Open Access Journal of Biomedical Engineering and Biosciences
DOI: 10.32474/OAJBEB.2019.03.000170
ISSN: 2637-4579
Mini Review

Method of geometrical involute for calculating of the optical parameters of conical concentrators

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Received: October 23, 2019 **Published:** October 29, 2019

Abstract

In this paper the features of using a geometrical involute method for calculating of the conical concentrators are discussed. The conditions for the passage of rays through the focon are analyzed. Working formulas are presented.

Keywords: Optics; reflection; light ray; path; multiple; conical; concentrator; focon; parabolic; incidence angle; parametric angle; critical angle; length; radius

Introduction

Among the optical elements used for the concentration of solar energy, focons are widely used. The simplest focus is an optical element with a cone-shaped reflective surface. Currently, methods for calculating optical fibers have been developed in sufficient detail [1,2] and can be successfully applied to the calculation of a certain type of solar collectors, namely for conical focons. Note that the main difference between the fiber and the focon is the great value of the parametric angle of the latter. In optical fibers, this angle is small. Let us consider the case of multiple reflection of rays in a conical focon (Figure 1).

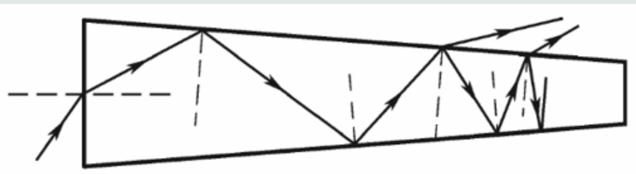

Figure 1: Multiple reflection of rays in the focus.

To calculate the optical parameters of the focon, it is convenient to use the geometric scanning method. In this case, it is convenient to consider the ray path in the scan of the focon (Figure 2). We introduce the following notation: R is the radius of the input end of the focon;

r is the radius of the output end of the focon;

γ is the parametric focal angle;

L is the length of the focon;

α is the angle of incidence of the beam into the focal area.

Consider the triangle AOW. We have

$$\sin\frac{\gamma}{2}=\frac{R}{AO},\ AO=\frac{R}{\sin\frac{\gamma}{2}}$$

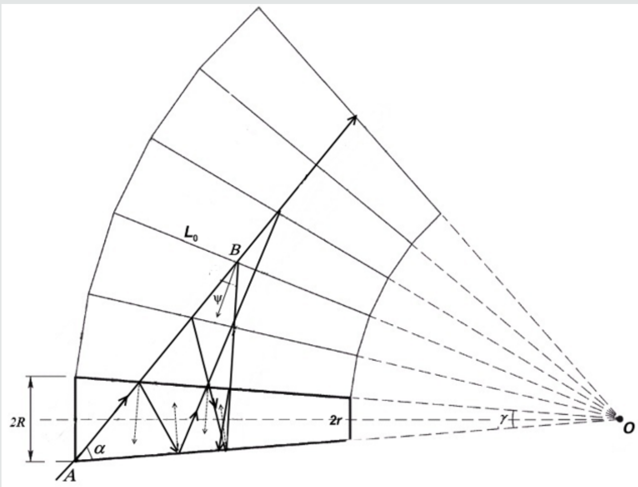

Figure 2: Geometric scan of focus.

According to the sine theorem

$$\frac{AO}{\sin(90+\psi)}=\frac{AO-L_0}{\sin\alpha}$$

The length of the focon, beginning with which the beam returns back, can be found from the condition that the angle of incidence ψ on the focon wall is zero, i.e. sin (90 + ψ) = 1. We have

$$AO = \frac{AO - L_0}{\sin\alpha} \Rightarrow \quad \frac{R}{\sin\frac{\gamma}{2}} = \frac{\frac{R}{\sin\frac{\gamma}{2}} - L_0}{\sin\alpha} \Rightarrow \quad R\sin\alpha = R - L_0\sin\frac{\gamma}{2}$$

From here

$$L_0 = \frac{R(1-\sin\alpha)}{\sin\frac{\gamma}{2}}$$

Knowing L0, we can determine r

$$\mathrm{tg}\,\gamma = \frac{R-r}{L_0}, \Rightarrow r = R - L_0\,\mathrm{tg}\,\gamma$$

A numerical analysis using the formulas obtained showed that the passage of rays through a focal glass with multiple reflections is possible only at small values of the parametric angle γ. This fact is the biggest drawback of the conical focus. For this reason, together with the conical focon, despite the difficulties of manufacture, parabolotoric focons are used [3,4].

In conclusion, we note that using the ratio of the areas of the input and output ends of the focus as an optical concentration coefficient is incorrect due to the presence of multiple reflections. To do this, use the following expression

$$C = \sum_i (\eta_i^+ R_s^i - \eta_i^- R_s^i)$$

Where Rs is the reflection coefficient, is the percentage of the number of reflection of rays (transmitted and non-transmitted rays), i is the multiplicity of reflections. In this case, the normalization condition must be observed. We also note that such concentrators were tested to increase the focal energy density in the Large Solar Furnace (LSF) in Parkent, Uzbekistan [5]

References

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DOI: 10.32474/OAJBEB.2019.03.000170