International Journal of Advanced Mechanical Engineering.
ISSN 2250-3234 Volume 4, Number 3 (2014), pp. 263-268

http://www.ripublication.com/ijame.htm

Synthesis and Analysis of Adjustable Planar Four-bar Mechanism

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Abstract

Adjustable mechanisms are capable of generating multiple paths with a change in one or more mechanism parameters and with essentially the same hardware. Little work has been done in the area of synthesis of adjustable linkages for continuous path generation, especially of adjustable planar four bar linkages. The path flexibility of adjustable four-bar linkage is analyzed. The limitation for four-bar linkages to generate continuous paths is that the desired continuous path can only be generated approximately. This limitation can be overcome by using adjustable four-bar linkages. Conventional linkage mechanisms provide high speed capability at a low cost, but fail to provide the flexibility required in many industrial applications. On the other hand, for most manufacturing automation applications, expensive multi-axis robots are employed for simple repetitive operations that require only limited flexibility. In order to provide an optimum solution between conventional mechanism-based automation and overly flexible robots, adjustable mechanisms were introduced. The changeable parameter can either be length of one or more links or a change in the position of a fixed pivot. Adopting adjustable mechanisms we can generate different paths accurately using a single four bar mechanism and reduce structural errors. Synthesis of mechanism is performed for different angles. Length of different links is adjusted to obtain different paths accurately and various paths are generated. Verification of adjustment of links, paths traced and force analysis is carried out on MSC ADAMS 2012.

Keywords: Synthesis of Mechanism, MSC ADAMS 2012, Different paths generated, Structural errors, Force Analysis.

1. Introduction
Mechanisms represent the skeleton of machinery.Classical mechanism synthesis techniques lead to mechanisms satisfying some kinematic requirements such as stroke, time ratio, specific link positions, specific function generation etc. A mechanism synthesis technique ranges from simple graphical techniques going through analytical approaches with many assumptions and trials to sophisticated techniques using optimization application [1]. Four-bar linkages can be used for path generation. There are two types of path generation problems namely, point-to-point path generation and continuous path generation. One is to specify a small numberof precision points on the path. The trajectory between any two precision points is not strictly required. This type of path generation is called point-to-point path generation [2, 3]. The typical applications include pick-and-place. In the case of a planar four-bar mechanism, there are at most nine parameters and one Boolean value which defines the mode of the linkage assembly and in point-to-point path generation the coupler point can be made to pass exactly through at most nine prescribed precision points. In continuous path generation the path is specified by a large number of points (more than nine) and the coupler point may or may not pass through all of them exactly. The continuous path generation problem is solved as an optimization problem, and one can obtain the four-bar mechanism parameters which minimize a desired objective function.

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. A simple example is that synthesizing a four-bar linkage to generate the function $y=f(x)$. In this case, x would represent the motion (crank angle) of the input crank, and linkage would be designed so that the motion (angle) of the output rocker would approximate the function y. A second type of synthesis is called path generation. This refers to a problem in which a coupler point is to generate a path having a prescribed shape. Common requirements are that a portion of the path be a circular arc, elliptical or a straight line. Sometimes it is required that the path cross over itself, as in a figure-of-eight. The third general class of synthesis problems is called body guidance. Here we are interested in moving an object from one position to another. The problem may call for a simple translation or a combination of translation and rotation. In the construction industry, for example, heavy parts such as scoops and bulldozer blades must be moved through a series of prescribed positions [4].

The paper is organized as follows: In Section 2, we define all the variables associated with an adjustable planar four-bar mechanism. In Section 3, formulation for tracing various paths by adjusting any of the independent parameter, in section 4we validate the results using dynamic simulation software (MSC ADAMS 2012) and in Section 5, we present the conclusion.

2. Adjustable Planar Four-bar Mechanism

Fig. 1shows the proposed adjustable four-bar linkage. When crank L_2 rotates through a full revolution, coupler point M generates the desired continuous path. Slider is used to adjust the location of pivot of link L_4. If slider is fixed, $L_1L_2L_3L_4$is a regular four-bar linkage and the desired continuous path can only be generated approximately. To generate the desired continuous path precisely, the location of pivot of link L_4 needs to be adjusted continuously.

