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CALCULATION OF THE EFFICIENCY OF A COMBINED SOLAR WATER-AIR HEATER COLLECTOR

Aliyarova Lola Abdijabborovna
Karshi Engineering Economics Institute, Karshi, Uzbekistan

ABOUT ARTICLE

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Abstract: The authors of the work proposed a combined solar heating installation for heat and humidity treatment of supply air for greenhouses. The object of study is a combined solar collector for the simultaneous heating of water and air.
Heat and humidity treatment of supply air is an energy-intensive technological process that requires huge consumption of thermal energy and water resources.
In this work, in order to reduce the consumption of traditional energy for heat treatment of supply air, a combined solar collector is proposed and the results of an experimental study of the operating modes of the installation in the conditions of Karshi are presented. As a result of experimental studies, the high energy efficiency of a combined solar collector in the "water + air" heating mode has been shown. It has been established that the efficiency of the installation is in the range of 0.57-0.80.

INTRODUCTION

The analysis of the energy strategies of the developed countries of the world shows that saving traditional energy resources and improving energy efficiency in various sectors of the economy is an important direction. At the same time, the share of energy costs in the cost of growing products in greenhouse complexes is from 60% to 90%. In this regard, diversification of the structure of the fuel and energy balance due to the creation and introduction of innovative energy and resource-saving technologies based on renewable energy sources is of great importance in the world [1-5].

In our republic, special attention is being paid to the development of greenhouse complexes in order to provide the population with quality and continuous fruit and vegetable products and to build new modern energy and resource-saving greenhouse complexes in order to reduce the energy consumption of the production of greenhouse products [6,7].

However, despite the achieved positive scientific results and the introduction of modern energy-saving devices, the share of energy in the cost of vegetables grown in the greenhouse remains high. At the same time, the effective use of low-potential solar heat in the system to ensure the heat-moisture regime of greenhouse air to create an optimal microclimate of greenhouse complexes is currently not sufficiently studied. In this regard, it is urgent to develop combined solar devices for heat-moisture treatment of greenhouse air and optimization of heat-moisture parameters [8,9].

MATERIALS AND METHODS

In general, the energy consumption of 1 hectare of greenhouse is about 1 MW of electricity and 2 MW of thermal energy. Taking into account the high specific cost of energy carriers in the price of products, a significant reduction in product costs and an increase in profitability can be achieved only by reducing energy costs.

In order to obtain a high-quality fruit and vegetable crop in greenhouses, it is necessary to create the necessary microclimate (energy- and resource-efficient ventilation system) with optimal thermal parameters. The increase in the productivity of fruits and vegetables grown in greenhouses largely depends on the level of maintaining the temperature and humidity regime of the greenhouse. One of the current solutions to this problem, available at the cost of installed technology and energy consumption, is the use of solar heat-humidity systems that save energy and resources in greenhouses and treat the air of greenhouses with heat and moisture.

Currently, due to low energy efficiency, high transport costs, worsening environmental sustainability, and dwindling reserves of traditional natural fuels, there is a need to develop alternative heat supply systems. One of the energy-saving alternatives to traditional heat supply systems of greenhouses is the combined solar heat-moisture supply systems of greenhouses based on renewable energy sources (use of low potential heat using the sun and heat pumps). Such systems are energy-saving and environmentally friendly technologies that ensure the preservation of traditional energy sources: natural gas, liquid, solid organic fuels, and electricity, along with providing a heat-humidity regime to the air of greenhouses [10-15].

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RESULT AND DISCUSSIONS

Technological

Low-potential solar heating devices for heat-moisture treatment of greenhouse air, heat and mass exchange processes in air heat-moisture treatment systems, and temperature and humidity regimes of greenhouses with helio devices are studied based on h-d diagram of moist air.

