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COMBINED THERMOPHOTO ELECTRIC INSTALLATION FOR INCREASING THE EFFICIENCY OF A SOLAR POWER INSTALLATION

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ABSTRACT

The article developed and investigated a thermo-photoelectric device for the combined production of heat and electricity from a single receiving surface. The proposed energy device consists of a solar heat collector absorber, on top of which polycrystalline solar cells are placed. This unit is a combined helio profile that can be installed on the roofs of buildings and structures. constructions. The design is intended to improve the energy performance of solar energy converters.

KEYWORDS: *Absorber, Photoelectric Converters, Thermo-Photoelectric Installation, Silicon Solar Cells, Helioprofiles, Thermo-Photoelectric Conversion Of Solar Energy.*

INTRODUCTION

One of the problems of solar energy is that the energy potential of the falling solar radiation is insufficient and the efficiency of photoconverters and other solar devices. low.To improve the efficiency of these systems, it is necessary to fully utilize the energy flow to the working surfaces of solar devices.

At this stage, photovoltaic modules are mainly used to generate electricity, while solar thermal collectors are used to heat the heating medium. However, with the development of modern science and technology, more and more solar devices have emerged that can produce both heat and electricity simultaneously through the same surface. These devices convert all solar radiation that simultaneously hits the surface into heat and electricity, that is, they simultaneously heat the coolant and serve as an alternating current generator[1].

LITERATURE REVIEW

Various studnamelys have included research on solar photovoltaic and thermal devices. [2-5]. However, such scientific sources contain data on various combinations of hybrid photo thermal devices [3, 5].

The use of combined thermo-photovoltaic devices can significantly save on the consumption of materials per unit of power for their production, which is a common phenomenon of efficiency and increases the efficiency of use [1].This is because absorbers of thermal heliosystems and solar panels receive and convert different wavelengths of the solar spectrum, so both heat and electricity can be obtained from a single working surface. The production of helio-photoelectric panels reduces the cost of materials required for expensive selective coating absorbers and photoelectric modular structures as a result of serial development by combining them into a single device [2].

The main problems of solar power plants are the small intensity of solar radiation, which is converted into electrical and thermal energy, efficiency is low, and as a result is the cost per unit of power. Due to the low potential of solar energy, high requirements are placed on the efficiency of the use of solar devices in the supply of heat and electricity, methods for determining the main parameters of efficiency, photovoltaic modules and heliocollector. A combination of a flat heat absorber and a photoelectric battery can create a design that allows efficiency use of incident solar radiation and increases its conversion factor.

On a modern industrial scale, mono- and poly-silicon solar cells have a flat constriction and an absorption coefficient of 95%, with an efficiency of 18-20%. In the conversion of radiation in solar cells, 80% of the energy is mainly used to heat the element, which negatively affects its quality. When solar cells are placed on the surface of the solar collector absorber, the efficiency of the device is significantly increased if ideal heat exchange takes place.

The removal of heat by the heat transfer fluid circulating along the contour of the solar system prevents the photovoltaics from overheating and, accordingly, the total amount of electricity produced increases. The high absorption coefficient of solar cells allows up to 80% of the absorbed solar energy to be used to heat the receiving surface of the heat absorber. For industrial-scale solar heaters, the conversion rate for most absorbers is as high as 80%.

MATERIALS AND RESEARCH METHODS

The article considers and studies the principle of operation of a combined thermo-photoelectric device, calculating its thermal and electrical performance.

The aim of the study is to theoretically and experimentally confirm the efficiency of the use of solar radiation incident on the surface of a thermo-photoelectric device and increase its conversion factor for the surface of the receiving unit.

All experiments were performed under natural conditions in the Namangan region, namely under constant sunlight during the experiment, with measuring instruments [6].

During the study, a method for directly measuring the current and voltage of a photovoltaic cell with a variable load resistance and a method for measuring the temperature of the heat carrier were used.

The experiments were performed in a wide range of natural conditions, in the open air, under natural sunlight. The experiments were performed in a wide range of natural conditions, in the open air, under natural sunlight.

