RESEARCH ARTICLE OPEN ACCESS

Kinematic Synthesis of Four Bar Mechanism using Function Generator

Nishant H.Patel*
* (Department of Mechanical engineering, Svbit, Vasan, Gandhinagar)

ABSTRACT
This article describes the detailed steps in the kinematic synthesis of a four bar Mechanism using Function Generator.
Keywords–synthesis, function generation

I. INTRODUCTION

If the dimensions of the mechanism are given, and we attempt to determine its motion characteristics, the process is called analysis. Synthesis is the inverse process. Given set of performance requirements .we attempt to proportion a mechanism to meet those specification. Synthesis is the procedure by which a product is developed to satisfy a set of performance requirements.

There are three customary tasks for kinematic synthesis: motion, path and function generation.

Motion generation or rigid body guidance

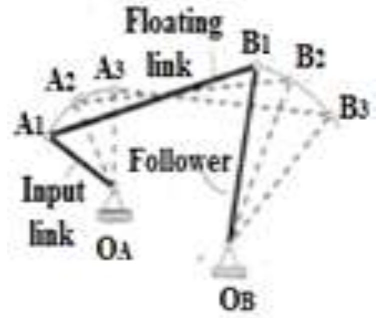
In motion generation (Fig. 1a) requires that an entire body be guided through a prescribed motion sequence. The body to be guided usually is a part of "floating link" (not directly connected to the fixed link). The corresponding input (driving) link motion may or may not be prescribed.

Path generation

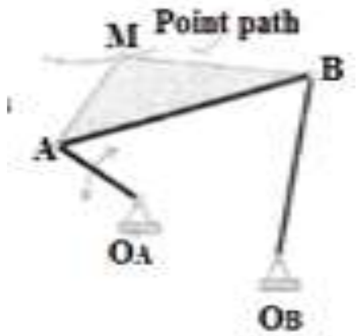
In path generation (Fig. 1b) a point of a floating link is to trace a part defined with respect to the fixed frame of reference. If the path points are to be correlated with either time or input link positions, the task is called path generation with prescribed timing.

Function generation

A frequent requirement in design is that of causing an output member to rotate, oscillate, or reciprocate according to a specified function of time or function of the input motion. This is called function generation. That is correlation of an input motion with an output motion in a linkage. A simple example is that of synthesizing a four-bar linkage to generate the function the function y=f(x). In this case, x would represent the motion (crank angle) of the input crank, and the linkage would be designed so that the motion (angle) of the output rocker would approximate the function y. (Fig. 1c) the motions of input and output (driven) link are correlated by the prescribed function. Since any real mechanism has a finite number of dimension parameters it is not possible in general to obtain a mathematical exact solution but that the mechanism match given function, path or body positions at only a finite number of positions called accuracy or precision points. Between these points generated (actual) function Φ(x) deviates from the given (prescribed) mathematical function F(x).



(a)



(b)

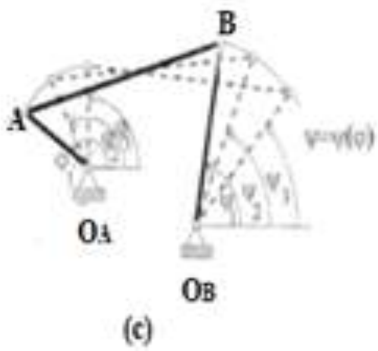


Fig.1 Kinematic synthesis

II. Parallelogram FUNCTIONGENERATORS WITH THREE ACCURACY POINTS

Consider a planar four-bar linkage (fig. 2). This linkage is characterized by having four revolute with parallel axes, the distances between successive axes being the parametersa_1, a_2, a_3 and a_4The synthesis of four-bar linkages, or means the determination of the four parameters that will yield an approximation to a desired function between the input and outputangles.

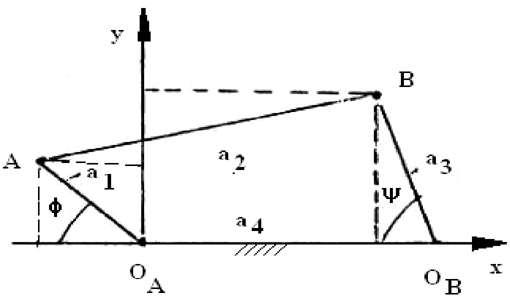


Fig.2 planar four-bar linkage

2.1 Solution for three precision points

Let the minimum and maximum values of independent variable x be called $x_i$andx_f. Our three precision points x_1, x_2, x_3 will fit between x_i andx_f. Chebyshev solution for N points is given by;

$$x_j = \frac{1}{2}(x_i + x_f) - \frac{1}{2}(x_f - x_i)\frac{\cos(2j-1)\pi}{6}, \text{ j=1, 2,3;}$$

2.2 Four-bar function generators with three accuracy points

The design of four-bar function generators, is considered here as an application of the three-accuracy-point synthesis.

