STUDY OF OPTICAL-ENERGY PARAMETERS OF PLANETARY EMISSION DETECTORS IN SOLAR MODULES WITH PARABOLOCYLINDRICAL HUB

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The role of solar energy in the energy of the future is determined by the capabilities of the industrial use of new physical principles, technologies, materials and designs of solar cells, modules and power developed in Russia.

The use of hubs in solar power plants or solar photovoltaic power plants is the most effective way to reduce the cost of photovoltaic power.

The need to develop energy from renewable energy sources, especially in rural areas, currently in Russia is more and more understanding, because it is characterized by the presence of large areas where the delivery of traditional energy sources are largely difficult, unprofitable, etc. It is in the latter case, the use of renewable energy sources becomes feasible, and, frequently, and cost-effective. This is especially true in the field of agricultural production, where production capacity due to their nature, tend to be removed from the existing centralized energy networks.

The purpose of research - development of mathematical models describing the functioning of the individual units and systems, distribution of the radiation on the surface of the photodetector, a comparative analysis of different designs of photovoltaic modules and study the thermal regime of the solar cell module with solar cells and parabolocylindrical hub.

Materials and methods of research. Ensuring optimal performance of the solar photovoltaic module consisting of: parabolocylindrical Hub amidships size R x L, where L is the length of the cylindrical axis of the hub; planar photodetector made of a parallel-series of switched high or planar photovoltaic width d. A photodetector mounted on a planar air-cooling device and is mounted in the focal plane of the concentrator. Moreover, the hub is part of the air-cooling device. To increase the power generation unit mounted on a support device for tracking the sun.

Scheme for construction of photovoltaic module with parabolocylindrical hub shown in Fig. 1.

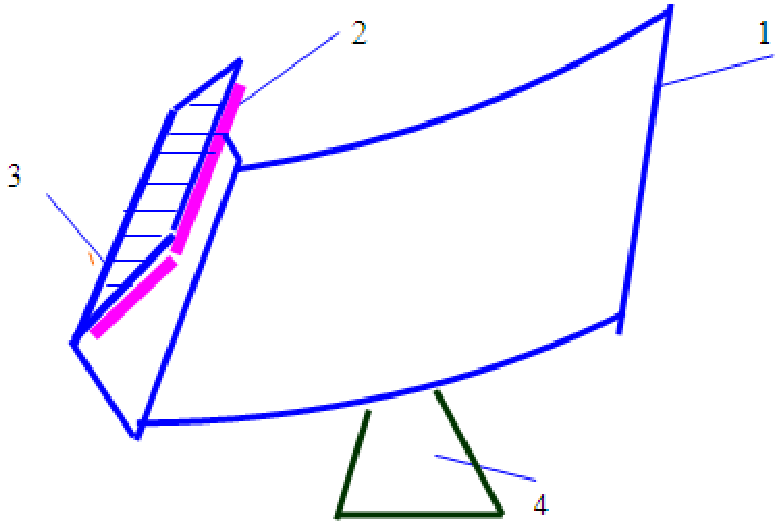

Fig. 1. Schematic design of the PV module with parabolocylindrical hub:

1 - a hub; 2 - planetary photoelectric receiver; 3 - air cooling device; 4 - support with sun-tracking device

Scheme for construction of photovoltaic module with parabolocylindrical hub and the course of the rays from the surface of the hub to the planar surfaces of the photodetector width d is shown in Fig. 2.

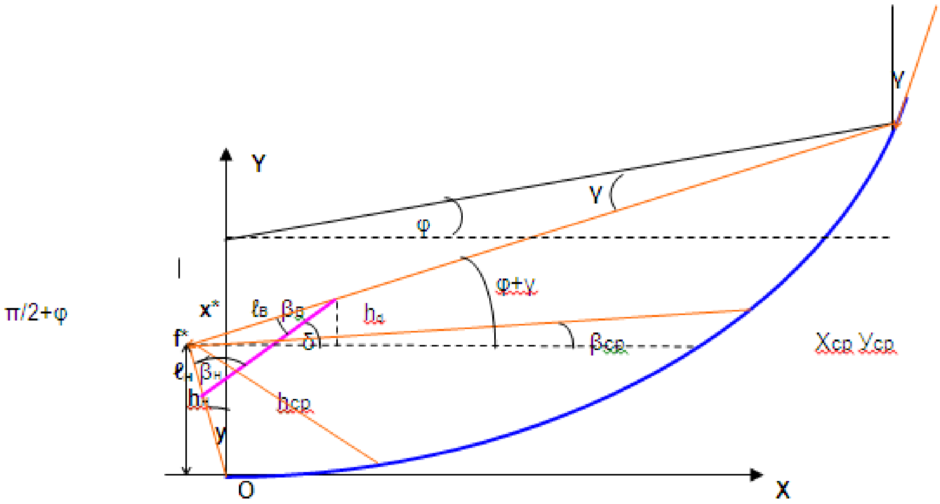

Fig. 2. The circuit design of the PV module with parabolocylindrical concentrator and ray path from the surface of the hub to the planar surfaces of the photodetector width d

