with a flat beam with a sweeping panel with projections fixed to the underside. It was noted at high airflow rates that the version with protrusions fixed to the underside is ineffective compared to the flat without protrusions. Efficiency is achieved by reheating the air flow of the heated lower channel (Fig. 1.e). In work [10], a plane beam was studied for an absorbing absorber and a beam absorbed an absorber with sharp projections in the form of a triangular shape. Comparing the heat transfer data obtained, it was shown that the channel with projections improves the heat transfer 1.5 times in comparison with the glazes at Re = 7276. In [11], an absorber with rectangular projections was investigated . The increased airflow speed increases the collector resistance, which leads to increased load, the consumption of additional energy by the fan. The results show that the heat transfer and the parameters of the thermohydraulic performance strongly depend on the relative height of the roughness. Because of the large number of partitions and ribs, the disadvantages of such a construction is shading, with a change in the angle of inclination of solar radiation.

In work [12] (Fig. 1.c), an option is considered that contributes to the increase of heat transfer coefficients between the absorber and air on the basis of metal grids. It was considered SAK with absorbers in the form of several layers of grids with flat walls of a matrix of two kinds: with a transverse and longitudinal air flow, polycarbonate was used as a transparent fence. The authors have noted the most promising are structures with "bulk" absorption of solar radiation, since in such absorbers it is possible to obtain heat transfer coefficients higher than for planar continuous absorbers. The results of the experiments showed that an SAK with a longitudinal air flow has higher energy indices by 10 to 12% than in the case of a transverse air flow. However, it has significantly (about 10-20 times) more pressure loss. The optimal number of layers of grids in the range 3 - 8. In [13], the authors proposed to set the mesh vertically with respect to the bottom of the collector, to reduce losses by convection through a transparent coating and to uniformly move the air flow.

The authors noted the efficiency increased with decreasing passages in the grid and with an increase in the mass flow rate of air, between 0.01 - 0.025 kg/s. This is obscheynayutsya that such designs air-heating disadvantage is a smaller area of heated surfaces. The authors of [14] proposed ways to increase the efficiency of a smooth absorber in a metal grid. For this purpose, two subchannels were developed in the smooth surface channel for conducting operations with double passes. The authors noted metal mesh significantly improves the efficiency of heat transfer compared to flat single-pass and two-pass operations using the same working flow.

In work [15], the heat transfer characteristics of the absorber by partitions in the form of a horizontal V-shaped one with holes (Fig. 1.d) were examined. The Reynolds numbers examined in the study were in the range of 3,000-10,000. The total thermal power was indicated. The hydraulic characteristics show the maximum value at a relative width of the partition of 5.0 cm.

The use of metal shavings as an absorber leads to a decrease in the metal capacity and the cost of construction, since metal shavings are considered to be a production waste.

In the work [16] (Fig. 1.a), when studying air heaters with a flat, perforated, with chips and a ground beam absorbing the surface. It is concluded that air heaters made with a heat receiver in the form of metal chips have energy advantages over air heaters with a flat heat receiver. In the work, 7 variants of air heaters with an absorber from metal chips were proposed. At the experiment, a layer of metal shavings was uniformly applied to the bottom of the air heater, the average size of which was 10-15 mm, covering them with black paint (furnace ash), simultaneously blackening and fixing them on the surface. All air heaters differed from each other in both the number and the different way of their glazing, as well as the way they are fed and laundered by the air of the heat receiver.

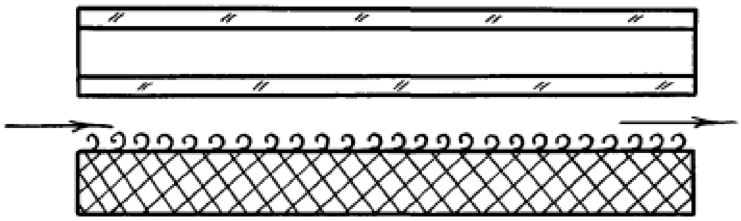

Fig. 2. SAK investigated by Fakhriddinova

In the claimed patent for inventions [17] (Fig. 2), The authors proposed the construction of the solar collector body 1 of a transparent coating 3 and a layer 16 of heat-insulating material. The absorber consists of a four-folded wavy slate arranged on four leaves 10 with a transverse arrangement of waves 11 relative to the tray, covered with a sheet 10 of a layer 5 of blackened shavings and fixing the mesh 7. The air is heated and turbulized upon contact with the 10 slate, the chip layer 5 and the mesh 7. The air cavities 12 between 10 and 4 serve as a thermal insulator.

