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SYSTEM OF HEAT SUPPLY *'ad hoc'* WITH SOLAR WALL

For the implementation of solar thermal installations it is necessary to optimize energy-efficient external enclosures due to the correct installation and design of these units at different orientations of external walls. Investigated the effectiveness of using solar energy in the conditions of shortage of energy in Ukraine. *Ad hoc* solar wall look at two modes of its operation. Given a variety of graphical, analytical expressions for understanding the operation of the proposed design. Given these changes of the heat carrier temperature solar wall income the amount of the specific instantaneous heat output through time. The article considers the possibility of using experimental models, solar wall under the influence of her unfavourable *ad hoc* factors. It is established that the proposed model is solar wall is quite effective and can be used in solar heating systems.

Keywords: solar wall, temperature, specific heat capacity, a coefficient of performance system

1. Introduction

One of the important issues of energy policy is the expediency and economic efficiency of energy use for technological processes in different

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branches of industrial and agricultural production. In addition to this, an important issue is the reduction of anthropogenic impact on the environment and as a consequence of this improving the environment.

In the 60s of the XXth century the population consumed approximately 50 % of that consumed by the population in the XXI century. This is primarily due to the fact that the use of energy has become the Foundation for a variety of processes as well as energy has become more available for use. This increase to using of energy is the root cause of modern environmental problems such as energy shortages and the problem of global warming.

On the average on one inhabitant of the planet Earth there are 2.5 [tfe] (tons of fuel equivalent) of energy resources. In the future, to 2100 the population on the planet Earth will grow to 10 bn, while the average specific energy – up to 10 [tfe], that is in overall energy production will reach 100 bn [tfe]. The level of air pollution also continue to grow, which will lead to the slow destruction of the biosphere. According to the group of American engineers, in 1800 for 1 million molecules of air there were 280 molecules of carbon dioxide, in 1960 there were 315, and at the beginning of the XXIth century – 370. By the end of that century, this number could rise to 550, which will lead to average temperature increases from 3 °C to 6 °C [1].

According to Carrington College, in the world may develop the Energy Revolution. Therefore, when comparing the baseline scenario of primary energy consumption with the implementation of renewable sources by 2050, the world could reduce the using of traditional fuel practically in 1.5 times (Fig. 1) [2].

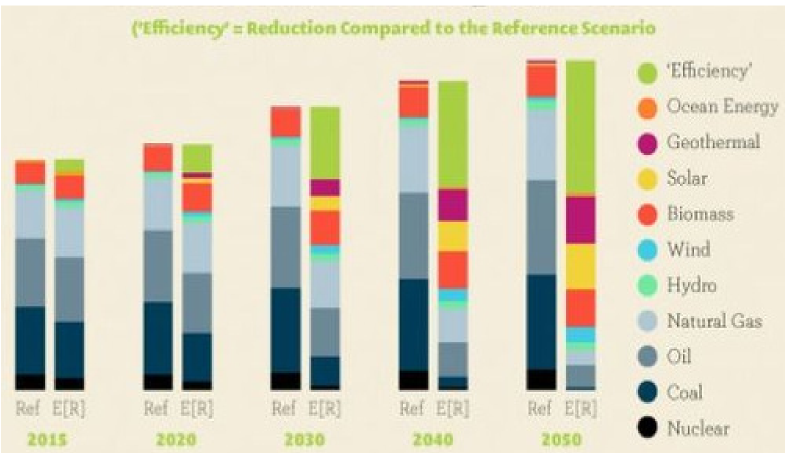

Fig.1. The forecast baseline scenario primary energy consumption and Energy Revolution

Interesting that according to Greenpeace, the five key principles for an energy revolution are:
1. creating greater equity in the use of resources;

2. respecting the environment's natural limitations;
3. phasing out unsustainable energy source;
4. implementing renewable solutions i.e. decentralizes energy systems and grid expansions;
5. decoupling economic growth from the consumptions of fossil fuels.

American scientist John Ricardo Cole asserts that the world stands on the threshold of the "Age of solar energy" [3].

Various designs of solar systems that contain a protective coating, insulating layer and a heat-conducting layer [4, 5].

A flat-plate collector – the most common type of solar collectors. Flat-plate collectors used in low temperature processes up to 80 [°C]. For higher temperatures necessary system with concentrators [6].

For the implementation of solar thermal installations it is necessary to optimize energy-efficient external enclosures due to the correct installation and design of these units at different orientations of external walls [7].

