Kinematic Analysis of Quick Return Mechanism: A Review

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Abstract :
To study the motion of a Quick Return mechanism, knowledge of velocity and acceleration analysis is required. The analysis of velocity and acceleration depend upon the graphical analytical as well as computer aided solutions. The graphical approach is suitable for finding out the velocity and acceleration of the links of a mechanism in one or two positions of the crank. However, if it is required to find these values at various configurations of the mechanism or to find the maximum values of maximum velocity or acceleration, it is not convenient to draw velocity and acceleration diagrams again and again. While in the case of analytical solutions, expressions for displacement, velocity and acceleration in terms of general parameters are derived. To get values of velocity and acceleration of a mechanism at different positions of the crank, it needs the analytical calculations or the alternate solving technology like a computer program. It is not convenient to draw the velocity and acceleration diagram again and again or to make the analytical calculations over again for different positions. So we are approaches to find out velocity and acceleration of quick return mechanism. This paper deal with the review and methodology of kinematics analysis of Quick Return mechanism using graphical, analytical as well as computer aided solutions.

Keywords:**Mechanism, Quick Return mechanism, Velocity analysis, Acceleration analysis**

INTRODUCTION

If a number of links are assembled in such a way that motion of one causes constrained and predictable motion to the others, it is known as mechanism. A mechanism transmits and modifies a motion. A machine is a mechanism or combination of mechanisms which, apart from imparting definite motion to the parts, also transmit and modifies the available mechanical energy into some kind of desired work. A quick return mechanism is a mechanism that converts rotary motion into reciprocating motion at different rate of velocities for its two strokes i.e working stroke and return stroke. When the time required for the working stroke is greater than that of the return stroke, it is a quick return mechanism. Currently, Quick return mechanism is widely used in machine tools, for instance, shaping machines, power-driven saws, and other applications requiring a working stroke with intensive loading, and a return stroke with non-intensive loading. Several quick return mechanisms can be found including the offset crank slider mechanism, the crank-shaper mechanisms, the double crank mechanisms, crank rocker mechanism and Whitworth mechanism. In mechanical design of the quick return mechanism, the kinematic analysis of the mechanism provides the brief idea of the motion of the mechanism. Since, the purpose of this project is to synthesize quick-return mechanism that converts rotational to translational motion.

A. Crank and slotted lever quick return mechanism:This mechanism is mostly used in shaping machines, slotting machines and in rotary internal combustion engines. In this mechanism, the link AC forming the turning pair with crank is fixed, as shown in Fig. The driving crank CB revolves with uniform angular speed about the fixed centre C. A sliding block is attached to the crank pin at B slides along the slotted bar AP and thus causes AP to oscillate about the pivoted point A. A short link PR transmits the motion from AP to the ram which carries the tool and reciprocates along the line of stroke R1R2. In the extreme positions, AP1 and AP2 are tangential to the circle and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position CB1 to CB2 (or through an angle β) in the clockwise direction. The return stroke occurs when the crank rotates from the position CB2 to CB1 (or through angle α) in the clockwise direction.

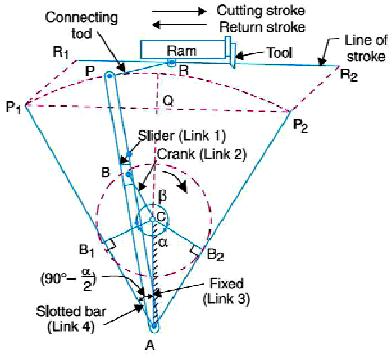

Fig.1 Crank and slotted lever quick return mechanism

LITERATURE

S. R. Patel, D. S. Patel and B. D. Patel[1] have explained the kinematic and dynamic analysis of single slider crank mechanism. They explain the

graphical and analytical formulation for the slider crank mechanism, with the future scope based on CAD. The research work on the kinematic and dynamic analysis has been reviewed and methodology for different mechanism, kinematic analysis is important to understand the position, velocity and acceleration of each linkage during the working of mechanism. The essentiality of dynamic analysis is to understand dynamic behavior of each link, during the working of mechanism. The mechanisms are subjected to force and its effort and due to that dynamic study is required to understand force and its effect on each member and also for the optimization of vibration and mass of mechanism. Study of dynamic analysis is important to study Stress distribution and also improve the output of torque

Ron P. Podhorodeski, Scott B. Nokleby and Jonathan D. Wittchen [2] they have described in a paper, "Quick return mechanism design and analysis Project", project related to Quick Return Mechanism design and analysis. The experiences familiarize the terminology of mechanisms, with concepts related to mechanism synthesis, with relative motion analysis, and with techniques and computer programs for the design and analysis of mechanisms.

Matt Campbell and Stephen S. Nestinger [3], have provided a software package for the analysis and design of a Whitworth Quick Return Mechanism. The Quick Return class can be used to calculate or plot the position, velocity, and acceleration of the mechanism. The Quick Return class also provides a function to create an X linkage animation file display the changes in configuration of the learning, and as a teaching aid.

Pravin S. Ghawade and Nilesh D. