



AUTONOMOUS AIR COOLING SYSTEM WITH COMBINED SOLAR PHOTOELECTRIC MODULES

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Abstract. *Air cooling systems for residential buildings are relatively inexpensive and easy to operate. In mechanical ventilation and air conditioning systems, the supply and exhaust of cooling air play an important role in the cooling process, that is, the correct selection of their position allows you to reduce energy consumption and increase cooling efficiency. Therefore, in order to ensure the required temperature regime in the room and effectively ventilate the room, it is necessary to conduct a thorough study of the air flow, air and temperature distribution in the room. To carry out these studies, the article presents an autonomous air cooling system with a combined solar photovoltaic module developed for air cooling systems for residential buildings.*

Keywords: *residential building, cooling system, cooling with a fountain, cooling air, heat load, solar radiation intensity, room.*

Introduction. The temperature and air flow distribution are studied based on experimental and theoretical models, i.e., living rooms are modeled as rectangular rooms. In this case, heat is transferred inside the room by conduction, natural, mixed or forced convection, and radiation. There are several research works on numerical modeling of ventilated rooms in the existing literature [1-9]. The work of Nielsen [8, 9] on the use of computational fluid dynamics to model the cavity of a building is considered a fundamental study. Most of the research of Nielsen et al. is focused on the aerodynamic effects and geometric parameters related to the size of the inlet

opening, the location of the inlet and outlet openings, the flow structure and the efficiency of ventilation in mixed convection.

Gan [10] compared the room air flow, thermal comfort and ventilation efficiency to evaluate the air distribution system in a mechanically ventilated office. According to the results, the air supply from below and the exhaust from above provide the maximum air distribution with the least energy consumption. Lee et al. [11] studied the flow characteristics and heat transfer in a room with an air-cooled system under forced and mixed convection conditions over a wide range of Reynolds numbers and found that the cooling efficiency is inversely proportional to the Reynolds number. Omri and Nasrallah [12] studied forced and mixed convection in a rectangular air-cooled room. In the study, different temperatures were provided on two vertical walls and adiabatic conditions were provided on the other two walls. Two cases of air inlet and outlet were considered. In the first case, cold air is introduced through the top of the hot wall and discharged from the bottom of the cold wall. In the second case, cold air is introduced through the bottom of the hot wall and discharged from the top of the cold wall. In both cases, the effect of different flow parameters and heat transfer was studied. According to the results, it was found that the most optimal configuration for optimizing cooling is to introduce cold air from the bottom of the hot wall and discharge it from the top.

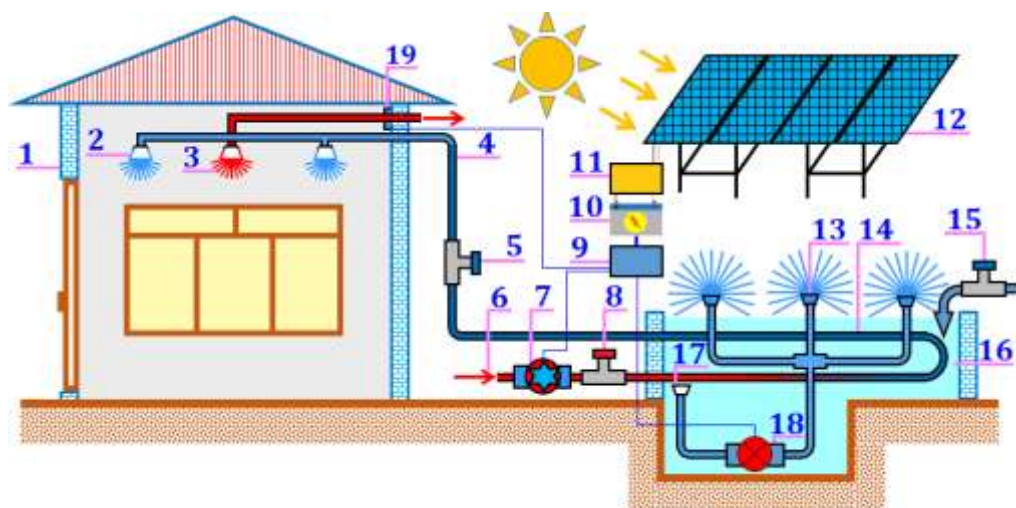
Singh and Sharif [13] examined six configurations of cold air inlet and outlet openings in a rectangular room through hot and cold walls. The study was conducted at Reynolds numbers of 50, 100, 300, and 500 and Richardson numbers of 0, 0.1, and 1.0. The results showed that the optimum cooling efficiency was achieved when the cold air was introduced from the bottom of the cold wall and discharged from the top of the hot wall. The effects of room geometry, air inlet cross-section, wall temperature, and the ratio of cold to hot air flow were studied by Costa et al. [14]. The results showed that the optimum cooling efficiency associated with minimal

flow reversal can be determined for a given room geometry and a given air flow velocity.

Numerous researchers have presented experimental results in closed and open ventilated rooms [15-18]. The above-mentioned studies provide detailed information on thermal parameters, such as Nusselt number, air temperature and velocity. Nielsen [19] presented experimental results for a room in which air is supplied under isothermal and turbulent flow conditions and air is discharged through a vertical wall. The room is 3.0 m high and 9.0 m wide, and the air is supplied from the top of the left wall and discharged from the bottom of the right wall, with all walls assumed to be adiabatic. The inlet size is $0.056H$, the outlet size is $0.16H$. Experimental results are presented for four different dimensionless sections of the room. Ramesh and Venkateshan [18] presented results on the study of natural convection of air in a closed room with differentially heated walls. The authors used a differential interferometer to obtain the temperature field. They achieved almost adiabatic conditions for the upper and lower walls by insulating the outer side of the wall. The authors proposed a correlation relationship for the average convective Nusselt number as a Grashof function.