The combined thermo-photovoltaic device (Fig. 1) is a full-size industrial helioprofile designed to directly cover the roofs of residential buildings. The helioprofile contains tubes for liquid heat transfer, air or heat-insulating material.

With such helioprofiles it is possible to cover an unlimited area of the roof up to 7 m in height and width. The receiving surface of the helioprofile has a chain of 36 solar cells connected in series. The photocells are attached to the receiving surface using a special heat-conducting paste with high ohmic resistance. The elements cover 1/3 to 1/2 of the surface of the lower part of the helioprofile (Fig. 1).

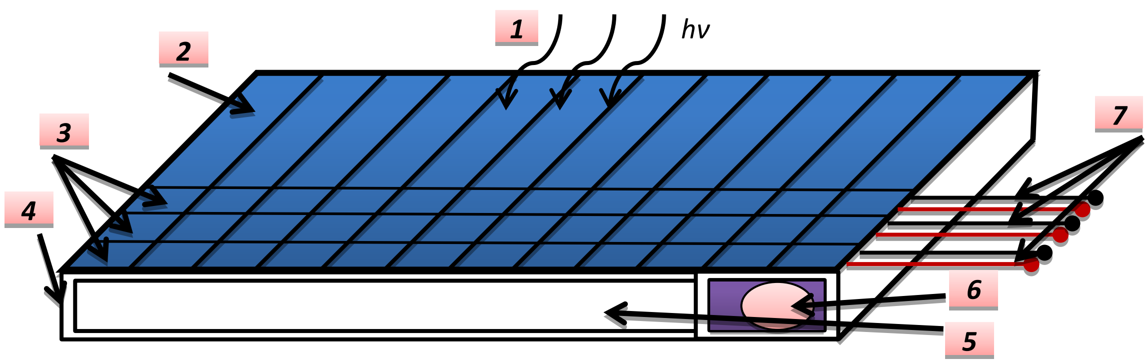

Figure 1.Thermo-photoelectric device

1 – falling sunlight; 2 –heat-absorbing surface; 3 –solar cells; 4 – walls of the helioprofile absorbing surface; 5 – air duct; 6 – water channel; 7 – electrical contacts of solar panels.

Due to the low temperature and circulation of the heat transfer fluid, the elements are cooled, which improves the quality of work. As silicon solar cells change parts of the spectrum other than those related to heat absorbers, an overall increase in energy production is observed.

Theoretical descriptions of the photovoltaic and absorber operation of a thermo-photoelectric device are represented by the following formulas (1-4) [7]:

The maximum capacity of a solar cell is expressed as follows:

$$P_{max} = F_{ff} I_{sc} U_{sp} = I_{max} U_{max} \quad (1)$$

Here, F_{ff} –filling factor, I_{sc} – short circuit current, U_{sp} – salt processing voltage, I_{max} – current at the operating point, U_{max} –operating point voltage.

It is known that the solar cell efficiency is calculated as follows:

$$\eta_{sc} = \frac{I_{max}\ U_{max}}{S_{us}.E_0} = \frac{P_{max}}{S_{us}.E_{i.}} \quad (2)$$

Here, $S_{us.}$ – useful surface of solar cells (m^2), $E_{i.}$ –illumination of the working surface (W/m^2).

The calculation of the heat absorber is also done in a certain way. Useful energy from the collector per unit time Q_u (W) [13]:

$$Q_u = F_R A[I_P(\tau a) - U_L(T_i - T_a)] \quad (3)$$

Here, A – collector surface (m^2), F_R – collector heat dissipation coefficient; I_P – the total intensity of solar radiation in the collector plane, (Rtaking into account the angle coefficient), W/m^2; τ–the light transmittance of transparent coatings against sunlight; a–the absorption capacity of the collector plate relative to sunlight; U_L–the total heat loss coefficient of the collector, $W/(m^2 grad)$; T_i–the temperature of the liquid entering the collector, °*C* (in nominal mode); T_a–ambient temperature, °*C*.