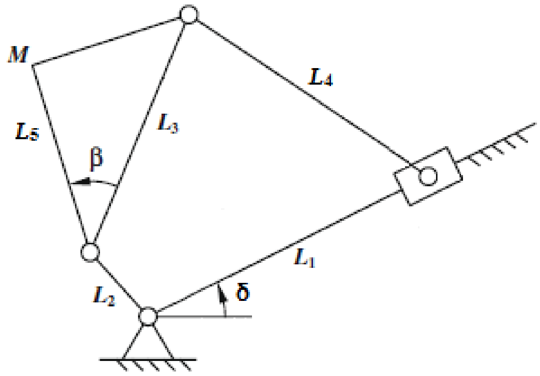


Fig. 1: Schematic of Adjustable slider mechanism.

The slider comes in use when we have to trace rectangular path so that the distance between the pivots is adjusted continuously so as to acquire the corner points precisely. These points can be termed to be precision points, thus the approximations in tracing the rectangular path may be reduced or eliminated. In order to get the precisions points the structural error has to be reduced so as to obtain optimal solution [5].

3. Formulations for Tracing Various Paths

Synthesis of a function generator, say, using the overlay method, is the easiest and quickest of all methods to use. It is not always possible to obtain a solution, and sometimes the accuracy is rather poor. Theoretically, however, one can employ as many precision positions as are desired in the process.

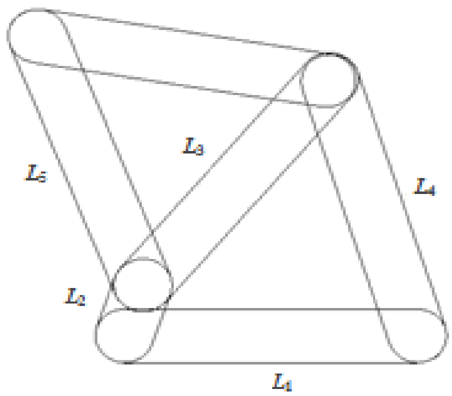


Fig. 2: Adjustable four-bar mechanism generated using MSC ADMAS (2012).

The procedure to be followed for overlays method is stated as follows. Using overlays method we achieve the approximate solutions for tracing various paths. Trial and error method can be used in order to obtain changes in size and parameters of various paths to be traced. The formulations for various paths are as follows:

3.1 Ellipse
Ellipse can be obtained by changing the length of the crank (i.e. L_2) and keeping the angle "β" fixed to 180˚. Thus keeping $L_1=L_3=L_4=L_5=2$units & varying the length L_2 from 0.4units - 2 units.The variation of link L_2 leads to change in the size of ellipse.

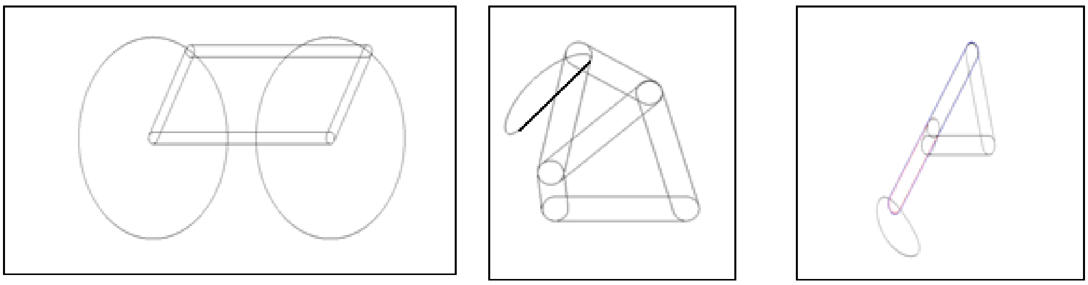
3.2 Circle
Simple coupler mechanism used in train can be used for tracing circular path. In which the opposites links are parallel and also $L_1=L_3$, $L_2=L_4$.

