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Analysis of Four Bar Link Mechanism

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A B S T R A C T

A four bar mechanism consists mainly of four planar links connected with four revolute joints. Straight line motion from a four bar linkages has been used in several ways as in a dwell mechanism and as a linkage to vehicle suspension. This paper studies the straight line motion obtained from planar four-bar mechanisms and Its classification according to grashof's equation and optimizes the design to produce the maximized straight line portion of the coupler point curve. The input is usually given as rotary motion of a link and output can be obtained from the motion of another link or a coupler point. The equations of motion for four different four-bar mechanisms will be derived and dimensional requirements for these mechanisms will be obtained in order to produce the straight line motion. Mechanisms are means of power transmission as well as motion transformers.

Keywords: Power Transmission ,Transformer ,Planar Link, Dwell Mechanism, Suspension.

1. INTRODUCTION

A machine is usually driven by a motor which supplies constant speed and power. A typical problem in mechanism design is coordinating the input and output motions. It is the mechanism which transforms this applied motion into the form demanded to perform the required task. It is a device that transforms one motion, for example the rotation of a driving shaft, into another such as the rotation of the output shaft or the oscillation of a rocker arm. The fourth link is called level or rocker ,if it oscillate or crank, if it rotate. With the tremendous advantages made in the design of instruments, automatic controls, and automated equipment, the study of mechanisms takes on new significance. One of the widely use mechanism is four bar link mechanism, it is most fundamental of plain kinematic chains. When one of the link is fixed it is called linkage or mechanism. A mechanism is the heart of a machine. It can also give desired out put motion according to type, position respective to used link in four bar link mechanism. A mechanism designed to produce a specified output as a function of input is called a function generator. Four bar link mechanism is also called four bar chain mechanism. A link opposite to fixed link is called coupler. A system that transmits forces in a predetermined manner to accomplish specific work may be considered a machine. Basically it consist of four rigid link which are connected in form of quadrilateral by four pin joint. A mechanism consists of a series of connected moving parts which provide the specific motions and forces to do the work for which the machine is designed. A link, which make complete revolution is called crank. Four bar chain mechanism is a much preferred mechanical device for the mechanization and control of motion due to its simplicity and versatility. The study of mechanisms is very important. Development One of the main objects of designing a mechanism is to develop a system that transforms motion in a specific way to provide mechanical advantage.

The history of kinematics, the story of the development of the geometry of motion, is composed of evolvement in machines, mechanisms and mathematics. The recent investigation of mechanism design by mathematicians and engineers have been stimulated in part by the increase in operating speeds of machines and in part by the expectation of evolving more logical approaches to the development of mechanisms.

Franz Reuleaux was the first scientist who systematically analyzed mechanisms, deviced machine elements, studied their combinations, and discovered those laws of operation which constituted the early science of machine kinematics. His now classical "Theoretische Kinematik " of 1875 presented many views finding general acceptance then that are current still and his second book, " Lehrbuch der Kinematic" (1900), consolidated and extended earlier notions. Reuleaux's comprehensive and orderly views mark a high point in the development of kinematics. He devoted most of his work to the analysis of machine elements.

In the one hundred years that followed Reuleaux, the contributions of such scientists as W. Hartmann, H. Alt, F. Wittenbauer and L Burmester developed the science of constructing mechanisms to satisfy specific motions, namely, kinematic synthesis. The techniques they used were based on mechanics and geometry.

It was not until 1940 that Svaboda developed numerical methods to design a simple but versatile mechanism known as four-bar linkage (Fig. 1.1) to generate a desired function with sufficient accuracy for engineering purposes. The input crank is OaA and the output crank is OgB. The scale to input crank indicates the values of the parameter of a function, and that on the output crank indicates the result of the function. Naturally, this four-bar linkage can generate only a limited number of functions because of the nature of the linkage itself. In 1951, the publication by Hrones and Nelson of an "atlas" containing approximately 10,000 coupler curves offered a very practical approach for the design engineers. The Kinematics of mechanisms has gradually become a popular field for scholarly and engineering investigation.

