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COMPARISON OF EFFICIENT OF THE COMBINED SOLAR COLLECTOR FOR ENERGY-EFFICIENT BUILDINGS FOR DIFFERENT MODES OF OPERATION

Альтернативна енергетика покликана сприяти вирішенню передусім двох важливих проблем: екологічної безпеки та енергоефективності. Сонячна енергія як енергоресурс майбутнього має безліч переваг: вона не шкодить здоров'ю людей та довкіллю, не спотворює ландшафт, її не потрібно експортувати та імпортувати, сама енергія є безкоштовним ресурсом, а головною перевагою є те, що вона відновлювана. В праці приділено значну увагу системам сонячного теплопостачання та запропоновано застосовувати геліоустановки в енергоефективних будинках на території України, що може бути основним рішенням для зменшення енергоспоживання. На ефективність геліоустановок насамперед впливає рівень сонячної енергії, який, своєю чергою, залежить від географічного положення території. Тому особливу увагу звернено на аналіз кількості теплового потоку, що надходив на площину сонячного колектора протягом експерименту внаслідок зміни інтенсивності сонячного випромінювання. В праці проаналізовано ефективність використання комбінованої системи теплопостачання за умов південної орієнтації на території та за різних режимів роботи. За результатами дослідження сформульовано висновки та рекомендації застосування комбінованих систем сонячного теплопостачання, спрямовані на збільшення частки сонячної енергетики та ефективності таких систем у загальному енергобалансі країни.

Ключові слова: системи сонячного теплопостачання, режим протоку, режим гравітації, тепловий потік, температура теплоносія, енергоспоживання будівель.

On the whole, alternative energy should contribute to taking the two pressing problems of environmental safety and energy efficiency. Solar energy, as energy resources of the future, has a lot of benefits. It is mainly harmless to people and the environment. It does not distort the landscape. There is no point in exporting or importing it. As for the energy itself, it is both free and renewable, the latter benefit being the most important one. In work paid considerable attention to solar heating systems and proposed to use this solar heating system in energy-efficient homes in Ukraine. This the primary solution may be used for decrease energy consumption of buildings. The overall effectiveness of solar installations is largely dependent on the level of solar energy, which in its turn is strongly dependent on the geographical position. Therefore, special attention is paid to the analysis of the heat flux, came onto the plane solar collector during the experiment, in consequence of changes in the intensity of solar radiation. In the work analysis the efficiency combined heating system in the conditions of southern orientation of the territory and the different modes. According to the study, the findings and recommendations of the use of combined solar heating at increasing the share of solar energy industry and efficiency of such systems in the overall energy balance of the country.

Key words: solar heating, strait mode, gravity mode, heat flux, temperature of heat carrier, energy consumption of buildings.

Introduction. Direction of social development requires efficient use of natural resources. The demand grows for fuel and energy with the development of technology. However, volumes of their consumption between industrial sectors or countries are different.

In the second half of the nineteenth century William Stanley Jevons noted that efficiency is the consequence development demand for used energy source. Also, from historical sources, we know that 1883 year in the world is beginning an era of application solar energy in electricity. In Ukraine, the solar power industry began to develop in 2004 and the heating industry - in 2011. This is a topical issue for Ukraine becouse it is located on the territory of a sufficient density at the surface of the solar radiation.

Solar thermal system in energy-efficient buildings in the territory of Ukraine is the main solution to reduce energy consumption of buildings.

Objectives the Formulation of the Problem. The slow development of solar systems has a number of causes, which can be the main stages in the development of solar heating system for Ukraine.

The predominant reasons of it are high cost on them and the efficiency has not the same standards for solar heating system. Therefore, it is advisable to analyze the possibility of using solar energy by solar systems and to investigate their effectiveness under conditions using this energy comparatively to the south orientation and different modes working of solar installations.

The Analysis of Recent Research and Publications. The issue of climate protection, energy consumption of buildings, installation of solar heating and their orientation relative to the horizon devoted several works [1-6]. Which also analyzes the potential of solar energy and the possibility to use on the territory of different countries.

The spectrum of design and technology solutions combined solar systems is very wide [7-8]. However, orientation relative to the horizon it is an important step when setting designs a solar heating system. The problem in these works are not analyzed in detail.

