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INCREASING SOLAR MODULES' OPERATION EFFICIENCY THROUGH THE USE OF FLAT FOCLINE CONCENTRATORS

Summary. *The issues of increasing the efficiency of solar modules through the use of flat focal concentrators are considered. Experimental studies have proven that the I_{scc} values change with changes in illumination, while the open-circuit voltage U_{ir} values remain practically unchanged.*

Key words: *Solar Cells, Module, Focline, Concentration Coefficient, Short Circuit Current, Open Circuit Voltage, Time Intervals.*

Introduction. The ability to reduce the cost of expensive $A^{III}B^{V}$ type semiconductor materials in solar cells, when using concentrated solar radiation, maks it possible not only to reduce significantly the cost of solar cells compared to conventional planar solar cells, but also to maintain, and in some cases significantly improve their energy parameters.

Calculation of the highest solar radiation concentration coefficient. In the process of carrying out the work, analytical calculations were carried out to determine the maximum concentration coefficient of solar radiation at the optimal ratio of the angle of inclination θ_k and height of the reflective surface for flat foclines.

The concentration coefficient was calculated based on the geometric components presented in Figure 1.

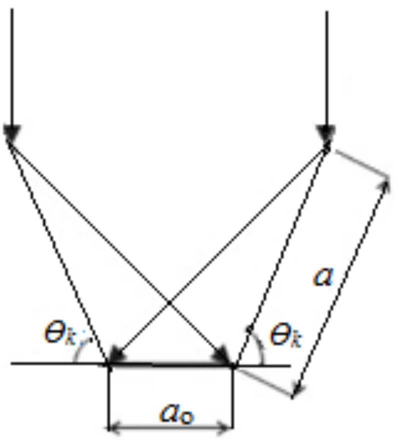

Fig. 1. Scheme of the focline's geometric components

The expression for the average concentration coefficient C_f has the form:

$$C_f = 1 + N\sum_{n=1}^{n_k}(-1)^n R_c^n \cos 2n\theta_k, \tag{1}$$

where N – is the number of concentrator faces;

R_c^n – is the reflection coefficient

The geometric concentration coefficient C_g has the form:

$$C_g = 1 + R_c^n N \frac{a}{a_0} \cos 2n\theta_k, \tag{2}$$

where a – is the reflective surface width;

a_0 – is the radiation receiver width;

θ_k – is the angle of inclination of the reflecting surface.

The problem solved by the authors in this work was to study a concentrator solar module based on flat foclines with improved optical efficiency.

The main element of a flat concentrator is flat reflective surfaces, which play a primary role in increasing the efficiency of the system as a whole. To ensure even distribution of illumination across the solar panel, the reflectors must be perfectly flat. At the same time, flat foclines retain the original value of the average concentration coefficient with low accuracy of orientation of the reflector axes on the Sun.

A focline concentrator module, shown in Figure 2, with flat reflectors (Fig. 2, 1) and a photoreceiver (Fig. 2, 2) were manufactured to carry out experimental studies.

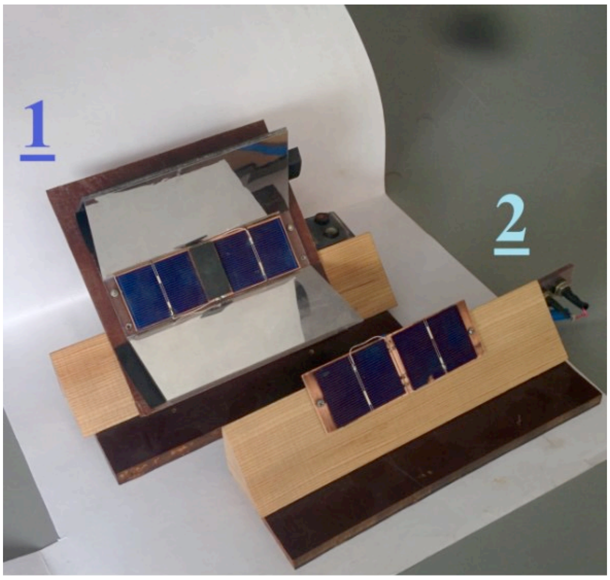

Fig. 2. Focline concentrator module

Both modules use two identical monocrystalline silicon photovoltaic converters connected in series.