3.3 Infinity Path
It can be obtained by changing the length of the crank angle "β". Thus keeping $L_1=L_3=L_4=L_5=2$units & keeping the length $L_2=0.7$units.

3.4 Straight Line
The Chebyshev linkage is a mechanical linkage that converts rotational motion to approximate straight-line motion. For which $L_1:L_2:L_3=4:5:2$ and $L_4=L_3+ \sqrt{[(L_2)^2-(L_1)^2]}$.

3.5 Inclined Line
It can be obtained by changing length of the crank from 0.6 units - 1 unit, and changing L_5 from 12 units - 14 units.

4. Analysis and Validation Using MSC Adams 2012
ADAMS/View is a powerful modeling and simulation environment. It enables you to design, visualize, and improve your mechanical system model prior to building a physical prototype.



(a) (b) (c)

Fig. 3: Paths traced using MSC ADAMS (2012); circle (a), inclined line (b), ellipse (c).

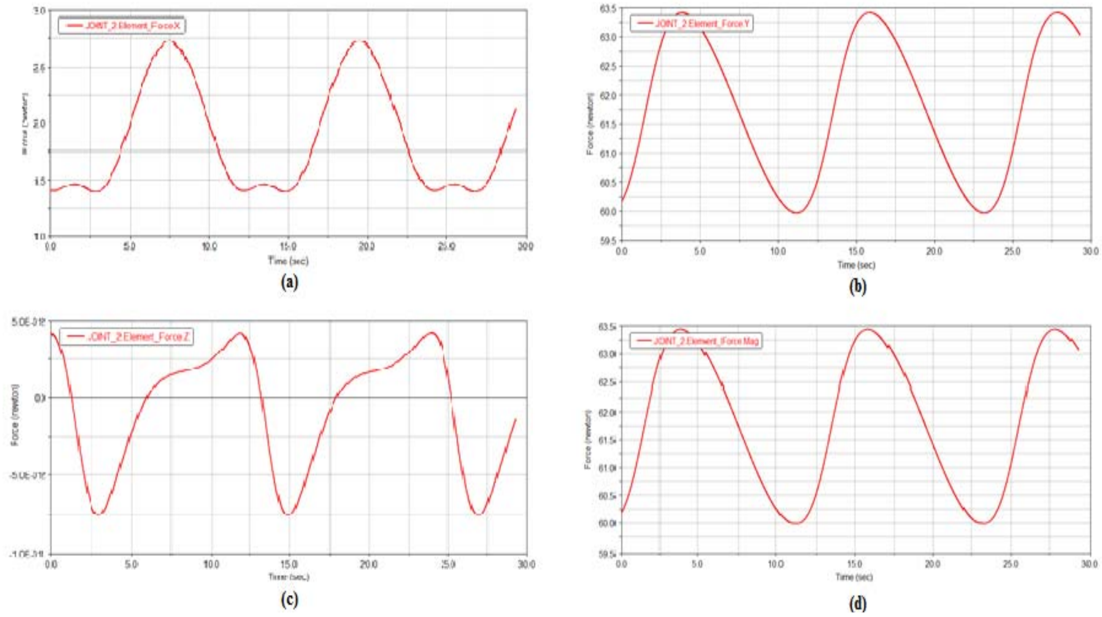


Fig. 4: Force analysis of elliptical path on joint 2 using MSC ADAMS 2012;
X-axis (a), Y-axis (b),Z-axis (c),Resultant magnitude (d).

5. Conclusion

This paper presents the various adjustments which can be done in the mechanism in order to trace various paths, the paths are traced approximately and in order to trace the exact paths, the structural errors has to be reduced by optimal synthesis of the mechanism. The desired continuous paths can be generated precisely by adjustable four-bar linkages with the continuous adjustment of one independent parameter, mainly slider can be used as the independent parameter in order to obtain the precise paths and acquire the corner points as in case of rectangular path generation.

6. Acknowledgements

We would like to express our special thanks of gratitude to our project guide Prof P.P Patunkar as well as our external guide Prof S.S. Hatawalane who gave us the golden opportunity to do this wonderful project.

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