The Main Material. One of the factors which determines the intensity of solar energy is the height of standing of the Sun over the horizon. It is known, that for Ukraine the optimum angle of inclination of the collector to the horizontal is the angle $\varphi+10^\circ$ for summer (seasonal) operation and $\varphi-10^\circ$ with year-round operation, where φ is the latitude. In addition, an important condition for efficient operation of a solar collector is its focus on the parties of horizon. That's why solar collectors on the territory of Ukraine it is advisable to place on the southern orientation.

The proposed models of a solar heating system has an improved design, as a function of absorber also serves the roof of the building in which is colored black (e.g., galvanized steel), that can reduce the cost, improve efficiency and simplify the design of the solar collector for large-scale use of such structures.

The proposed combined experimental solar heating systems can work in two different modes, namely: "gravity" and "strait".

To investigate the amount of heat flux, which acted on these experimental models we measured the intensity of solar radiation with a pyranometer. The amount of heat flux from solar radiation Q, kJ/m^2, that has entered the plane of the solar collector performs the conditions of the one modal distribution of values (Fig. 1). An experimental model of the solar system in a mode gravitation works: the heat carrier enters to the tank battery, when you open and set the shut-off control valve the water enters the solar collector is heated under the influence of solar energy and on the principle of natural convection moves back into the tank battery.

At the initial stage, the heat carrier flows into the tank of cold water an experimental model. Then the water enters the solar collector, in which a preset flow rate of the heat carrier moving in the tank of heated water. The selection of the heated heat carrier implemented through the pipe to the tank of heated water. Measurements of water temperature in the lower and upper tanks were conducted with mercury thermometers. Experimental model of the solar system in the flow mode relates to low-temperature single-circuit heating systems. This system in the flow mode can be used for seasonal water pre-heating for pools and showers, solar-fuel boiler-houses, for domestic purposes, etc.

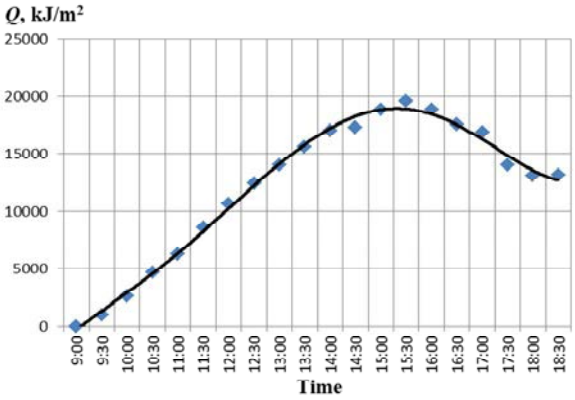

Fig. 1. The amount of heat flux from solar radiation Q, kJ/m^2, that comes from radiation to the combined solar collector in the southern orientation

Maximum temperature tank-battery mode under conditions of gravity southern orientation averaged was 52ºC in the dining time of day (Fig. 2). The averaged intensity at this point of time, that the plane of the solar collector received was 458 W/m^2.

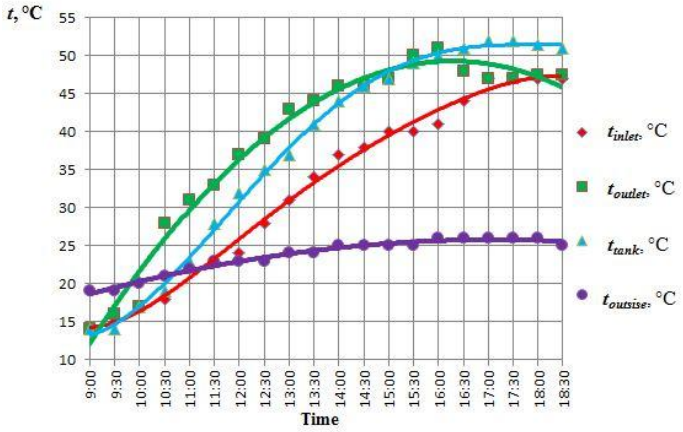

Fig. 2. Changing the heat carrier temperature in the a tank-battery t_{tank}, ºC, in the inlet pipe of the solar collector t_{inlet}, ºC, in the outlet pipe of the solar collector t_{outlet}, ºC and the temperature outside $t_{outside}$, ºC in the southern orientation by gravity mode

Solar heating in the mode strait has the temperature of the heat carrier reached to 23.5 ºC, which is 32 % higher than the inlet temperature of the heat carrier (Fig. 3).