A simplified version of this formula is more suitable for practical calculations:

$$Q_u = S_{SC} G C_P (T_{exit.} - T_i)\ (W) \quad (4)$$

Where S_{SC} –is the collector surface(m^2).

Accordingly, the efficiency of a solar collector is determined by the following formula:

$$\eta_{sc} = \frac{Q_u}{S_{sc} E_{i.}} \quad (5)$$

E_i-illumination for the combined device is the same as for the collector and photocell elements. The values of S_{sc} and S_{eq}-surfaces are equivalent, that is:

$$\eta_{sc} = \frac{P_{sc}}{S_{csd}\ E_{i.}}, \eta_{sc} = \frac{P_{sc}}{S_{csd}\ E_{i.}} \quad (6)$$

can be written as.

here (of the combined device)η_{sc}– solar collector, and η_{sc}– the efficiency of the solar cell;P_{sc} andP_{sc}– the power coming out of the collector and the solar cell, respectively, S_{csd}–it is the useful surface of a combined solar device filled with solar cells.

The total power of the combined device is equal to the sum of the powers of the thermal and photovoltaic parts of the device:

$$P_{csd} = P_{sc} + P_{sc} = S_{csd}\ E_{i.}(\eta_{sc} + \eta_{sc}) = S_{csd}\ E_{i.}\eta_{csd} \quad (7)$$

hereη_{csd} general efficiency of the combined device.

Thus, with the increase in solar energy due to the photoelectric component, the overall efficiency of the device increases, while the area and illumination of the working surface remain constant.

If the receiving surface of the combined device is not completely covered with solar cells, formula (7) can be replaced by:

$$P_{csd} = S_{csd} E_{i.} (\eta_{sc} + f_{QEK} \eta_{QB}) \quad (8)$$

heref_{ces} – the coefficient of filling of the receiving surface of the combined device with solar cells. In our case, it varnamelys from 1/2 to 1/3.

As a result of heating, the efficiency of solar cells decreases according to formula (9):

$$\eta_{sc} = f_{ces} \eta_0 (1 - k(T_i - T_0)) \quad (9)$$

hereη_0 –efficiency of the photocell at T_0= 25 ° C, T_i–the temperature of the heated photocell(we consider it to be equal to the temperature of the liquid at the entrance to the collector), the decrease in the efficiencyof the solar cell depends on the k - depending on the temperature gradient and up to 0.3 ÷ 0.5% / ° C [5].

With this in mind, formula (8) looks like formula (10):

$$P_{scd} = S_{scd} E_{i.} \frac{G C_P (T_{exit\ .} - T_i)}{E_0} + S_{scd} E_{i.} f_{ces} \eta_0 (1 - k(T_i - T_0)) \quad (10)$$

According to formulas (1-10), all the parameters and propertnamelys of the Combined Solar Device can be determined by taking into account the collector and photocell elements.

RESULTS AND THEIR ANALYSIS

For the experiments, we used two solar devices of equal size, located at the same angle to the sun with the same heat absorber (Fig 2). Solar cells are placed on the absorber surface of one device and the dimensions of the devices are 3x2 meters. The photoelectric part of the device consists of three photoelectric modules with the same power. Because the surfaces of the devices are equal, both devices receive the same amount of sunlight.

Figure2. Solar heating (left) and thermo-photoelectric (right) devices

During the experiments, the heat energnamelys produced by the two solar devices were compared as shown in the graph (Fig 3).

The data show that the temperature difference of the heat carrnamelyrs at the output of the device in the simultaneous production of heat and electricity is only 1-2 °C, and these devices have almost no difference in heat production. Only here the combined thermo-photoelectric device also generates electricity. Due to the losses in the transfer of heat energy from the photocells to the absorber, differences of 1-2 ° C are recorded during heating. If the quality of the combined absorber is improved, the losses can be further reduced.