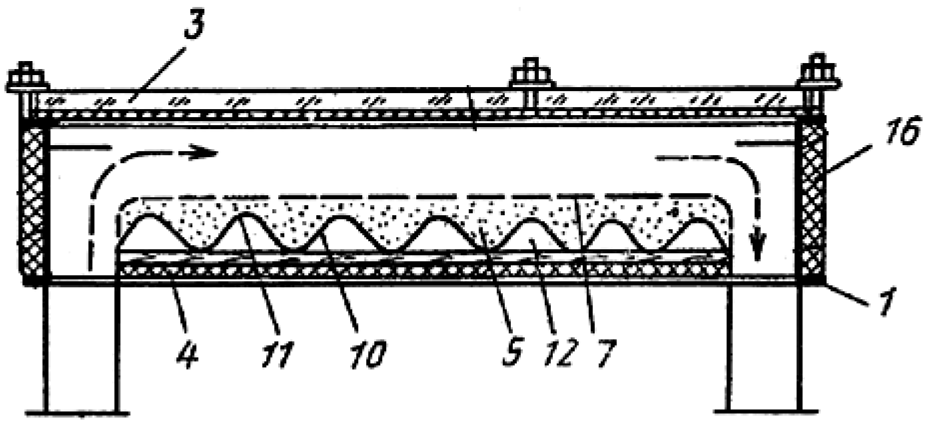

Fig. 3. SAK with fine blackened metal shavings

The drawback of this design is the small contact surface of the air and the absorber due to the fact that the flow of air without passing through the chip layer tends to pass along the path of less resistance, i.e. in a free air channel. Due to this disadvantage, the degree of heating of air is low, which leads to a decrease in efficiency.
In the claimed patent for inventions, the authors of [18] (Fig. 4.) Investigated the design of the SAK on the air-permeable plate 2 installed in the casing 1, the translucent structure 3 is arranged with the transversal through-cells 4. Below and above the level of the plate, there is a supply pipe 5, and the outflow nozzle 6. Cells partially filled with absorbing spherical particles 9 have a blackened grid 7.

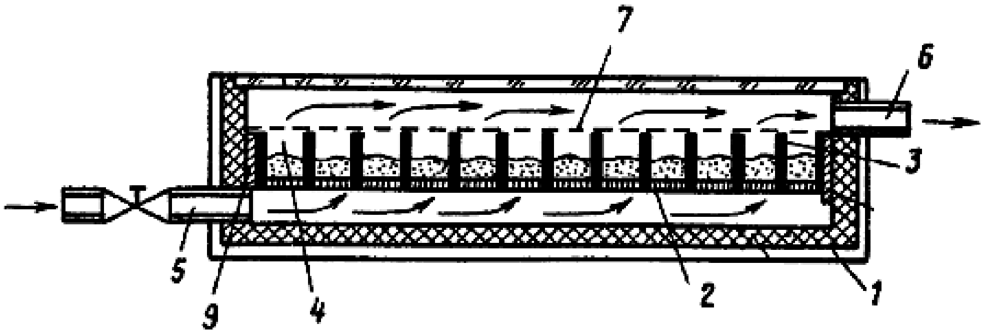

Fig. 4. SAK with absorbing spherical particles

The air is fed through the distribution manifold 9 and passes through the upper air channel 6. By washing the absorber 3 from the side of the capillary structure, which turbulizes the flow and intensifies its heating, air passes through the through capillaries 5, while heating and flowing into the cavity 8, its heating and through the collection manifold 10 are taken to the consumer.

Since the surface of air channels and passing capillaries are included in the heat exchange process, the surface of heat exchange increases by 2-3 times. In addition, the entry and exit of air jets lead to turbulization of the air flow both on the upper surface of the absorber and on the surfaces of the lower cavities, which intensifies the process of its heat exchange with these surfaces. Intensive heat dissipation in the entire volume of the absorber will reduce the temperature of the structure, and, consequently, the heat loss of the air heater into the environment and thereby increase its efficiency.

In the works of the authors [19], a solar air heater with an absorber made of stainless steel chips was examined. Studies have shown the considered version of the solar air collector effective, the efficiency is increased due to the structure of the chips and color..

Conclusion

As the speed of the airflow is increased, the efficiencies of the collectors in question drop sharply, due to the small contact surface between the absorber and the coolant and the absence of turbulent airflow. Thus, the above constructions are more appropriate for the natural circulation of air through the collector.

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