The aim of this work was to offer cost-effective design of a solar system, without losing the efficiency of the system by reducing its cost. On the other hand, to investigate the proposed construction of the solar heat supply system and to establish the thermal characteristics of the influence on it of the proposed factors.

2. The Main Material

The research was used an experimental setup design of solar walls as solar heat supply systems, with subsequent analysis on the coefficient of performance (COP). The design of the solar wall are a universal solution to conserve traditional energy resources, because it is a combination of the outer structure of the building and the solar collector. Scheme of the experimental installation of solar walls in a gravity mode depicted in Fig. 2.

This solar heating system was studied in the regime of 'gravity' and 'flow'. Water from the storage tank 6 is supplied into the tubes of the circuit 4, which is heated on the principle of natural convection through the radiator 12 and is returned into the storage tank 6 and possible for the selection of the heat carrier through the pipe 7.

Mathematical processing of the results obtained in the measurement of the physical properties performed on the developed special programs.

The intensity of the flow of energy that radiates the source must be measured by the actinometer.

The temperature of the heat carrier at the inlet and outlet in the solar collector and in the storage tank it is necessary to measure thermal converters of resistance 50M, working with a meter controller type PT-0102. The ambient air temperature and its speed was measured by thermo-electro-anemometer TESTO 405 – V1.

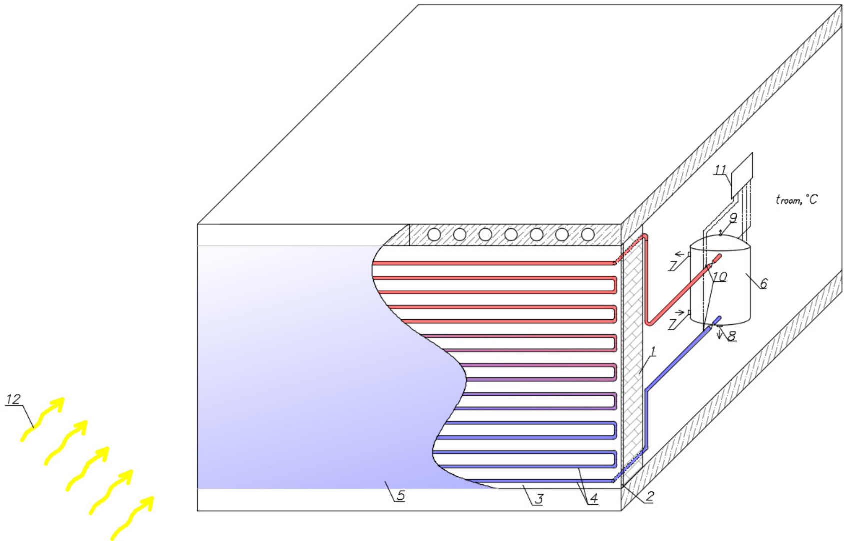

Fig.2. The experimental setup, where 1 – solar wall; 2 – thermal insulation layer; 3 – heat reflecting layer; 4 – tube circuit (serpentine heat absorber); 5 – plaster, 6 – storage tank; 7 – pipes for selection and flow of heat carrier; 8 – the discharge pipe of the heat carrier; 9 – air outlet valve; 10 – thermometer; 11 – display; 12 – radiation source

The basis of determining the coefficient of performance system of solar heat supply η_{SSHS} in general, the amount of energy received by the storage tank Q_{rec} use formula 1:

$$\eta_{SSHS} = \frac{Q_{rec}}{Q_{rad}} \cdot 100 \text{, } (\%) \quad (1)$$

where: Q_{rec} – the amount of heat received by the storage tank for the time ΔT - was determined experimentally;
Q_{rad} – the amount of radiant heat received on the surface of the solar wall during the same time period ΔT.

Specific heat capacity of solar collector (SC) Q_{SC}, (W/m^2) determined by the formula (2):

$$Q_{SC} = \frac{m \cdot c \cdot (T_{outlet} - T_{inlet})}{F_{SC}} \text{, (W/m}^2\text{)} \quad (2)$$

where: m – mass of the heat carrier in the tank-battery, (kg);
c – the average specific heat capacity (at constant pressure) at the arithmetic average of the heat carrier, (J/(kg·K));
T_{inlet}, T_{outlet} – the heat carriers temperature at the inlet and outlet SC

respectively, (K),

F_{SC} – the square SC, (m^2).