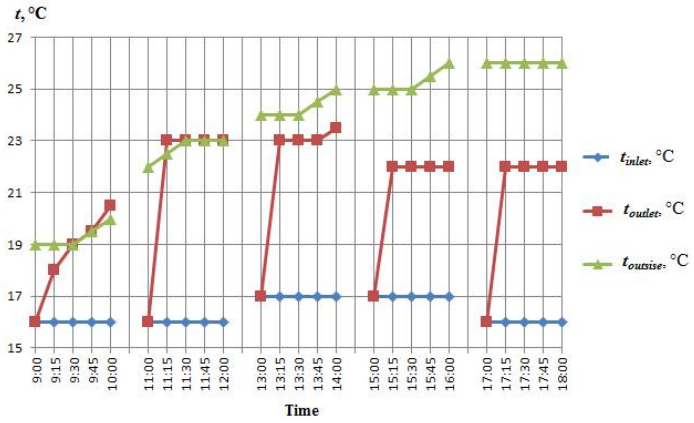

Fig. 3 Changing the heat carrier temperature in the inlet pipe of the solar collector t_{inlet}, ºC, in the outlet pipe of the solar collector t_{outlet}, ºC and the temperature outside $t_{outside}$, ºC in the southern orientation by strait mode

Fig. 4 and Fig. 5 shows the experimental efficiency of combined solar heat in the summer time.

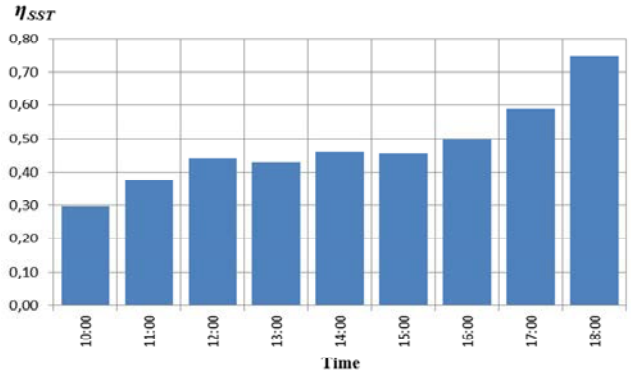

Fig. 4. Efficiency solar heating system gravity η_{SST} the conditions of southern orientation

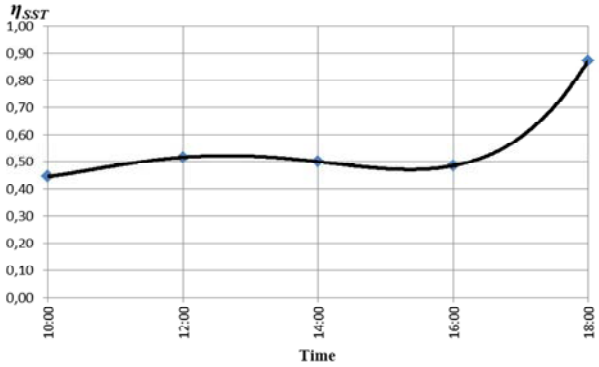

Fig. 5. The efficiency of solar heating system η_{SST} in the mode strait in conditions of southern orientation

The coefficient of performance (COP) of solar heating takes a growing trend and reaches its maximum in the evening in both modes. This is due to the accumulation of heat plane solar collector from the environment because temperature fluctuations during the experiment had a little character. For the morning period characterized by the fact that the average efficiency of the mode itrait reached 45 %, that gravity is 15 % less.

Conclusions. In the experimental studies the combined heat supply system has reached 70 % of their efficiency and the efficiency mode strait 80 %.

An experimental model of the strait mode is effective for building a low-temperature the heat carrier (heating is on average 6,5ºC per hour). In the gravity mode the heat carrier is heated from 14 °C to 52 °C. Maximum flow of heat flux from solar radiation was 20 MJ/m^2.

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