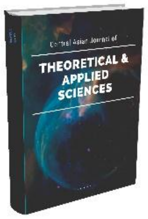


CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES

Volume: 04 Issue: 08 | Aug 2023 ISSN: 2660-5317
https://cajotas.centralasianstudies.org

Calculation of Optical-Energy Parameters of Trapezoidal Radiation-Receiving Solar Modules With Parabolic-Cylindrical Concentrators

Astan Ibragimovich Ismailov
Associate Professor of Andijan machine-building institute

Donyorbek Dilshodovich Alijanov
Associate Professor of Andijan machine-building institute

Shokhrukhbek Kozimjon Ugli Bakhramov, Ph.D
Student of Andijan machine-building institute

Received 25th Jun 2023, Accepted 25th Jul 2023, Online 26th Aug 2023

Abstract: *This article explores new photovoltaic modules, including trapezoidal receivers with photo batteries installed at their edges, parabolic cylindrical concentrators in the form of a half-rod (semi-parabolic-cylindrical concentrator) that form a parabolic cylinder that efficiently converts solar energy into heat and electricity. Furthermore, in this article, we calculated optical-energy parameters of trapezoidal radiation-receiving solar modules with parabolic-cylindrical concentrators.*

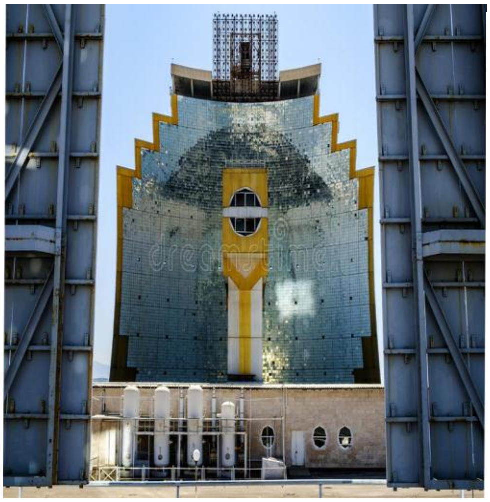
Keywords: *Solar energy, photovoltaic modules, photoelectric converters (PEC), trapezoidal photo-receiver (TPR).*

Introduction. Solar energy can be used for both heat production and electricity production. In the first case, flat concentrated solar collectors are used. Water, air or antifreeze can be used as a heat carrier. In the second case, the energy of the light flux is directly converted into electrical energy in photoelectric converters, or traditional schemes of thermal electro-plants are used.

Since ancient times, people have felt the power of the sun and felt that they depended on it for life. That's why they thought of using the sun more and more. First, they tried to obtain additional energy from sunlight - heating water and buildings, cleaning sea water and other goals[1].

Currently, all countries of the world are trying to use solar energy, which is considered an environmentally friendly energy. Solar energy, heat and electricity are used in production. Obtaining low-temperature heat (up to 100°C) with the help of solar energy is not very complicated according to the currently developed technologies, and it has a long history of development at various points on the earth's surface. The types of solar collectors are shown in figures 1 and 2.

[1] Panchenko V.A. Review and application of solar modules developed and manufactured by GNU VIESH. Vestnik VIESH, 2014, No. 4 (17), p. 20 - 29.



The function of the solar concentrator is to concentrate the rays. The rays of the sun can be in containers with a cooling liquid, for example, oil or water, which absorb solar energy well. Concentration methods are different: parabolic cylindrical concentrators, parabolic mirrors or heliocentric towers.

In some concentrators, the solar radiation is located along the focal line, in others - in the center where the receiver is located. When the sun's rays are reflected from a larger surface on a smaller surface (the surface of the receiver), a higher temperature is reached, the coolant moves through the receiver and absorbs heat. The whole system also includes a storage part and a power transmission system[2].

The efficiency of concentrators is significantly reduced during cloudy periods, since only direct sunlight is directed. Therefore, such systems achieve the highest efficiency in areas with a high degree of insulation: in deserts, in the equatorial region. To increase the efficiency of using solar radiation, concentrators are equipped with special trackers and tracking systems that provide the most accurate direction to the direction of the sun. Because the cost of solar concentrators is high and the monitoring systems require periodic maintenance, their use is mainly limited to industrial power generation systems[3].

Such installations can be used in hybrid systems, for example, in combination with hydrocarbon fuel, and the storage system reduces the cost of the produced electricity. This is possible because generation occurs day and night.

Discussion. Figure 1 shows the structural scheme of a solar module with a parabolic-cylindrical concentrator through the path of rays from the surface of the concentrator to the surfaces of the trapezoidal photo-receiver (TPR). TPR is produced in the form of three lines of high-voltage or planar photoelectric converters (PEC) installed on the faces of a trapezoid with width d_H, d_{cp}, d_B. Each face of the TPR is illuminated by a specific part of the concentrator.

