

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.

Keywords: *mechanism synthesis, oscillating cylinder mechanism*

AMS Classification: 82-04, 93A30, 37N25

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 φ_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 φ_0 , l_0 , l_3 or s_0 , l_0 , l_3 set.

2. Main Results

We can write (see Figure) the relations:

$$S_0^2 = l_0^2 + l_3^2 - 2l_0l_3 \cos \varphi_0 \quad (1)$$

$$(S_0 + s_1)^2 = l_0^2 + l_3^2 - 2l_0l_3 \cos \varphi_1 \quad (2)$$

$$(S_0 + s_2)^2 = l_0^2 + l_3^2 - 2l_0l_3 \cos \varphi_2 \quad (3)$$

By replacing φ_1 with $\varphi_0 + \varphi_{10}$ and φ_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:

$$s_1^2 + 2S_0s_1 = 4l_0l_3 \sin \left(\varphi_0 + \frac{\varphi_{10}}{2} \right) \sin \frac{\varphi_{10}}{2} \quad (4)$$

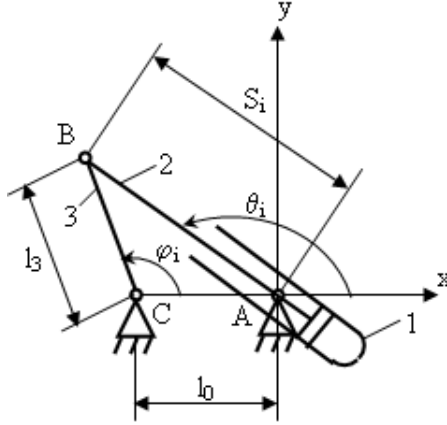


Figure 1. *Oscillating Cylinder Mechanism*

$$s_2^2 + 2S_0s_2 = 4l_0l_3 \sin\left(\varphi_0 + \frac{\varphi_{10} + \varphi_{21}}{2}\right) \sin \frac{\varphi_{10} + \varphi_{21}}{2} \quad (5)$$

By making the notations $A = s_1^2 + 2S_0s_1$ and $B = s_2^2 + 2S_0s_2$ and by dividing each side of the relations (4) and (5), we obtain the following relation:

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

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

$$C \sin \varphi_0 + D \cos \varphi_0 = 0 \quad (7)$$

where:

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

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

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

$$\sin(\varphi_0 + \alpha) = 0 \quad (10)$$

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

$$\varphi_0 = -\alpha, \text{ for } \alpha \leq 0 \quad (11)$$

$$\varphi_0 = \pi - \alpha, \text{ for } \alpha > 0 \quad (12)$$

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

$$S = l_0 + l_3 \quad (13)$$

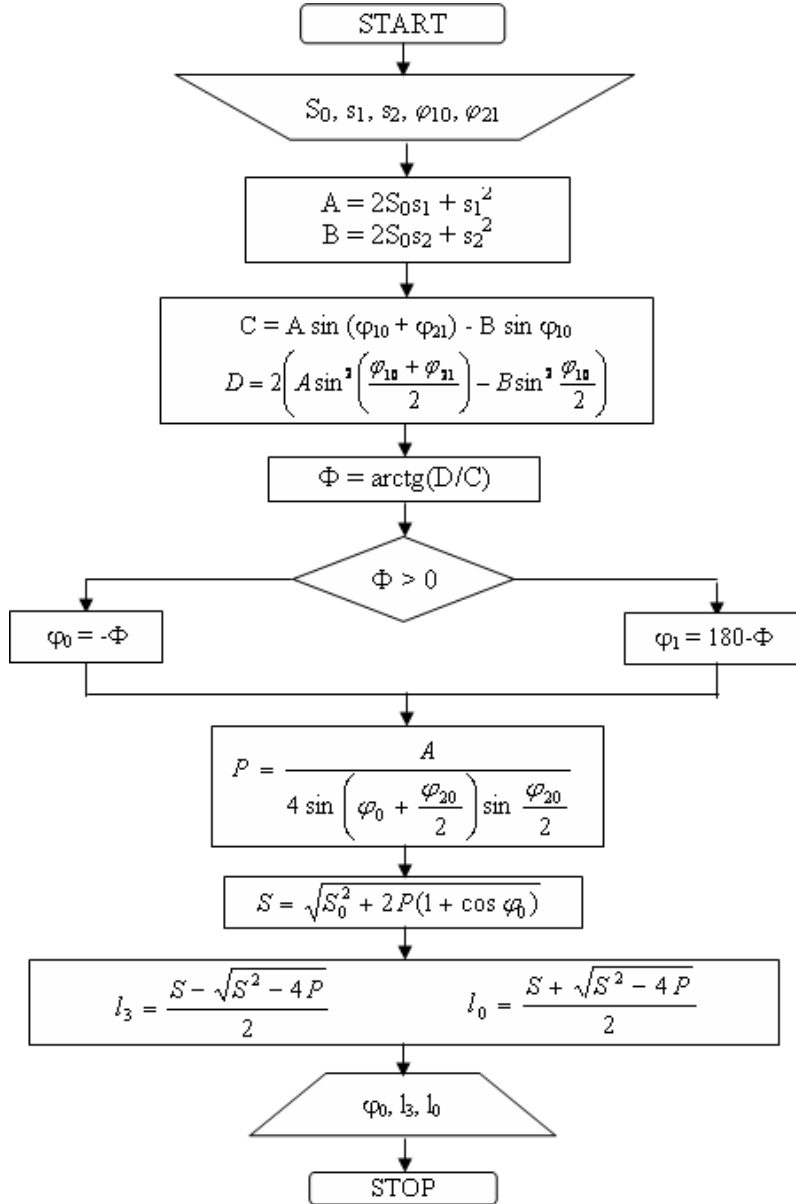


Figure 2. The algorithm

$$P = l_0 l_3 \quad (14)$$

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

$$S_0^2 = S^2 - 2P(1 + \cos \varphi_0) \quad (15)$$

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

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

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

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

where $\varphi_{20} = \varphi_{10} + \varphi_{21}$.

With the solutions (17) and (18) we build the second degree equation:

$$x^2 - Sx + P = 0 \quad (19)$$

which has the following roots:

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

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 :

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

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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