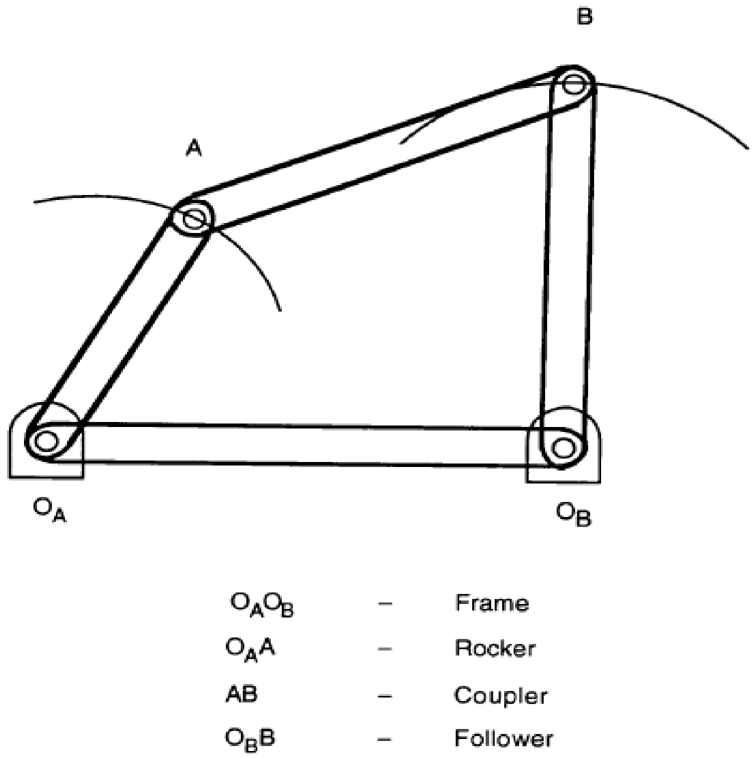

Fig1.1 Four bar link mechanism

2. FOUR BAR LINK MECHANISM

A four-bar linkage is a versatile mechanism that is widely used in machines to transmit motion or to provide mechanical advantage. Four-bar linkages can also be used as function generators. Their low friction, higher capacity to carry load, ease of manufacturing, and reliability of performance in spite of manufacturing tolerances make them preferable over other mechanisms in certain applications. It is also the most fundamental linkage mechanism, and many more complex mechanisms contain the four-bar linkage as elements. Therefore, a basic understanding of its characteristics is essential.

A four-bar mechanism (Figure 1.2) consists of four rigid members: the frame or fixed member, to which pivoted the crank and follower, whose intermediary is aptly termed coupler. These members are connected by four revolute pairs.

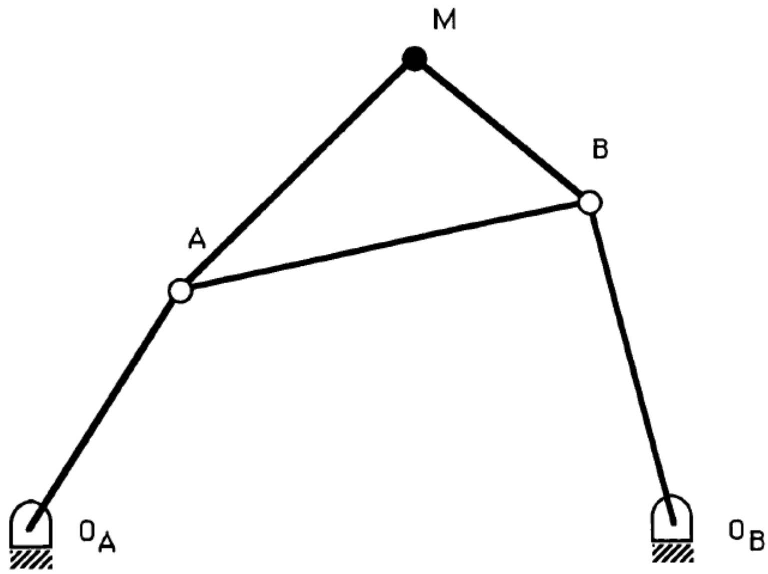

Fig.3.1 Four bar link mechanism

A point on the coupler is called the coupler point, and its path when the crank is rotated is known as a coupler point curve or coupler curve and the number of such curves are infinite. By proper choice of link proportions and coupler point locations useful curves may be found. A curve's usefulness depends on the particular shape of a segment, for example, an approximate straight line or a circular arc, or on a peculiar shape of either the whole curve or parts of it. The coupler point because of its motion characteristic, is now the output of the linkage.

