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CALCULATION OF OPTIMAL SIZES OF REFLECTING ELEMENTS OF THE MOSAIC CONCENTRATOR

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ANNOTATION

The article deals with the main relations of choosing the optimal sizes of mosaic concentrator elements, as well as large- sized faceted elements on a paraboloid and mosaic basis, taking into account the optimal size of the scattering spot (receiver) at the maximum efficiency value obtained for the power generating station.

KEYWORDS: *parabola, mosaic, focus, facet and concentrator, receiver.*

INTRODUCTION

Currently, in solar thermal power stations (SES) of high power, two schemes of concentration of solar radiation are used. The first, "point" focusing (tower SES) and the second, "linearly" focusing with linear concentrators (LC) - Luz SES [1]. Concentrators of solar radiation are optical systems (mirror, lens, or mixed mirror-lens) that change the course of the sun's rays (by reflection or refraction) so that they reach a certain radiation receiver. In the general case, two optical schemes for the concentration of solar radiation can be distinguished: single-mirror (single-lens) and multi-mirror (multi-lens). The former include, for example, cylindrical with various second-order curves in the section, spherical, parabolic, etc. [2].

The production of solid parabolic and mosaic mirrors is associated with great technological difficulties, so it is more economical to produce powerful energy concentrators from separate reflecting elements [3-5]. One of the variants of this type is mosaic concentrators, the individual elements of which have a flat surface [6-7]. Having an approximate parabolic and mosaic surface made in one way or another during the process of gluing flat elements to the surface of the concentrator, adjusting these elements, you can achieve a good quality of the focal spot [8-9].

MATERIAL AND METHODS

Using a theoretically accurate paraboloid and a mosaic of rotation of a certain diameter and focal length, we will try to solve the following problem. A separate mirror of a certain size is installed relative to this parabolic and mosaic surface. Find the dependence of the element size (flat mirror) on the size (diameter) of the

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focal spot. In this case, let us consider the case when rays fall on a parabolic surface that are parallel to the optical axis of the paraboloid by rotations of the focal zone has a flat shape [10].

The angle between the optical axis and the tangent to the paraboloid has different values for different points on the parabolic surface, and the smallest value is obtained for the most extreme point. This means that from the mirror installed at this point, a beam of rays will go most deflected to the optical axis, and these rays, cut by the focal plane, will give the largest size of the spot.

DISCUSSION RESULTS

Therefore, if the dimensions of the mirrors are the same, we will make calculations for the extreme mirror. The angle **2U** and the angle between the incident beam and the normal to the reflecting surface **α** are connected, i.e.

$$U = 2\alpha \,. \tag{1}$$

From Δ ABC and Δ MKE we have:

$$b = l\cos\alpha \tag{2}$$

$$b = d'\cos U \tag{3}$$

Hence, given (1), we get

$$l = d'\frac{\cos U}{\cos(U/2)} = d'\frac{\sqrt{2\cos U}}{\cos U + 1}\,. \tag{4}$$

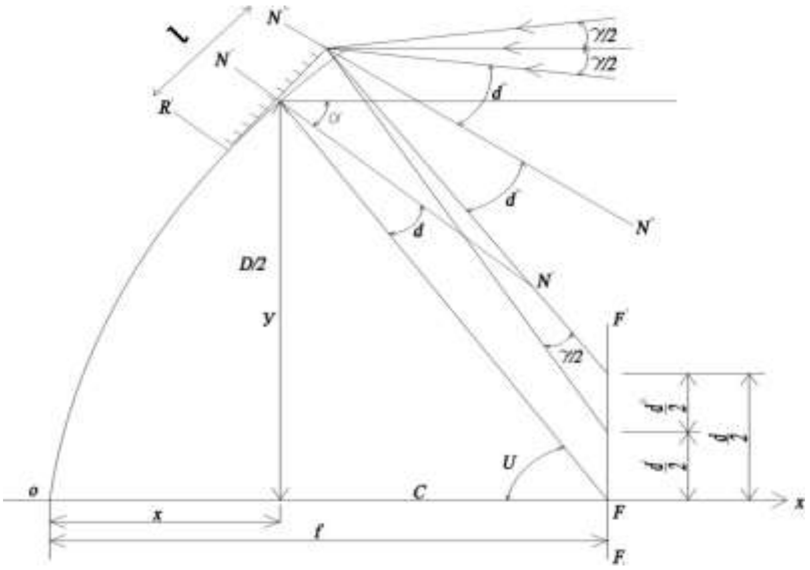

Figure 1.To calculate the dependence of the size of the element l on the f and D of the concentrator, taking into account the angular size of the Sun.