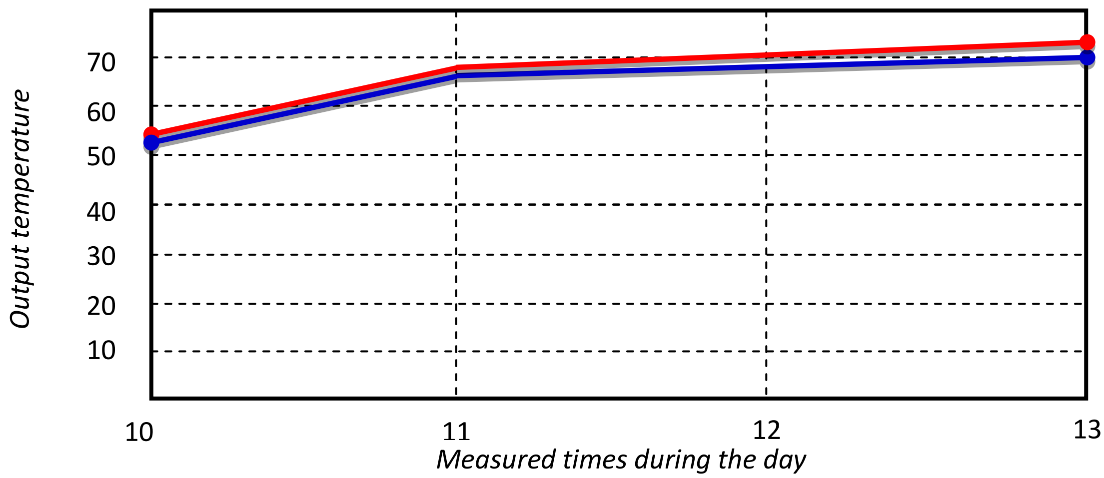

Figure 3. The outlet temperature of the heat transfer fluid

– thermalhelioprofile; – combined helioprofile.

Fig. 4 shows graphs of the specific heat capacity characteristics (W / /m^2) of each solar device.

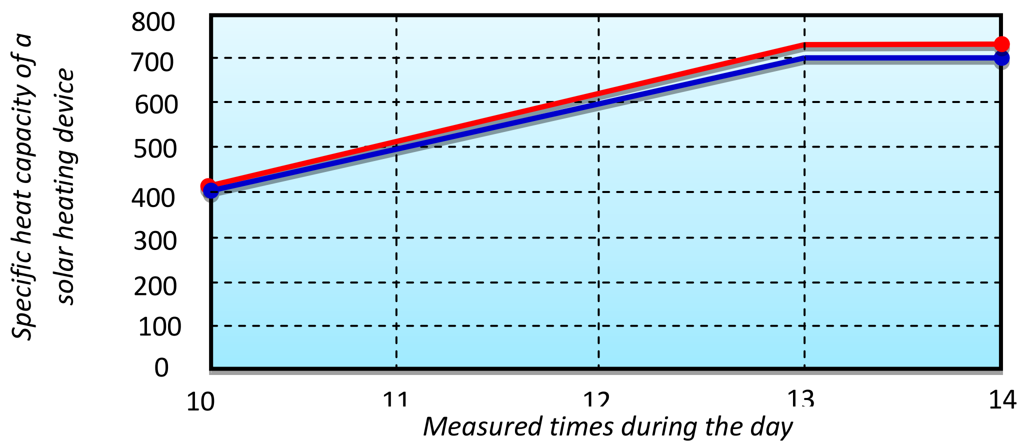

Figure 4. Specific heat capacity characteristics of devices

– thermalhelioprofile; – combined helioprofile.

Each of the three photovoltaic cells produces 48 W of power when the photovoltaic cells in the solar profile are in operation. In this case, 1/3 of the helioprofile surface is covered with photocells and the total power of the modules is 144 W. Table 1 shows the electrical characteristics of the thermo-photoelectric device output.

The results of the study show that the use of heat carriers and photocells with high temperatures under the influence of a heated surface due to solar infrared radiation significantly increases the overall conversion factor of the solar device.Thus, the combined helioprofile photovoltaic cells each generate approximately 50 W of electricity (Table 1) and the thermal capacity of the two solar devices being compared remains approximately constant (Fig. 4).

