# AN ALGORITHM FOR THE SYNTHESIS OF THE FUNCTIONS GENERATOR CYLINDER MECHANISM

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**Abstract**

*The aim of this paper is to give an algorithm for the synthesis of the oscillating cylinder mechanism as a functions generator mechanism.*

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## 1. Introduction

We have to get the synthesis of the oscillating cylinder mechanism for three positions, given by the positioning angle of the driven rocker (3) and the driving piston of the cylinder (2). Given the coordinates of the piston (see Figure 1) in three different positions (by the distances $S_0$; $S_1 = S_0 + s_1$; $S_2 = S_0 + s_2$ and the corresponding positions of the rocker (3) by the angles $\varphi_0$, $\varphi_1 = \varphi_{10} + \varphi_0$ and $\varphi_2 = \varphi_{21} + \varphi_1$), we have to obtain the dimensions of the mechanism so as to ensure this correspondence. In other words, we want to find the set of values unknowns $\varphi_0$, $l_0$, $l_3$ or $s_0$, $l_0$, $l_3$ set.

## 2. Main Results

We can write (see Figure ) the relations:

$$S_0^2 = l_0^2 + l_3^2 - 2l_0 l_3 \cos\varphi_0 \tag{1}$$

$$(S_0 + s_1)^2 = l_0^2 + l_3^2 - 2l_0 l_3 \cos\varphi_1 \tag{2}$$

$$(S_0 + s_2)^2 = l_0^2 + l_3^2 - 2l_0 l_3 \cos\varphi_2 \tag{3}$$

By replacing $\varphi_1$ with $\varphi_0 + \varphi_{10}$ and $\varphi_2$ with $\varphi_0 + \varphi_{10} + \varphi_{21}$ and by subtracting the relation (1) from the relation (2) and the relation (3) respectively, we obtain the following relations:

$$s_1^2 + 2S_0 s_1 = 4l_0 l_3 \sin\left(\varphi_0 + \frac{\varphi_{10}}{2}\right)\sin\frac{\varphi_{10}}{2} \tag{4}$$

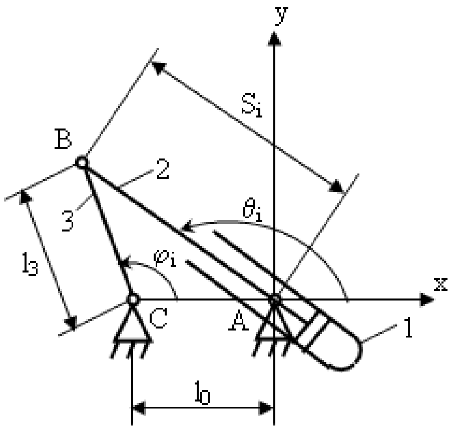


Figure 1. *Oscillating Cylinder Mechanism*

$$s_2^2 + 2S_0 s_2 = 4l_0 l_3 \sin\left(\varphi_0 + \frac{\varphi_{10}+\varphi_{21}}{2}\right)\sin\frac{\varphi_{10}+\varphi_{21}}{2} \tag{5}$$

By making the notations $A = s_1^2 + 2S_0 s_1$ and $B = s_2^2 + 2S_0 s_2$ and by dividing each side of the relations (4) and (5), we obtain the following relation:

$$\frac{A}{B} = \frac{\sin\varphi_0 \sin\varphi_{10} + 2\cos\varphi_0 \sin^2\left(\frac{\varphi_{10}}{2}\right)}{\sin\varphi_0 \sin\left(\varphi_{10}+\varphi_{21}\right) + 2\cos\varphi_0 \sin^2\left(\frac{\varphi_{10}+\varphi_{21}}{2}\right)} \tag{6}$$

We can rewrite the relation (6) in the following form:

$$C\sin\varphi_0 + D\cos\varphi_0 = 0 \tag{7}$$

where:

$$C = A\sin\left(\varphi_{10}+\varphi_{21}\right) - B\sin\varphi_{10} \tag{8}$$

$$D = 2\left(A\sin^2\left(\frac{\varphi_{10}+\varphi_{21}}{2}\right) - B\sin^2\frac{\varphi_{10}}{2}\right) \tag{9}$$