The function y= x tan (θ) is to be generated in the interval 1<x<2 by means of a four-bar linkage OAABOB (fig. 3). The variables x and y are represented, respectively, by the crank and follower angles φ and ψ through the relations:

$$\frac{\phi-\phi_s}{\Delta\phi} = \frac{x-x_s}{\Delta x}\,\frac{\psi-\psi_s}{\Delta\psi} = \frac{y-y_s}{\Delta y}$$

Three accuracy points are taken in the interval 1<x<2 with Chebyshev spacing (fig. 4) whence the corresponding values of the variables x and y are:

x_1= 1.0669 y1 = 1.54
x_2=1.5 y2 = 2.19
x_3=1.933 y3 = 2.81

The ranges of variation of φ and ψ must be selected. They are chosen as $\Delta\theta = \Delta\phi =$ 124.4°.and $y_s = 1.46$ and $y_f = 2.92$.

$$\emptyset_2 - \phi_1 = \frac{x_2 - x_1}{\Delta x}\Delta\phi = 54.73°\psi_2 - \psi_1 = \frac{y_2 - y_1}{\Delta y}\Delta\psi = 55.38°$$

$$\emptyset_3 - \phi_1 = \frac{x_3 - x_1}{\Delta x}\Delta\phi = 108.2\ °\psi_3 - \psi_1 = \frac{y_3 - y_1}{\Delta y}\Delta\psi = 108.2°$$

With the present method, the angles $\phi_1$and, $\psi_1$crank and follower positions corresponding to the first accuracy point, must also be selected at the start. Choosing $\phi_1 = \psi_1 = 55.6°$.
$\emptyset_2 = 110.3\,°\psi_2 = 110.9°$
$\emptyset_3 = 163.8°$ $\psi_3 = 163.8°$

Finding the proper values of a1, a2, a3 and a4 for three related pairs (φ1, ψ1), (φ2, ψ2), and (φ3, ψ3). The procedure is based on the Freudenstein displacement equation.

$$k_1\cos\emptyset - k_2\cos\psi + k_3 = \cos(\phi - \psi) \tag{1}$$

Where,

$$k_1 = \frac{a_4}{a_3}$$

$$k_2 = \frac{a_4}{a_1}$$

$$k_3 = \frac{a_1{}^2 - a_2{}^2 + a_3{}^2 + a_4{}^2}{2a_1a_3} \tag{2}$$

This equation was deduced from Eq.(1) by rearranging the terms. When written for three pairs of values, (φ1, ψ1), (φ2, ψ2), (φ3, ψ3), this equation yields a system of three equations linear with respect to K1, K2, K3.

$$k_1\cos\emptyset_1 - k_2\cos\psi_1 + k_3 = \cos(\phi_1 - \psi_1)$$

$$k_1\cos\emptyset_2 - k_2\cos\psi_2 + k_3 = \cos(\phi_2 - \psi_2)$$

$$k_1\cos\emptyset_3 - k_2\cos\psi_3 + k_3 = \cos(\phi_3 - \psi_3)$$

Tedious third-order determinants may be avoided by first subtracting the second and third equations from the first, thus eliminating K3.

$$k_1(\cos\emptyset_1 - \cos\emptyset_2) - k_2(\cos\psi_1 - \cos\psi_2) = \cos(\phi_1 - \psi_1) - \cos(\phi_2 - \psi_2)$$

$$k_1(\cos\emptyset_1 - \cos\emptyset_3) - k_2(\cos\psi_1 - \cos\psi_3) = \cos(\phi_1 - \psi_1) - \cos(\phi_3 - \psi_3)$$

and solving the following resulting system of two equations with two unknowns,.

$$m_1 k_1 - m_2 k_2 = m_3$$
$$m_4 k_1 - m_5 k_2 = m_6$$

Thus

$$k_1 = \frac{m_2 m_6 - m_3 m_5}{m_2 m_4 - m_1 m_5} \quad (3)$$

$$k_2 = \frac{m_1 m_6 - m_3 m_4}{m_2 m_4 - m_1 m_5} \quad (4)$$

In which

$$m_1 = \cos\phi_1 - \cos\phi_2 = 0.91$$
$$m_2 = \cos\psi_1 - \cos\psi_2 = 0.92$$
$$m_3 = \cos(\phi_1 - \psi_1) - \cos(\phi_2 - \psi_2) = 0.01$$
$$m_4 = \cos\phi_1 - \cos\phi_3 = 1.52$$
$$m_5 = \cos\psi_1 - \cos\psi_3 = 1.52$$
$$m_6 = \cos(\phi_1 - \psi_1) - \cos(\phi_3 - \psi_3) = 0$$

Put this value in equation (3) and equation (4) we get $k_1 = -1$ or $k_2 = -1$.

Substituting values of K1 and K2 into one of the three original equations yields K3 as

$k_3 = \cos(\phi_i - \psi_i) - k_1\cos\phi_i + k_2\cos\psi_i$, i=1, 2 or 3

$k_3 = 1$.

Now put value of k_1, k_2 or k_3 in equation (2),

$$k_1 = \frac{a_4}{a_3}$$

$$-1 = \frac{a_4}{a_3} a_3 = -a_4 \quad (5)$$

$$k_2 = \frac{a_4}{a_1}$$

$$-1 = \frac{a_4}{a_1}$$

$$a_1 = -a_4 \quad (6)$$

$$k_3 = \frac{a_1^2 - a_2^2 + a_3^2 + a_4^2}{2a_1 a_3}$$

$$a_2 = a_4 \quad (7)$$

III. CONCLUSION

In conclusion, we performed synthesis of four-bar mechanism. From synthesis of four bar mechanism using function generators we conclude that this planar four bar mechanismare parallelogram.

REFERENCES

[1] Hartenberg, R., Denavit, J., Kinematic synthesis of Linkages, McGraw Hill Book Company.