The upper surface is the boundary coordinates of the concentrator $\{X_{\mathbf{B}}, Y_{\mathbf{B}}; X, Y\}$ lit by the part that is[4]; The values of the X, Y coordinates are the width of the concentrator X_{BH}, Y_{BH} coordinates are determined by the following formula:

---

[2] Strebkov D.S., Bobovnikov N.Yu., Irodionov A.E., Kirsanov A.I., Panchenko V.A., Filippchenkova N.S. The One Million Solar Roofs program in Russia. Vestnik VIESH, 2016, 3(24), 84-87.

[3] Panchenko V. Photovoltaic solar modules for autonomous heat and power supply. IOP Conference Series: Earth and Environmental Science 317 (2019) 012002, 9 p. doi:10.1088/1755-1315/317/1/012002.

[4] Panchenko V., Izmailov A., Kharchenko V., Lobachevskiy Y. Photovoltaic Solar Modules of Different Types and Designs for Energy Supply. International Journal of Energy Optimization and Engineering, Volume 9 Issue 2, 2020, pp. 74 – 94, DOI: 10.4018/IJEOE.2020040106.

$$X_{вn} = 2f\left[1/\cos(\xi-\delta_n) - \mathrm{tg}(\xi-\delta_n)\right]; \qquad (1)$$

$$Y_{вn} = X^2_{вn}/4f, \qquad (2)$$

Here: $\delta_n = (\phi + \xi)n \;\; n_0$; $n = 0, 1, \ldots, n_0$;; f is the focal length of the parabola.

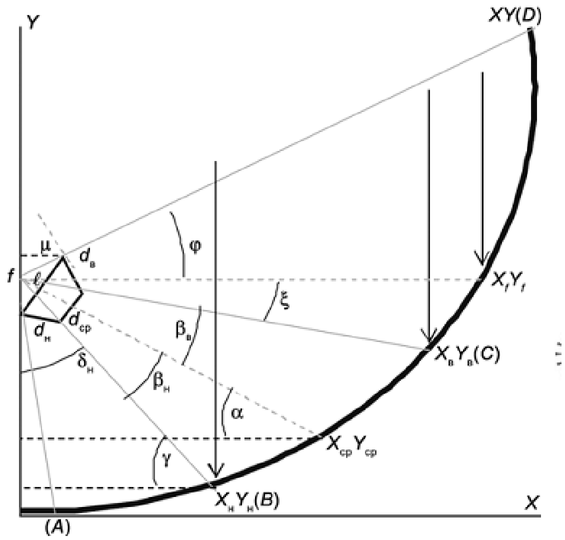


Figure 1. Photoelectric module design scheme for the parabolic-cylindrical concentrator and the width of the beam path d_H, d_{CP}, d_B from the concentrator surface to the TPR.

The distribution of the illumination concentration over the width of the focal point on the upper surface of the TPR is determined as follows.

$K_{Вn} = \Delta X_{Вn} / \Delta d_{Вn}$, (3)

Here

$d_{Вn} = \ell \sin\delta_n / \cos\beta \sin(\mu + \beta + \delta_n)$; (4)

$\Delta d_{Вn} = d_{В(n+1)} - d_{Вn}$; (5)

$\Delta X_{Вn} = X_{В(n+1)} - X_{Вn}$; (6)

$\mathrm{tg}\mu = (\ell - d_{cp})/2d_{В}$. (7)

The distribution of the illumination concentration and the angles of incidence of solar radiation along the width of the focal point on the upper surface of the TFO' are shown in Fig. 2 according to the width of the faces d_H, d_{cp}, d_B, in particular 4 × 4 × 4 cm.

Boundary coordinates of the concentrator $\{X_n, U_n; X_v, U_v\}$ Through the middle edge illuminates; The values of the concentrator in this area are determined by the formulas X_{cp}, U_{cp}.

$$X_{српn} = 2f\left[1/\cos\delta_n - \mathrm{tg}\,\delta_n\right]; \qquad (8)$$

$$Y_{српn} = X^2_{српn}/4f. \qquad (9)$$

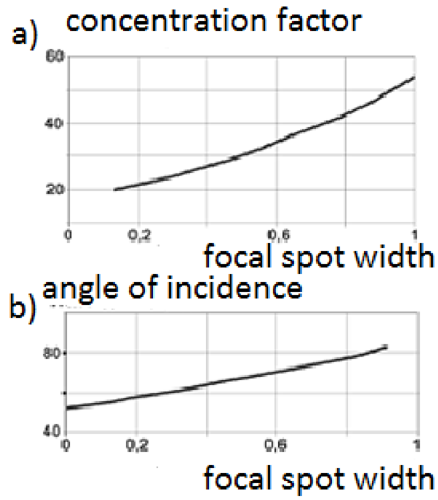


Figure 2. Distribution of illumination concentration (a) and angles of incidence of solar radiation (b) on the width of the focal point of the upper surface of TPR.

The distribution of light concentration and incidence angles of solar radiation on the average surface of TPR is determined by analogy with formulas (3) - (6) and is shown in Fig. 3.