Results and discussion. From the analysis of the above studies, it is clear that no studies have been conducted to determine the speed and temperature of the air flow in the room, the height and length of the room, when the air inlet speed is different in rooms with an air cooling system. Taking into account the above, this dissertation work studies the issues of providing an air cooling system for residential buildings based on a solar photovoltaic module and an air cooling system (ACS) and increasing the energy efficiency of the cooling system. The main purpose of the study is to develop an autonomous air cooling system for residential buildings based on a combination of a solar photovoltaic module and an ACS and to substantiate its thermal and technical parameters. Taking into account the potential of solar energy in the conditions of the city of Karshi, a principle scheme of an autonomous air

cooling system with a combined solar photovoltaic module for residential buildings was developed (Figure 1) and a pilot model of a residential building in which the system was implemented was built (Figure 2). The proposed autonomous air cooling system (AACS) allows to study air cooling systems in an experimental house using a direct solar photovoltaic module (PV) and an air cooling system (ACS), to determine the variation of the indoor air temperature in the house depending on the height and length of the house, the cold load on the cooling system depending on the air velocity in the house, the outdoor temperature and the intensity of solar radiation, to evaluate the cooling efficiency of the ACS and the amount of conditional fuel saved in the cooling system, and is designed to conduct an experimental study of heat losses through the house.



1-experimental house; 2-cold air supply; 3-hot air exhaust; 4, 6-cold and outside air supply pipes; 5, 8, 14-valves; 7, 19-fans; 9-inverter; 10-battery; 11-controller; 12-solar PV; 13-fountain; 14-heat exchanger; 16-water basin; 17-pre-chamber; 18-circulation pump

Figure 1. Schematic diagram of an autonomous air cooling system with a combined solar photovoltaic module:



Figure 2. General view of the experimental house

The cooling system of the experimental house built according to the proposed scheme operates on the basis of a combination of solar PV, ACS and a two-circuit heat exchanger (HE), pumps and fans. AACS consists of the following main and auxiliary equipment:

a) ACS (Fig. 3, a) - serves to cool the outside air supplied to the experimental house to the required temperature. The amount of heat transferred from the outside air through the pipe to the cooling water is continuously cooled by a fountain and a constant temperature of the cooling water is ensured. The dimensions of the water basin are 2x3x0.6 m. The number of diffusers is 14 pieces;



Figure 3. Main and auxiliary equipment of the AACS

b) tubular HE (Figure 3, b) - designed to transfer heat from air to cooling water, consists of two circuits, and the length of each circuit is 11.2 m;

c) solar PV (3, c-figure)-serves to provide electricity to pumps and fans in the AHST. Its main thermal and technical parameters are as follows: brand Lepton Solar LP182182-M-72-MH-550, mass 27 kg, dimensions 2279x1134x35 mm, cell dimensions 182x182 mm, number of cells 72x2 pcs., maximum system voltage 1500 V, distribution box: IP68, power 550 W, peak voltage 49.80 V, short circuit current 13.99 A, module efficiency 21.28%. Lepton Solar is manufactured using semiconductor element technology, with 108 half-solar elements installed instead of 60 full-size elements;

d) To ensure the circulation of water in the ACS, a LISTOK brand circulating water pump with a capacity of 200 W was used (Figure 3, d). The main technical characteristics of the pump are as follows: voltage - 220 V, frequency - 50 Hz, maximum water capacity - 5000 l/h, maximum immersion depth - 5 m, maximum water lift height - 5 m, protection class IP68;

e) To ensure air movement in the AACS, a centrifugal fan of the Geruifeng brand with a power of 120 W (Figure 3, e) was used. Its main technical characteristics are as follows: voltage 220 V, frequency 50 Hz, capacity 280 m³/h;

f) An M-100 fan is installed to extract internal air, with a power consumption of 14/16/24 W, air capacity of 98/185/295 m³/h, diameter of 100 mm, and rotation speed of 2300 rpm.

The water tank is filled with water with an average temperature of 18°C by means of a valve, a temperature sensor installed on the side wall of the house measures the temperature every hour and sends a signal to the control system. When the temperature in the house exceeds 24°C, the air suction fan connected to the control system is activated. The fan sucks in hot air from the outside environment and transfers it through a pipe to the heat exchange pipes installed in the water tank, in which case the valve is in the open position. Cold air with an average temperature

of 20°C is transferred from the heat exchange pipes to the cold air transfer device fixed on the ceiling of the house, in which case the valve is in the open position. At the same time, a fan installed on the side wall of the house and connected to the control system is used to exhaust the hot air. starts, a temperature sensor is installed in the water basin and transmits a signal to the control system when the water temperature exceeds 22°C, the control system starts the circulating water pump connected to the pre-chamber and fountains and cools the water to the required temperature, the electrical equipment and control system receives power from solar photovoltaic panels equipped with a controller, battery and inverter.

Conclusion. An autonomous air cooling system for residential buildings based on a combination of solar photovoltaic modules and air cooling systems has been proposed. An environmentally friendly air cooling system operating entirely at the expense of solar energy, which allows maintaining the required temperature regime in residential buildings in the summer season, has been proposed. The proposed autonomous air cooling system is based on a solar photovoltaic module and air cooling system, and the developed autonomous air cooling system with a combined solar photovoltaic module allows reducing the specific energy consumption in cooling residential buildings. By using an autonomous cooling system for homes powered by solar photovoltaic panels, it is possible to save an average of 8 kWh per day in homes with a volume of 32.4 m³, or 1,216 kWh of electricity per cooling season, and increase the reliability of the cooling system.

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