By making the notation $\alpha = \arctan\left(\frac{D}{C}\right)$, the equation (7) is equivalent with the equation:

$$\sin(\varphi_0 + \alpha) = 0 \tag{10}$$

which admits the following solutions ($\varphi_0 \in [0, \alpha]$):

$$\varphi_0 = -\alpha,\ for\ \alpha \le 0 \tag{11}$$

$$\varphi_0 = \pi - \alpha,\ for\ \alpha > 0 \tag{12}$$

In order to obtain the other two unknowns $l_0$ and $l_3$, we make the following notations:

$$S = l_0 + l_3 \tag{13}$$

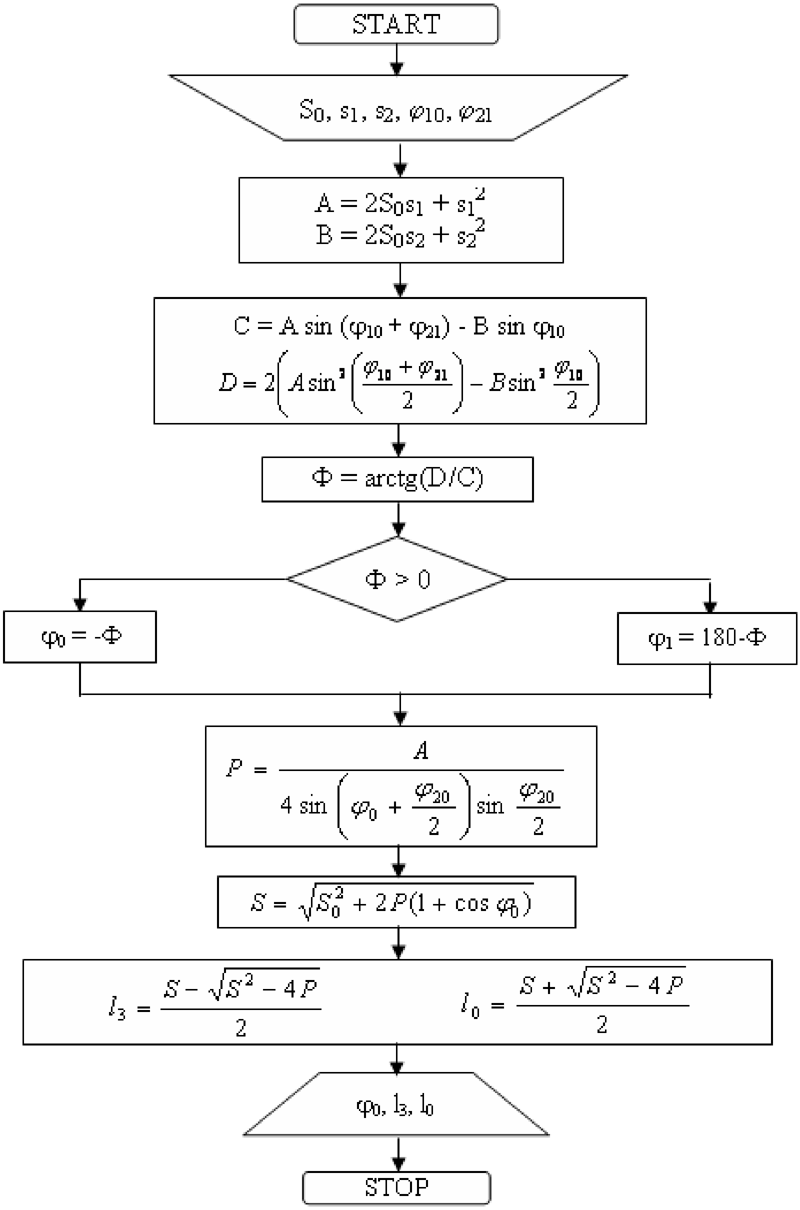


Figure 2. *The algorithm*

$$P = l_0 l_3 \tag{14}$$

and the relations (1) and (4) become:

$$S_0^2 = S^2 - 2P\left(1 + \cos\varphi_0\right) \tag{15}$$

$$A = 4P\sin\left(\varphi_0 + \frac{\varphi_{10}}{2}\right)\sin\frac{\varphi_{10}}{2} \tag{16}$$

By solving the system formed by the equations (15) and (16), we obtain the following solutions:

$$S = \sqrt{S_0^2 + \frac{A(1+\cos\varphi_0)}{2\sin\left(\varphi_0 + \frac{\varphi_{10}}{2}\right)\sin\frac{\varphi_{10}}{2}}} \tag{17}$$

$$P = \frac{A}{4\sin\left(\varphi_0 + \frac{\varphi_{20}}{2}\right)\sin\frac{\varphi_{20}}{2}} \tag{18}$$

where $\varphi_{20} = \varphi_{10} + \varphi_{21}$.
With the solutions (17) and (18) we build the second degree equation:

$$x^2 - Sx + P = 0 \tag{19}$$

which has the following roots:

$$x_1 = \frac{S + \sqrt{S^2 - 4P}}{2},\ x_2 = \frac{S - \sqrt{S^2 - 4P}}{2} \tag{20}$$

By comparing the solutions obtained from the equations (15) and (16) with the solutions obtained from the equations (1) and (4), we have obtained the following expressions for the unknowns $l_0$ and $l_3$:

$$(l_3 = x_1; l_0 = x_2) \text{ and } (l_3 = x_2; l_0 = x_1) \tag{21}$$

## 3. **Conclusion**

Based on the above considerations, the algorithm for the synthesis of the oscillating cylinder mechanism as a functions generator mechanism can be described as in figure 2.

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