Simulation of Four Bar Mechanism For Path Generation

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Abstract—Design process of a mechanism involves synthesis so as to understand the movements of the respective links. It is further necessary to check whether the proposed mechanism is providing the required function generation for the given input. A four bar rigid link mechanism is simulated using the software CATIA V5 R19. Three different combinations are considered in order to estimate the resulting output. In case of equal link length of coupler and rocker output is observed to be equal to the input displacement. This type of mechanism is useful for a parallel motion transfer. The constraints defined in the CATIA and the simulation tool provides a means to check the motion and path generation. This information is useful in design of a parallel jointless miniature mechanism.

Keywords—four bar mechanism, synthesis, mobility analysis, simulation

I. INTRODUCTION

This research is on 4-bar Mechanisms for path generation and mobility analysis. In the mechanism, function generation, path generation and analysis are important. Hence, this research is focused on the simulation of a four bar mechanism in order to assess its suitability for typical micromechanism applications. It gives an in depth knowledge about the desired motion given by the mechanism.

This simulation is very useful for the concept of analytical modeling and the analysis of a miniature mechanism.

II. LITERATURE SURVEY

Alejandro E. Albanesi considered rigid links for the synthesis and used FEM formulation for understanding the behavior of compliant mechanism. Talekar used ADAMS for the simulation of four bar mechanism. CHAO Dai-hong [3] used Pro-Engineer and ANSYS for simulation. Tzong-Mou Wu [4] used Visual basic program to analyze and simulate the four bar mechanism. Alejandro E. Albanesi et. al [1] explained about mechanisms design. One of the more common tasks in kinematic synthesis is motion generation (rigid body guidance), where a rigid body is moved through specified motion. This approach of considering rigid links is used in the present research.

Nitin B. Talekar [2], in a report on ADAMS software which stressed on the use of ADAMS, which stressed on the use of ADAMS mentioned that Function generation is a branch of kinematic synthesis where a given relationship between the input and the output angular motion is required. CHAO Dai-hong [3] et. al. in their paper mentions the use of different softwares for simulations. The simulation calculations are of nonlinear type based on FEM. Pro-Engineer 2001 and ANSYS 8.1 softwares are used to perform all simulations on a CPU 2.8 GHz processor. Similar to Pro-Engineer 2001, but more user friendly CATIA V5R19 can be used for the simulations. Tzong-Mou Wu [4] in his research presented an automated design program for planar four-link mechanism.

Hence it became necessary to synthesize and analyze a four bar mechanism so as to facilitate the further design of a miniature four bar mechanism. The first step in the design is to check the desired function and path generation.

III. PLANAR MECHANISMS

A mechanism composed of rigid bodies and lower pairs is called a linkage. In planar mechanisms, there are only two kinds of lower pair’s i.e. revolute pairs and prismatic pairs. The simplest closed loop linkage is the four bar linkage which has four members, three moving links, one fixed link and four pin joints. As previously stated linkage that has at least one fixed link is called as Mechanism.

A. Functions of Linkages

The function of a link mechanism is to produce rotating, oscillating, or reciprocating motion from the rotation of a crank or vice versa. Stated more specifically linkages may be used to convert:

- Continuous rotation into continuous rotation, with a constant or variable angular velocity ratio.
- Continuous rotation into oscillation or reciprocation (or the reverse), with a constant or variable velocity ratio.
- Oscillation into oscillation, or reciprocation into reciprocation, with a constant or variable velocity ratio.
Linkages have many different functions, which can be classified according to the primary goal of the mechanism.

- Function generation: the relative motion between the links connected to the frame.
- Path generation: the path of a tracer point.
- Motion generation: the motion of the coupler link

B. Four bar Mechanism

One of the simplest examples of a constrained linkage is the four link mechanism. A variety of useful mechanisms can be formed from a four link mechanism through slight variations, such as changing the character of the pairs, proportions of links, etc. Furthermore, many complex link mechanisms are combinations of two or more such mechanisms. In the range of planar mechanisms, the simplest group of lower pair mechanisms is four bar linkages. A four bar linkage comprises four bar shaped links and four turning pairs as shown in Figure 1.

![Fig. 1 Four bar Linkage](image)

The link opposite the frame is called the coupler link, and the links which are hinged to the frame are called side links or lever. A side link which revolves relative to the frame is called as crank whereas the one which does not revolve is called as rocker.

IV. MOBILITY OF RIGID LINK FOUR BAR MECHANISM

Various combinations of rigid link Four bar Mechanisms as shown in Figure 2 are analyzed by simulation for the mobility and the path being traced so as to select suitable combination for the further analysis.

![Fig. 2 Various combinations](image)

A. Path Tracing Simulation

Combination 1: First combination of the linkages for a Four bar Mechanism is as shown in Figure 2 (a). The simulation is carried out and it is shows in Figure 3.3, initial and final positions are also shown in Figure 3.3 (a and b) respectively. The dimensions of links are \( ab = 34.5 \) mm, \( bc = 95 \) mm and link \( cd = 54.5 \) mm. Link ad is kept constant (\( ad = 90 \) mm) for all the combinations.

![Path 1](image)

(a) Initial Position
It is observed that input link ‘ab’ traces a curved path and output link ‘bc’ also traces a curved path but amplification in the displacement is observed. This combination is not suitable for the parallel motion transfer.

**Combination 2:** Second combination of the linkages for a Four bar Mechanism is as shown in Figure 3.2(b). The simulation is carried out and it is shown in Figure 3.3, initial and final positions are also shown in Figure 3.4 (a and b) respectively. The dimensions of links are ab = 44.5, bc = 90 mm and link cd = 44.5 mm. It is observed that input link ‘ab’ traces a curved path and output link ‘bc’ also traces a curved path but no amplification in the displacement is observed.

Combination 3: Third combination of the linkages for a Four bar Mechanism is as shown in Figure 3.2 (c). The simulation is carried out and it is shown in Figure 3.5, initial and final positions are also shown in Figure 3.5 (a and b) respectively. The dimensions of links are ab = 54.5 mm, bc = 95 mm and link cd = 34.5 mm.
The phenomenon exhibited by simulation for mobility is verified using analytical method i.e. Grashof’s theorem and it is discussed in following section.

V. MECHANISM MOBILITY ANALYSIS BY GRASHOF’S THEOREM

In analytical method of assessing mobility of four bar linkages, some basic nomenclature is required. The line segment between hinges on a given link is referred as a bar where:

- \( s \) = length of shortest bar
- \( l \) = length of longest bar
- \( p, q \) = lengths of intermediate bar

Mobility is assessed using Grashof’s theorem which mentions that a Four bar Mechanism has at least one revolving link if

\[ s + l \leq p + q \]

Using the link lengths \( ab = s = 45 \text{ mm}, bc = l = 90 \text{ mm}, ad = p = 90 \text{ mm} \) and \( cd = q = 45 \text{ mm} \).

For a typical mechanism under study and applying Grashof’s theorem

\[ 45 + 90 = 90 + 45 \]

As the Grashof’s criteria are satisfied the simulation results of mobility of selected combination are validated.

VI. CONCLUSION

In the analysis of a four bar mechanism of various combinations, it is observed that the path traced by the link of mechanism of combination 2 (where input link-crank and the output link-rocker) are equal replicates the path.

It is essentially required in case of micromechanisms. Simulation using software is useful in tracing the path of various combinations of the mechanisms as well as it provides a means to investigate the effect of varying the link length on the path being traced. The combination 2 is a promising combination in the development of a four bar micromechanism. Next phase of this research work is to develop a joint less four bar mechanism which is useful in the development of microfactories.

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REFERENCES