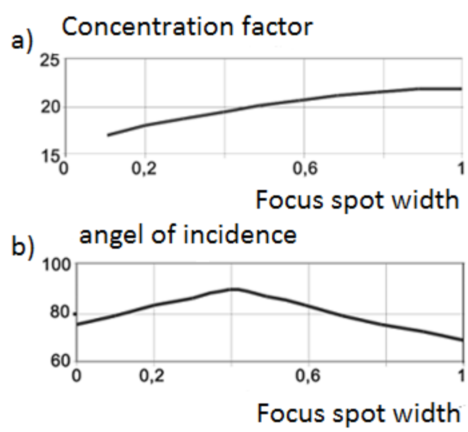


Figure 3. Distribution of illumination concentration (a) and solar radiation incidence angles (b) on the focal width of the average surface of TPR.

The boundary coordinates of the lower edge concentrator $\{X_H, Y_H; 0.0\}$. The values of the concentrator coordinates in this area X_{Hn}, Y_{Hn} are determined by the following formulas:

$$X_{Hn} = 2f\left[1/\cos\delta_n - \mathrm{tg}\,\delta_n\right]; \qquad (10)$$

$$Y_{Hn} = X_{Hn}^2/4f. \qquad (11)$$

Volume: 04 Issue: 08 | Aug 2023, ISSN: 2660-5317

The light concentration distribution on the lower surface of the TPR and the angle of incidence of solar radiation according to the focal width are determined according to the following formulas[5].

$K_{Нn} = \Delta X_{Нn}/\Delta d_{Нn}$; (12)

$d_{Нn}/\sin\delta_{Нn} = \Delta f/\sin\gamma^{*}$; (13)

$\Delta f = \ell\sin(\mu + \beta_{н})/\cos\beta_{н}\sin(\mu + \beta_{н} + \delta_{н})$; (14)

$\gamma^{*} = \mu + \beta_{н} + \delta_{н} - \delta_{Нn}$, (15)

and it is shown in Figure 4.

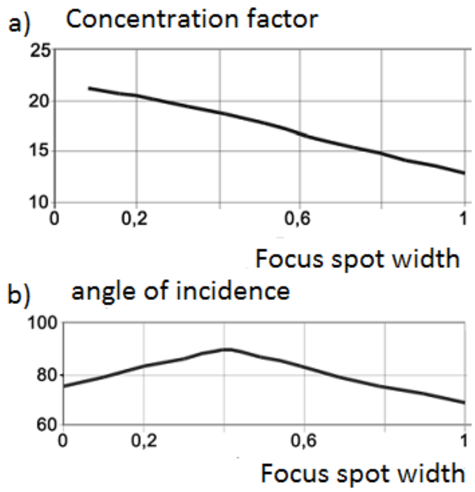


Figure 4. Distribution of illumination concentration (a) and solar radiation incidence angles (b) over the focal width of the bottom surface of the TPR.

As can be seen from the graphs, the design ensures the operation of the solar photovoltaic module at high concentrations (up to 50 times) and the uniform illumination of the photoreceptor (up to 0.25 of the average value).

Thus, based on the above calculation model and the light concentration distribution graphs on the working surfaces of the TPR, the size, concentration value, distribution of the solar battery (SB) module blocks and the light on the working surfaces of the photoreceptor are optimized according to the formula.

$$W = E_0\eta_{опт}\cos j_{ср}S\tau, \qquad (16)$$

Here W – developed SB electricity; E_0 – sun illumination; $\eta_{опт}$ – optic efficiency of SB ; $\cos j_{ср}$ – $j_{\min}$ va $j_{\max}$ the average daytime value of cosj at the limit value (j is the angle of inclination of solar radiation to the normal SB model); S – model surface of SB; τ – daytime hours of SB, in which the energy production of the photoreceptor at each edge and the entire photoreceptor can be determined[6].

[5] Arbuzov Yu.D., Evdokimov V.M. Fundamentals of photoelectricity. M.: GNU VIESKh, 2007.
[6] Strebkov D.S., Tveryanovich E.V. Concentrators of solar radiation. M.: GNU VIESKh, 2007

USED LITERATURE:

1. Panchenko V.A. Review and application of solar modules developed and manufactured by GNU VIESH. Vestnik VIESH, 2014, No. 4 (17), p. 20 - 29.
2. Strebkov D.S., Bobovnikov N.Yu., Irodionov A.E., Kirsanov A.I., Panchenko V.A., Filippchenkova N.S. The One Million Solar Roofs program in Russia. Vestnik VIESH, 2016, 3(24), 84-87.
3. Panchenko V. Photovoltaic solar modules for autonomous heat and power supply. IOP Conference Series: Earth and Environmental Science 317 (2019) 012002, 9 p. doi:10.1088/1755-1315/317/1/012002.
4. Panchenko V., Izmailov A., Kharchenko V., Lobachevskiy Y. Photovoltaic Solar Modules of Different Types and Designs for Energy Supply. International Journal of Energy Optimization and Engineering, Volume 9 Issue 2, 2020, pp. 74 – 94, DOI: 10.4018/IJEOE.2020040106.
5. Arbuzov Yu.D., Evdokimov V.M. Fundamentals of photoelectricity. M.: GNU VIESKh, 2007.
6. Strebkov D.S., Tveryanovich E.V. Concentrators of solar radiation. M.: GNU VIESKh, 2007.