Taking into account the above approaches, it is possible to reduce energy and resource consumption in technological processes of air heat-moisture treatment systems, which act as an autonomous solar heating supply system of greenhouses in the winter season, and prevent overheating of the internal air of greenhouses in the spring-autumn period. A new solar heating technology with a combined solar water-air heating collector and a mixed heat exchanger, which treats the ventilation system of greenhouses with heat moisture and cold, will be created and introduced to greenhouse complexes.

socio-economic

In our republic, increasing energy efficiency in economic sectors and the social sphere, wide introduction of energy and resource-saving technologies, and energy devices based on renewable energy sources are defined as the current directions of state policy. The scientific solution and implementation of this practical project will be a practical solution to the priority tasks identified above [16-18].

As a result of the implementation of the combined solar water-air heating collector and mixed heat exchanger heli-heating device for heat-moisture and cold treatment in the ventilation system of greenhouses, the following technical and economic efficiency is achieved:

a) in a greenhouse with a useful area of 100 m2, during the season up to 12790÷12800 kW/h, i.e. 3,700,000 soums, or in a greenhouse with a useful area of 1 hectare, up to 1279200÷1280000 kW/h during the season, i.e. 377,600,000 soums of energy savings will be achieved;

b) in order to ensure the required temperature-humidity regime in the greenhouse, a heat-moisture treatment of the ventilation air and a solar heating system was created, which allows heating, cooling, and humidification of the air, as well as obtaining additional hot water, and in the greenhouse with a useful area of 100 m2 during the season 22÷25% conditional fuel savings are achieved;

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c) as a result of the introduction of a combined solar water-air heating collector and mixed heat exchanger for heat-moisture and cold treatment in the ventilation system of greenhouses, the cost of the product grown in the greenhouse is 1.27÷1.3 times higher, and energy consumption compared to conventional systems It is possible to reduce by 2.5÷3.0 times.

The scientific-theoretical and technical-economic basis of the new solar heating technology with a combined solar water-air heating collector and a mixed heat exchanger, which treats the ventilation system of greenhouses with heat-moisture and cold, in the conditions of Uzbekistan, is a scientific basis for ensuring the heat-moisture regimes of stable greenhouses.

Commercialization prospects

In the implementation of the practical project, the scientific-theoretical and technical-economic basis of the new solar heating technology with a combined solar water-air heating collector and a mixed heat exchanger, which treats the ventilation system of greenhouses with heat-moisture and cold, in the provision of heat-moisture regimes of stable working greenhouses. implementation of the results of scientific, scientific-technical, and innovative activities, as well as works related to the production of industrial batches of the innovative product for the serial production of the new solar heating technology with a combined solar water-air heating collector and a mixed heat exchanger.

The heat and moisture treatment system in the greenhouse is a combined solar water-air heating collector. Figure 1 shows the scheme of the developed experimental combined solar water-air heating collector.

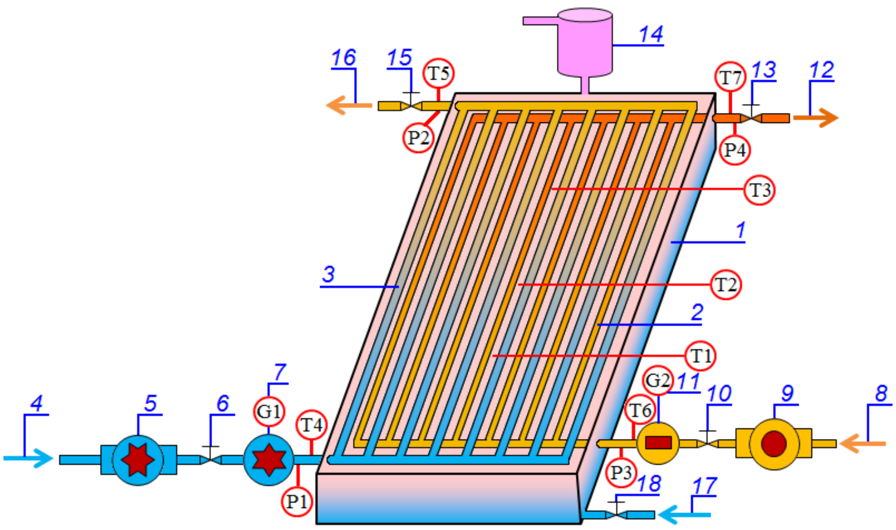

Fig.1. Scheme of a combined solar water-air heating collector.