The main design ratio of the rays from the concentrator to parabolocylindrical photoelectric detector:

$$f^* = \frac{Y - Xtg(\varphi+\gamma)}{1+tg\gamma tg(\varphi+\gamma)};\ Y_{cp} = \frac{R^2}{16f};\ h_в=\ell_в\sin(\varphi+\gamma);\ h_н=\ell_н\cos\gamma;\ \ell_в = \frac{d\sin\beta_н}{cos\varphi};$$

$$\ell_н = \frac{\ell_в \sin\beta_в}{\sin\beta_н},$$

where γ - parametric parabolocylindrical angle or the angle between the upper reflected beam coming in the focal region at the level of f and lower reflected beam coming into the focal region at f *; φ - the angle between the upper reflected beam coming into the focal area and the level of f f; βv - the angle between the upper reflected beam coming in the focal region of f * and a photodetector, rotated by an angle δ = φ + γ + βv with respect to the x-axis; βn - the angle between the photodetector rotated by an angle δ = φ + γ + βv respect to the axis line O and OH f *, where the values of R, f, γ, δ, d selected according to the boundary conditions. Concentration distribution across the width of the focal spot on the surface of the detector is determined by the relation:

$$K_n=\Delta X_n/\Delta d_n .$$

The results of research. On the basis of the calculation formulas of the illumination distribution produced by the photodetector surface width d = 30 cm, γ = parametric 10o angle, the rotation angle of the photodetector relative to the axis OX δ = 20 °, the parabola focal length f = 90 cm, the width of the parabola midsection R = 270 cm, shown in Fig. 3.

If you change the values of R, f, γ, δ, d photodetector composed concentrator changing values and the concentration distribution of the illumination of the photoelectric receiver, ie, with a decrease in the area of the photoelectric detector d increases the geometric concentration photovoltaic module K; If you change the values of the angles γ, δ varies concentration distribution of illumination of the photodetector, ie, you can change the size and distribution of the concentration photovoltaic module light without changing the dimensions of the hub 1 and the selected type of photoelectric detector 3.

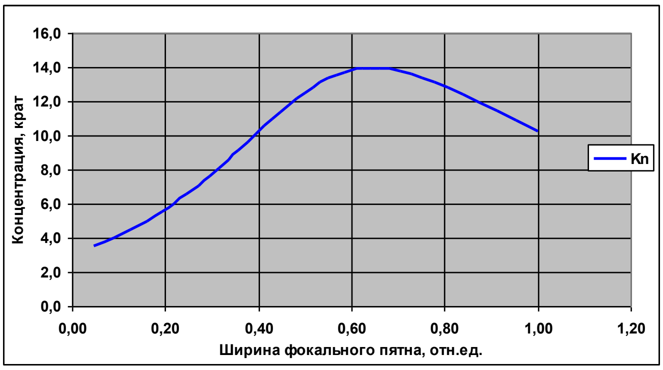

Fig. 3. The distribution of the illumination surface of the photodetector width of 30 cm in width (in relative units) of the focal spot

Thus, on the basis of the above calculation model distribution graphs and a concentration of the working surfaces of the photodetector can be optimized trapezoidal dimensions of the solar battery module units, and the magnitude of the concentration distribution of the illuminance on the working surfaces of the photodetector in accordance with the formula:

$$W = E_o \eta_{опт} \cos j \; S \; \tau$$

can detect power generation of the solar battery.

Fig. 4 shows the comparative design characteristics of power generation (excluding the transparency of the atmosphere) module of planar solar cell area of 3 m^2 and the efficiency of the solar cells 15 %, operating at steady state and the solar cell module with a concentrator midsection area 3 m^2, reflectance $\eta otr = 0.8$, solar cells with an efficiency of 15 %, operating in a sun-tracking.