To carry out measurements along the horizontal axis, we calculate the initially normalized values t_n of time intervals using expression (3):

$$t_n = \frac{t - t_0}{30}, \tag{3}$$

$$t = t_0 + 30n,$$

where t_0 – is the start of measurements, min.;

t – is the current time, min.;

n – is the measurement interval.

After measuring the short-circuit current I_{scc} and the open-circuit voltage U_{ir} of the focline concentrator module (FCM) and the control photoreceiver module (CPM), we calculate the concentration coefficient C_c using formula (4):

$$C_c = \frac{P_{FCM}}{P_{CPM}} \cdot FF, \quad (4)$$

where P_{FCM} – is the focline concentrator module power, mW/cm^2;

P_{CPM} – is the control photoreceiver module power, mW/cm^2

FF – is the parameter of mono silicon, in calculations we assume that FF=0,17.

The results of measurements and calculations will be put in Table 1.

Table 1

Results of measurements and calculations

Module parameters		Time intervals				
		1	2	3	4	5
FCM	I_{scc}, mA/cm^2	1,03	1,08	1,13	1,15	1,78
	U_{ir}, V	0,78	1,25	1,48	1,6	1,12
	P_{FCM}, mW/cm^2	0,81	1,35	1,67	1,82	2,09
CPM	I_{scc}, mA/cm^2	1,56	1,87	2,01	1,59	1,99
	U_{ir}, V	0,35	0,42	0,47	0,47	0,45
	P_{CPM}, mW/cm^2	0,54	0,78	0,94	0,74	0,91
	C_c	1,5	1,7	1,8	2,4	2,2

According to the results obtained, shown in Table 1, we will build plots of time dependencies (Fig. 3).

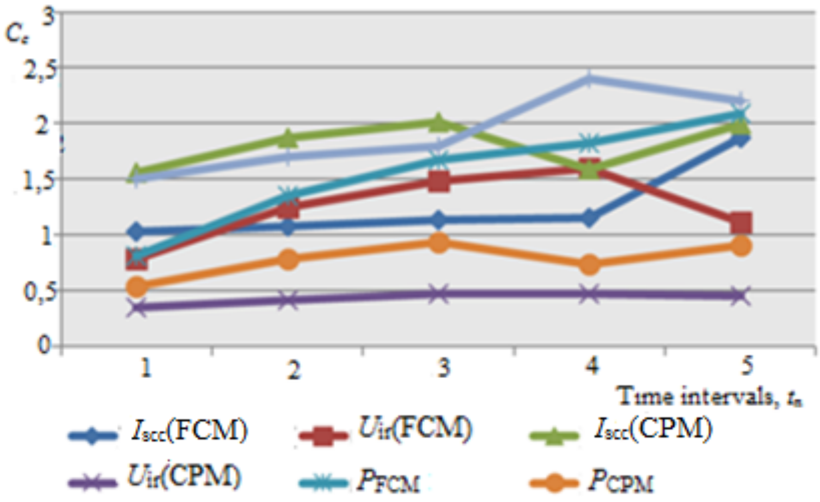

Fig. 3. Time dependency plots

After conducting experimental studies, we will move on to conclusions about the work.

Conclusions. The conducted research allows us to draw the following conclusions:

– with constant time flushing and a one-hour increase in temperature, the I_{scc} parameters practically do not change;

– the I_{scc} plot actually reproduces the change in illumination. The minimum at point 4 (see Fig. 3) is associated with partly cloudy;

– the decrease in the concentration coefficient C_c between intervals 5 and 4 (see Fig. 3) confirms the beginning of degradation processes;

– the use of focline concentrators with flat light reflectors makes it possible to relatively simply increase the light flux density by 1,5 – 2,4 times and, accordingly, the photoconversion efficiency;

– to ensure the thermal regime of the photoelectric converter crystal, taking into account the ambient temperature and a given concentration coefficient $C_c \geq 3$, it is necessary to introduce additional structural elements that provide heat removal.

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