The the following expressions can be written (Figure 1):

$$RF = x + f \tag{5}$$

$$C = f - x \tag{6}$$

$$C = RF\cos U \tag{7}$$

$$C = (f + x)\cos U \tag{8}$$

$$\cos U = \frac{f - x}{f + x}\,. \tag{9}$$

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Considering $x = \frac{2Y}{16f}$, (10)

we get $\cos U = \frac{16f^2 - 2Y^2}{16f^2 + 2Y^2}$. (11)

Substituting the cos U value in expressions (4), we define

$$l = d' \frac{16f^2 - 2Y^2}{4f\sqrt{16f^2 + 2Y^2}}. \quad (12)$$

Consider the actual condition of the concentrator, that is, when a beam of rays coming from the Sun falls on it. We take into account that the angular size of the Sun, Δγ = 32 '= 0.0093 radian, f- focal length, F- focal plane.

The dependence of the diameter of the focal spot on the angular size of the Sun has the following meaning:

$$d'' \approx ftg\gamma \quad (13)$$

In a first approximation, it can be assumed that the rays from the extreme mirror determine the additional increase, i.e., the actual diameter of the focal spot, taking into account the angular size of the Sun from a separate plane mirror, installed with respect to the mosaic, parabolic and parabolic cylindrical surface, is

d = d' + d". (14)

Substituting the values of d 'into expressions (4) and (12), we can obtain

$$l \approx (d - ftg\gamma) \frac{16f^2 - 2Y^2}{4f\sqrt{16f^2 + 2Y^2}}; \quad (15)$$

$$l \approx (d - ftg\gamma) \frac{\cos U}{\cos(U/2)}; \quad (16)$$

Thermal solar systems in practice, the most beneficial is the opening angle 2U=90°. Then, given

$$f = \frac{2Y}{4} ctg \frac{U}{2}$$

Can find $l \approx 0{,}5774d - 0{,}0054f$, (17)

or $l \approx 0{,}5774d - 0{,}0023 * 2Yf$, (18)

or $l \approx 1{,}7320l + 0{,}0093f$, (19)

or $l \approx 1{,}7320l - 0{,}0040 * 2Y$, (20)

We establish the relationship between the size of the element, the diameter of the concentrator and the concentration coefficient. From the expression (16) it follows:

$$l \approx (d - \frac{2Y}{4} ctg \frac{U}{2} tg\gamma) \frac{\cos U}{\cos(U/2)}. \quad (21)$$

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From here $\frac{l}{d}=\frac{d}{2Y}\frac{\cos U}{\cos(U/2)}-\frac{\cos U}{4\sin U/2}tg\gamma$.

Because $\left(\frac{2Y}{d}\right)^2=K_g$

where, concentration coefficient,

Dependence of the concentrator diameter (D) on the size of the elements (*l*).

Table 1

D,m	K_g values							
	100	200	400	600	800	1000	1200	1400
0,5	27,7	19,3	13,3	10,7	9,1	8	7,2	6,6
1,0	55,4	38,5	26,6	21,3	18,1	16	14,4	13,1
1,50	83,1	57,8	39,9	32	27,2	24	21,8	19,7
2,0	110,8	77	53,2	42,6	36,2	32	28,8	26,2
2,50	138,5	96,3	66,5	53,3	45,3	40	36	32,8
3,00	166,2	115,5	79,8	63,9	54,3	48	43,2	39,3
3,50	193,9	134,8	93,1	74,6	63,4	56	50,4	45,9
4,00	221,6	154	106,4	85,2	72,4	64	57,6	52,4
4,50	249,3	173,3	119,7	95,9	81,5	72	64,8	59
5,00	277	192,5	133	106,5	90,5	80	72	65,5
6,00	332,4	231	159,6	127,8	108,6	96	86,4	78,6
7,00	387,8	269,5	186,2	149,1	126,7	112	100,8	91,7
8,00	443,2	308	212,8	170,4	144,8	128	115,2	104,8
9,00	498,6	346,5	239,4	191,7	162,9	144	129,6	117,9
10,00	554	385	266	213	181	160	144	131

$$l\approx\left(\frac{1}{\sqrt{K_g}}\frac{\cos U}{\cos U/2}-\frac{\cos U}{4\sin U/2}tg\gamma\right)2Y \qquad (22)$$

at, $2U=120^0$, $$l\approx\left(\frac{1}{\sqrt{3K_g}}-0{,}0023\right)2Y \qquad (23)$$

CONCLUSIONS

1. The dependence of the size of the element (flat mirror) on the size (diameter) of the focal spot for concentrating systems with parabolic and mosaic mirrors for the case of the flat shape of the focal zone has been revealed.
2. A method of calculating the dimensions of individual reflecting elements of a mosaic concentrator with a rigid parabolic surface has been developed.

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