At the heart of the experimental research methodology of the proposed construction of the wall was carried out the analysis of its heat characteristics. The methodology was taken from collection of published data, analysis of existing designs of solar installations, mathematical and experimental studies of the proposed design of the solar wall on the thermal characteristics.

Along with experiments was carried out monitoring of factors that could cause errors in the measurements.

Conducted the following measurements: water temperature at the inlet and outlet of the solar wall, temperature of water in the storage tank. Alternatively, the experimental part of the solar wall studied in two regimes, and processing of research results was carried out in different ways.

In research was used the intensity of the flux of solar energy I = 600 W/m^2 at the plane of the collector. Since the intensity of solar radiation is the radiant energy flux received per unit surface area that passes through any point perpendicular to the direction of radiation. Therefore, for the optimization experiments is permissible to use at the laboratory solar simulator.

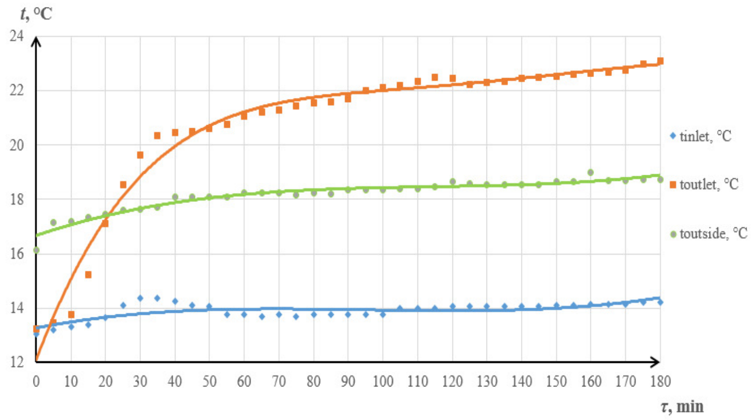

Fig.3. The temperature of the heat carrier due to the research of solar walls with the serpentine heat absorber in the regime of gravity.

The temperature of the heat carrier with the same design feature sof the solar wall, namely d=10 mm, l=20 mm, δ = 20 mm and the volume of the storage tank 0.015 m^3 has varied over the experiments and at the output from the solar wall was reached 15 °C in flow mode and 23 °C in the gravity mode, for a comparison of these temperatures on the charts, it was proposed to bring the ambient temperature and the inlet temperature in the solar wall (Fig. 2 and 3).

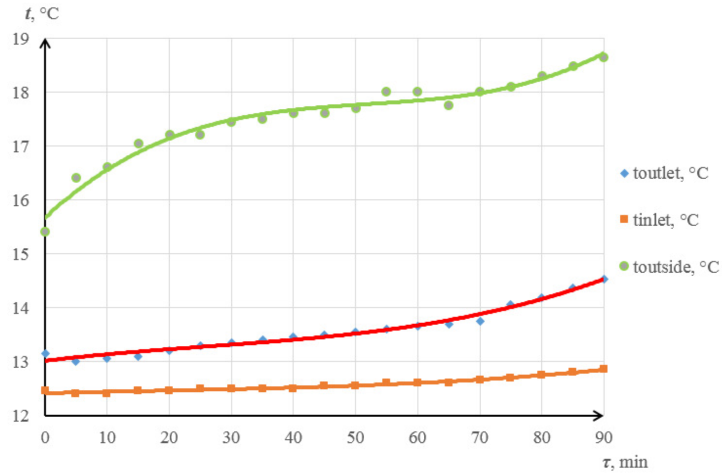

Fig.4. The temperature of the heat carrier due to the research of solar walls with the serpentine heat absorber in the flow mode

Interesting question in these structural parameters in the regime of gravity was more to consider changing the heating temperature in the storage tank and lead it to the average (Fig. 5) for such parameters, namely d =10 mm, l=20 mm, δ = 20 mm and the volume of the storage tank 0.015 m^3.