2.1 Component of Mechanism

- **Link :-** A link is one of the rigid bodies or members joined together. The term rigid link or sometimes simply link is an idealization used in the study of mechanisms that does not consider small deflections due to strains in machine members.
- **Frame :-** The fixed or stationary link in a mechanism is called the frame. When there is no link that is actually fixed, one link may be considered as being fixed and determine the motion of the other links relative to it.
- **Joint or Kinematic pair :-** The connections between links that permit relative motion are called joints. An unconstrained rigid body has a mobility of six degrees of freedom. Each joint reduces the mobility of a system.
- **Lower and higher pair :-** Connections between rigid bodies can be categorized as lower and higher pairs of elements. The two elements of a lower pair have theoretical surface contact with one another, while the two elements in the higher pair have theoretical point or line contact (if we disregard deflections).
- **Kinematic chains :-** A kinematic chain is an assembly of links and joints. In a closed kinematic chain, a link is connected to two or more other links.
- **Mechanism :-.** A mechanism is a kinematic chain in which one link is considered fixed but motion is possible in other links. As noted above, the link design as the fixed link need not actually be stationary relative to the surface of the earth kinematic chain is usually identified as a mechanism if its primary purpose is to modification or transmission of motion.
- **Linkage :-** If kinematic chains are needed to be examined without regard to its ultimate used as assemblage of rigid bodies connected by kinematic joints of lower pairs are identified as a linkage.

3. ANALYSIS OF PROPOSED WORK

When mechanisms are analyzed both graphical and analytical methods can be useful. When position of a point or set of points are to be determined for a single linkage position, graphical methods are usually more convenient. Analytical methods are more practical when a sequence of positions of a mechanism must be analyzed. The use of a computer permits a detailed study of a full cycle of motion. Once the initial programming is completed, little effort is required to examine the effect of design changes. On the other hand, if we were to use graphical methods, each linkage position would require a separate plot and each change in length of a link would require a new sequence of plots. This chapter deals with the analytical method of determining the positions of the links relative to one another. Methods of vector analysis are important tools, which could be used for mechanism analysis and synthesis.

Vectors provide graphical and analytical means to represent motion. A quantity described by its magnitude and direction can be considered a vector and can be graphically represented by an arrow. In general, a vector of unit magnitude can be called a unit vector. Thus, A^ = A / A is a unit vector in the direction of A, where A = IAI is the magnitude of vector A. A coordinate system in which the axes are mutually perpendicular is called a rectangular coordinate system. Unit vectors i, j, k parallel to the x, y, z coordinate axes, respectively, are particularly useful, since we are going to use only rectangular coordinate system throughout this work. These unit vectors are also called rectangular unit vectors. A vector may be described in terms of its components along each coordinate axis.

When we use vectors to describe the motion of a linkage, it is advisable to make a sketch of the linkage adjacent to vector diagrams so that vector directions can be referred to linkage orientation

3.1 Solution of Planar Vector Equations

Consider the planar vector equation,

A+B+C=0,

or in terms of unit vectors (A^u etc.) and magnitudes (A etc.),

$A^U{}_A + B^U{}_B + C^U{}_C = 0$

If the magnitude and direction of the same vector are unknown, then the solution is easily obtained. If C is unknown, we use

$$C = -(A_X + B_X)\,i - (A_Y + B_Y)\,j \;\; or$$

$$C = -(A\,.\,i + B\,.\,i)\,i - (A\,.\,j + B\,.\,j)\,j$$

If the magnitudes of two different vectors are unknown, a vector elimination method may be used. Suppose, for example, magnitudes A = I A I and B = I B I are unknown in the vector equation $A^U{}_A + B^U{}_B + C^U{}_C = 0$. We take the dot product of each term with $B^U \times k$ noting that $B^U \cdot (B^U \times k) = 0$ since vector B^U is perpendicular to vector $B^U \times k$. Thus, we obtain

$$A^U A.(B^U \times k) + C - (B^U \times k) = 0$$

from which the magnitude of vector A is given by,

$$A = \frac{-C.(B^U \times k)}{A^U.\times (B^U \times k)} \ldots\ldots\ldots\ldots\ldots (4.1)$$

Similarly, the magnitude of B is given by,

$$B = \frac{-C.(A^U \times k)}{B^U.\times (A^U \times k)} \ldots\ldots\ldots\ldots\ldots (4.2)$$