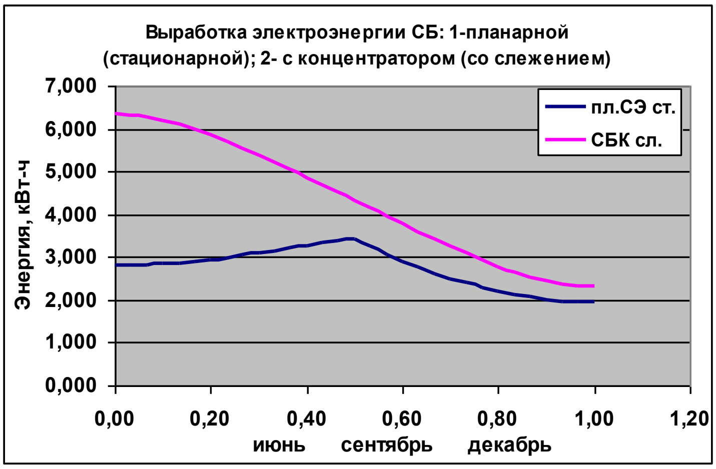

Fig. 4. Design characteristics of power generation module of planar solar cell area of 3 m^2 and ηFP = 15 %, stationary mode and solar modules to the hub area of the midsection 3 m^2, ηotr = 0.8, ηFP = 15 %, tracking

These characteristics indicate that the solar cell in the tracking mode, the sun is 1.5 times may increase the annual production of electricity. However, it should be noted that it was preferable to use modules with solar concentrators smaller because reduces the number of deficient matrix photovoltaic cells. Hubs can be made from thin sheets of aluminum (0.3-0.5 mm) with a smooth working surface, decreases the accuracy of solar tracking, reduced structural deformation processes in general, less time-consuming process of assembly, adjustment, replacement of defective modules repair; all this reduces the cost of construction and operation of solar installations.

We study the thermal regime of the solar cell module with solar cells and parabolotsilindricheskim hub that provides the photovoltaic cells at concentrations above 10. The analytical model of the solar cell module with solar cells and concentrator parabolotsilindricheskim shown in Fig. 1. The hub has the shape of a parabola half-branches from ABCD, and receivers concentrated radiation is the surface of solar cells, which are mounted on a metal plate connected to the hub. Cooling - air and heat exchange with the natural environment. A calculated manner, the following average concentrations: on the surfaces of the receiver, exposed arc Hub AB - 17,5; BC - 19,5; CD - 35. The receiver is shifted relative to the focus F of the parabola.

Statement of the problem. Photodetector with planar or high solar cells irradiated with solar flux at a concentration of 10 is required to determine the cooling efficiency of the photoelectric converter using a hub as a radiator.

The parameters of the module and the external environment. Parabolotsilindrichesky Hub: midsection 2700h1250 mm^2; sheet sizes 3438h1250h2 mm^3; material - aluminum alloy, the thermal conductivity = 100-150 W / (m K) = 3.375 m^2 .Fap. Receiver concentrated radiation: 1250h300h2 mm^3; length L = 1,25 m.

Inputs: - temperature of the photoelectric transducer 50-70 ° C. The substrate is made of a photoelectric converter such as an aluminum alloy sheet as the hub between perfect thermal contact at the ends. Ambient temperature 30 ° C, wind speed of 0-3 m / s.

Required to find the temperature distribution along the length of the sheet, and heat flows in the radiator discharged specified environmental conditions.

The area of the receiving surface Fpp = 0,3x1,25 = 0.15 m^2, the optical efficiency: η_{opt} = 0,9x0,9x 0,9 = 0,729, where the reflection coefficients hub r = 0.9, absorption receiver ά = 0.9 capture and f = 0.9; efficiency of the photoelectric converter η_{FEP} = 0.12; direct solar radiation R, W / m^2; ambient temperature t_a, °C; wind speed V, m / sec.

Cooling requirements - the maximum temperature of solar cells deposited on the side of the receiver 3x0,04 m, 50 °C.

Calculations.

Absorbed receiver stream: $Q_{пп}= \eta_{опт} R\ F_{ап}$

Heat losses to the environment:

$$\text{convection: } Q_{конв}=ά(t_c - t_a)F,$$

where α - the heat transfer coefficient, defined by the formula Mc Adams:

$$\alpha = 5,7 + 3,8\ V,$$

where V - velocity of the wind in m / s; tc - the average temperature of the walls of the receiver is determined by iteration;

Radiation: $Q_{рад}=\varepsilon\sigma(T_c^4-T_a^4)\ F$, where ε - the emissivity of the wall; σ - Stefan-Boltzmann constant; T - the absolute temperature, K,

efficiency of the photoelectric converter depends on the temperature:

$$\eta = \eta_0[1 - k(T_f - T_0)]$$

where η_0 - the efficiency of the photoelectric converter 298 at a reference temperature K, - the temperature of the photoelectric converter, K; k - temperature coefficient (k less than 0.003).

Solution of the problem. We consider the stationary regime. Heat exchange between the environment and the radiator occurs by Newton's law, and the temperature distribution is described by an exponential function:

$$\theta = \exp(-\sqrt{Bi}\frac{x}{l}),$$

where the criterion Bio $Bi = \frac{\alpha l}{\lambda}$; x - the beginning of the current coordinate frame of reference of the joint sheet with a photoelectric converter; l - length of the sheet, m; α - the heat transfer coefficient.

Temperature distribution along the length of the sheet, depending on the wind speed is shown in Fig. 5 to the temperature of the photoelectric transducer 50 °C and in Fig. 6 - to 70 °C. These calculated characteristics show that with increasing wind speed at hub reduced temperature 6-10 ° C at the end of the sheet as compared with the temperature at the joint between the substrate sheet and the photoelectric converter hub.

The heat flux density is determined by:

$$q = \frac{\lambda(T_{conz} - T_a)}{l}\sqrt{Bi}$$

where T_{conz} - Hub temperature, °C; T_a - Ambient Temperature, °C.

The heat flow is defined as $Q = qF$, where F - leaf area of the radiator.

The dependence of q and Q streams of the wind velocity at the photoelectric converter 50 °C is shown in Fig. 7 and at 70 °C - Fig. 8.

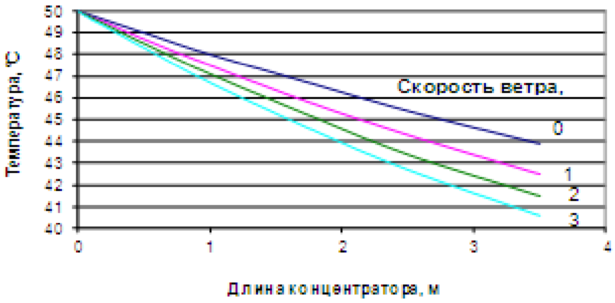

Fig. 5. The temperature distribution along the length of the hub at the photoelectric converter 50 °C and the wind speed 0, 1, 2, 3 m / s

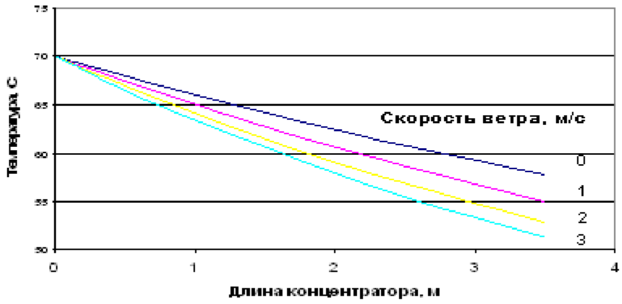

Fig. 6. The temperature distribution along the length of the concentrator at a temperature of 70 °C and a photoelectric converter speed vetra0, 1, 2, 3 m / s

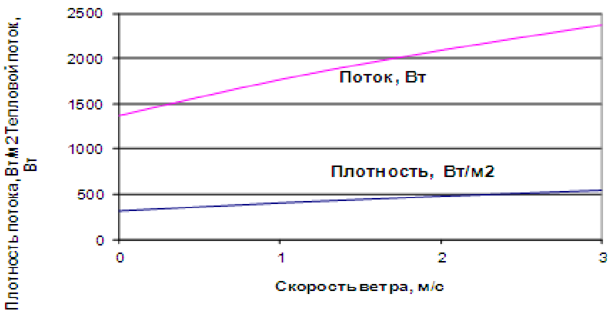

Fig. 7. Dependence of heat dump the wind speed at T_{FEP} = 50 °C

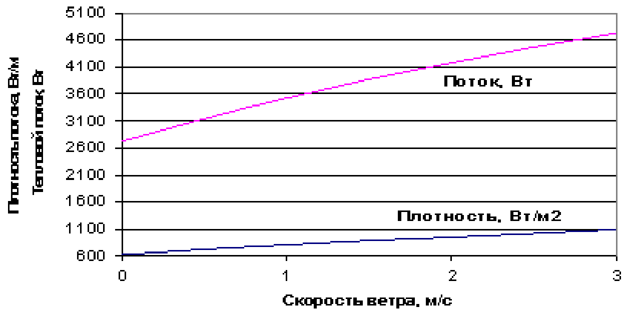

Fig. 8. Dependence of discharge heat from the wind speed at T_{FEP} = 70 °C

Analysis of the discharge characteristics shows the possibility of heat absorbed by the photoelectric converter at a temperature within the heating source 50-70 °C type solar battery module (approximately 1.5-2 kW) with a hub of the radiator, at concentrations of the order of 10 solar radiation.

Conclusions

Based on the calculation models, the calculated optical-energy parameters and characteristics of planar type radiation detectors in solar modules with parabolocylindrical concentrators can make a comparative analysis of the parameters and the choice of design and photodetectors parabolocylindrical hubs. Given the timing of work and power generation module can determine the appropriateness of the design of solar cells of different types and modes of operation.