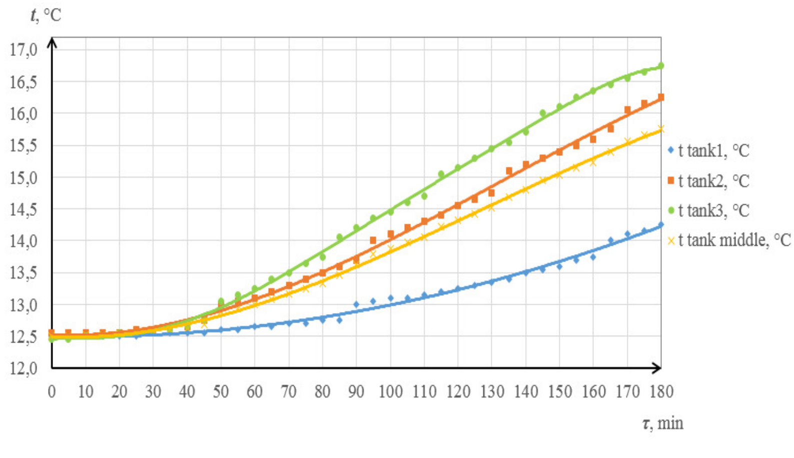

Fig.5. The temperature change of the heat carrier in the storage tank

An important issue in the regime of the flow was to investigate the instantaneous values of specific heat capacity for the solar heat supply system, which is shown in Fig. 6. Instantaneous specific heat capacity at d =10 mm, l=20 mm, δ = 20 mm, and the volume of the storage tank 0.015 m^3 and at a constant volumetric flow of 0.25 l/min is acquiring growing importance, which may be associated with the heating system, the instantaneous change in specific heat capacity for these parameters occurred from 61-147 W/m^2 for a constant solar radiation of 600 W/m^2.

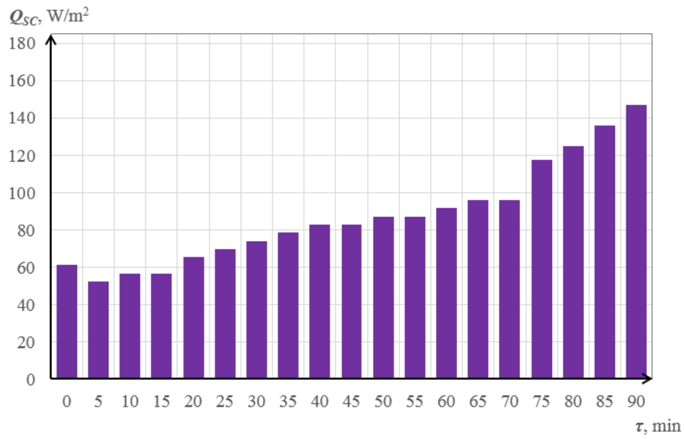

Fig.6. Instantaneous specific heat capacity of the system in the flow mode

The important point of the study of the solar wall was to examine the change in the coefficient of performance of the heat supply system as a whole a solar wall in gravity mode depending on the tube diameter of the circulation loop d and the distance l between them at constant v = 0.25 m/s and δ = 20 mm (Fig. 7).

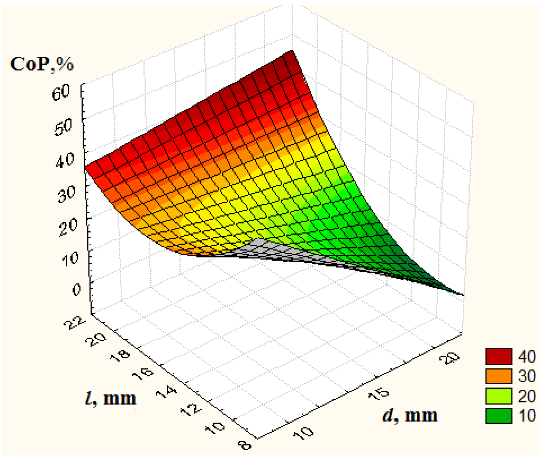

Fig.7. Change of the COP as a whole with serpentine heat absorber in the regime of gravity depending on the diameter of the tubes of the circuit d and the distance between them l

Such a solution would enable the engineers to calculate such systems for practical use with the assumption of the practical efficiency of such a system, depending on the diameter of the tubes of the circuit d and the distance l between them. The maximum achieved efficiency of the system of heat supply with solar wall in gravity mode was approximately 60 %.

3. Conclusion

The main thesis of this work is the installation of accessibility to the consumer, because the design does not require a separate installation and can be installed in an existing wall. In addition, the solar wall in both modes, has a sufficient efficiency for combined domestic hot water or pre-heating the heat carrier heating system. For example, the radiation intensity of 600 W/m^2 in the mode of flow the coefficient of performance was 49 %, while in gravity mode was 60 %.

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