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1st corps; 2-water pipes; 3-air pipes; 4-atmospheric air; 5th fan; 6, 10, 13, 15, 18 valves; 7, 11 flow meters; 8-water tank; 9th pump; 12-hot water; 14th expansion tank; 16 - heated air; 17 – cold water inlet.

In order to save heat energy, the air heat and moisture treatment system is equipped with a solar water-air heating collector with a combined heat accumulator. A solar water-air heating collector with a combined thermal accumulator provides simultaneous heating of the water and air required for the air heat and humidity treatment system.

Designed for modeling and experimental research of hydrodynamic and heat exchange processes in terms of speed and consumption. The main heat-technical device of the air heat-moisture treatment system is a low-potential flat combined solar collector. Figure 1 shows the pilot plant of the developed Combined solar water-air heating collector and mixed heat exchanger heliothermal plant.

Helio-heating device with a combined solar water-air heating collector and mixed heat exchanger for heat-moisture treatment of air. The mathematical model of the temperature-humidity regime of the greenhouse takes into account the engineering systems of microclimate maintenance and changes in the heat-technical parameters of the environment and indoor air. developed without The equation for calculating the heat and moisture balance of a greenhouse with a heat-moisture air treatment system is obtained, and this equation allows determining the amount of moisture necessary to maintain the humidity regime of the greenhouse.

The solar heating device with a combined solar water-air heating collector and a mixed heat exchanger, developed on the basis of experimental research, has a heat carrier temperature of 40...42°C (air) and 45...50°C, respectively when operating in the “water+air” heating mode. (water) has been determined to reach, and are considered acceptable parameters for the heat-moisture treatment system for greenhouse air [19-20].

We calculate the thermal efficiency of the solar collector based on the following equation:

$$Q_{h.w.} = G_m \cdot c_p \left(t_2 - t_1\right) \cdot 10^3, W \qquad (1)$$

here, G_m - consumption of hot water, kg/sec; c_p - specific heat capacity of hot water, $c_p = 4{,}19 \dfrac{kDj}{kg \cdot {}^0 C}$; t_1, t_2 - the temperature of water at the inlet and outlet of the vacuum solar collector, °C.

We determine the solar radiation energy falling on the heat exchange surface of the solar collector using the following formula:

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$$Q_r = q_r \cdot F_{coll}, W \qquad (2)$$

here, q_r - the energy of solar radiation falling on the unit surface of the solar collector, W/m²; F_{coll} - light receiving surface of the solar collector, m².

We determine the efficiency of the vacuum solar collector based on the following equation:

$$\eta = \frac{Q_{h.w}}{Q_r} = \frac{Q_{h.w..}}{q_r \cdot F_{coll.}} \qquad (3)$$

Using the above formulas, the results of the experiments and calculations carried out in the conditions of the city of Karshi and the solar collector are presented in Table 1.

Table 1.

Solar collector test results (July 2023)

local time	Inlet water temperature, t_1, °C	Water consumption, G_m, kg/sek	Outlet water temperature, t_2, °C	Heat production efficiency, $Q_{h.w.}$, W	The amount of solar radiation, Q_r, W	Solar collector, η
9:00	20	0,005	58	798	980	0,81
10:00	20	0,005	63	903	1200	0,75
11:00	22	0,005	68	966	1215	0,79
12:00	24	0,005	72	1008	1400	0,72
13:00	26	0,005	75	1029	1500	0,68
14:00	28	0,005	78	1050	1550	0,67
15:00	26	0,005	73	987	1480	0,66
16:00	23	0,005	65	882	1420	0,62
17:00	20	0,005	59	819	1400	0,58
18:00	20	0,005	53	693	1200	0,57

CONCLUSIONS

In the conditions of the city of Karshi, the use of a combined solar water-air heating collector and mixed heat exchanger for heat and moisture treatment of ventilation air in a greenhouse with a useful area of 100 m2 allows saving 12792 ÷ 12800 kWh of electricity during one period of greenhouse operation. and energy costs are reduced by 22÷25% compared to conventional systems.

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