Load performance data for individual helioprofiles.

TABLE 1 DATA LOAD CHARACTERISTICS OF A SEPARATE SOLAR CELL IN A HELIOPROFILE

Characteristics of a separate solar cell											
I (A) – experimental value	3,5	3,5	3,5	3,5	3,3	3,25	3,2	3,2	3	2,2	0
U(V) – experimental value	0	2	4	6	8	10	12	14	16	18	19
P(W) – experimental value	0	7	14	21	26,4	32,5	38,4	44,8	48	39,6	0
Illumination of module characteristics 808 W/m^2, Obtained at $T_{air}=30$ °C											

This is because the photocells convert radiation of a different wavelength that differs from the spectrum required (enough) to heat the collector heat transfer fluid [6]. When non-heat-conducting solar cells operate, the energy of the infrared component of solar radiation is used to heat the photocells, which can often cause them to overheat, reducing the efficiency of the photocells [7].

CONCLUSION

The results of the study showed that from the developed combined helioprofile surface can be obtained from 1 m2 to 750 W of heat and up to 150 W of electricity.

From the results of the experiments, it can be concluded that the combined production of heat and electricity will be effective for solar-powered devices.

Theoretical calculations on increasing the coefficient of variation by comparing the experimental data obtained by comparing the operation of the heat collector and the combined device in practice were confirmed.

The total conversion factor of solar energy of the combined thermo-photoelectric device will be increased to 85%. In this case, the efficiency of the helioprofile is up to 70%, and the efficiency of solar cells is more than 15%.

The study also included the study of the results of complete coating of the collector surface with photocells, the redirection of the generated heat for energy purposes, and the efficient use of solar energy through the transmission of electricity directly to consumers. provided.

REFERENCES:

1. Kuznetsov K. V. Issledovaniekharakteristiksolnechnogovozdushnogogibridnogokollektora / K. V. Kuznetsov, I. I. Tyukhov, EH. D. Sergievskij // EHnergoobespechenieiehnergosberezhenie v sel'skomkhozyajstve, Trudy 6-j

Mezhdunarodnojnauchno-tekhnicheskojkonferentsii, 13-14 May 2008 g. - Moscow, GNU VIEHSKH, 2008. - CH. 4. - S. 227 - 231. (in Russian)

2. Kuvshinov V.V. Pat. 150121Rossijskayafederatsiya; MPK N 01 L 31/00. Fototermopreobrazovatel' solnechnojehnergii / Kuvshinov V. V., BashtaA.I., Safonov V. A.;patentoobladatel' Kuvshinov V. V. – Zayavka № 2014149414/93; zayavl. 17.10.2014; opubl. 27.01.2015, Byul. № 3.(inRussian)

3. Tursunov M. N. et al. Photothermal batteries of different designs: comparative analysis // Heliotechnika. - 2017. - No. 1. - P. 26.

4. Yuldoshev, I.A., Shoguchkarov, S.K., Kudratov, A.R. et al. A Study of the Parameters of a Combined Photo-Thermoelectric Installation under Field Conditions. Appl. Sol. Energy 56, 125–130 (2020).https://doi.org/10.3103/S0003701X20020115.(inEnglish)

5. Tursunov M. N. et al. Photothermal electric battery based on silicon solar cells // Applied Solar Energy. - 2011. - T. 47. - No. 1. - S. 63-65.(inEnglish)

6. Koltun M.M. Optikaimetrologiyasolnechnykhehlementov / M.M. Koltun // – M.: Nauka, 1985. – 300 s. (in Russian)

7. V.V. Kuvshinov, KakushinaE.G., CHvanovaD.A. Ispol'zovaniefotoehlektricheskojustanovkidlyaobespecheniyabesperebojnojrabotyavtonomnykhpotrebitelej. EHnergeticheskieustanovki i tekhnologii, Tom 2, № 1., str. 3-12, 2016. (inRussian)