If the vector directions Au and Bu are unknown but all vector magnitudes are known, the solution to the equation A + B + C = 0 is more difficult,

$$A = \pm\{B^2 - [(C^2 + B^2 - A^2)/2C]^2\}^{\frac{1}{2}}\,(C^U X k)$$

$$+\{[(C^2 + B^2 - A^2)/2C] - C\}\,C^U \ldots\ldots\ldots\ldots (4.3)$$

And ,

$$B = \pm\{B^2 - [(C^2 + B^2 - A^2)/2C]^2\}^{\frac{1}{2}}\,(C^U X k)$$

$$+[(C^2 + B^2 - A^2)/2C]\;C^U \ldots\ldots\ldots\ldots\ldots (4.4)$$

When the magnitude of A and the direction of B are unknown, A and B may be found by the following equations:

$$A = \left\{-C.A^U \pm \sqrt{B^2 - [C.(A^U \times k)]^2}\right\} A^U \ldots\ldots\ldots\ldots\ldots (4.5)$$

$$A = \left\{-[C.(A^U \times k)](A^U \times k) \pm \sqrt{B^2 - [C.(A^U \times k)]^2}\right\} A^U \ldots\ldots\ldots (4.6)$$

The above approach uses vector notation throughout, unlike alternate methods that use vector analysis to derive scalar equations. When the above method is used for computer-aided analysis and design of mechanisms, computer subroutines will be incorporated to handle the conversion from vector to scalars. The above equation will be applied to the analysis of planar linkages.

4.2 Graphical Representation of Basic The Four Bar Link

A graphical layout of a four bar linkage can be easily constructed. We only require to know the position of one link be given in relative to the frame and the link lengths. One such layout for the simplest four bar mechanism is given. Analytical formulas are to be developed to determine all the link positions needed to write a computer program.

The following analysis provides an analytical solution for a simple mechanism shown as vector notations and this can be modified to suit the different kinds of four bar mechanisms in the later parts of this chapter. Note that there are two different modes of assembly possible for a non-Grashof mechanism.

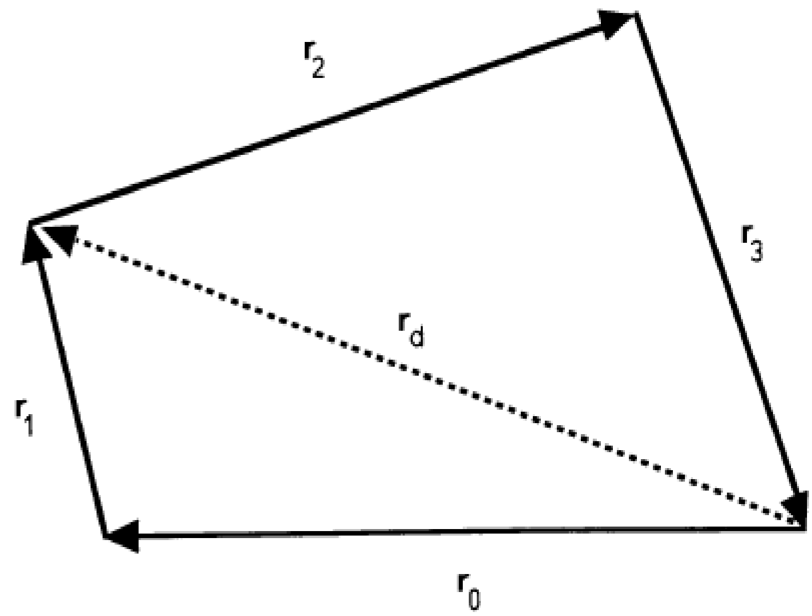

Fig.3.1 Vector Representation of A Planar Four Bar Link

4. Conclusion

We have studied mechanism origin and basic four bar link mechanism in brief and how they are originated and have various applications due to their simplicity and versatility. In this work, mechanisms and in particular four bar linkages have been studied and their components and classifications according to “Grashof” have been discussed. Four special four-linkages that are capable of producing a straight line output are introduced and their mobility in short. Position analyses of all the links in a four-bar mechanism have been done using vector algebra and based on this, separate algorithms to numerically generate the basic mobility have been arrived at computer codes and the plots thus obtained.

REFERENCES

Arun K. Natesan “Kinematic analysis and synthesis of four-bar mechanisms”

A. Pankaj Aswal, B. Rajkumar Singh, C. Rohit kumar, D. Avinash Bhatt, E. Tej Raj “Resovling the four bar mechanism”

L. Roy, A. Sen, R. P. Chetia and M. J. Borah, “Analysis and Synthesis of Fourbar Mechanism”

Joshua K. Pickard, Juan Carretero, Jean-Pierre Merlet,. “Appropriate analysis of the four-bar linkage”

A. M. Vaidya and P. M. Padole, “A Performance Evaluation of Four Bar Mechanism Considering Flexibility of Links and Joints Stiffness

Hartenberg, R. S. and J. Denavit, Kinematic Synthesis of Linkages. New York. McGraw-Hill Book Company, 1964.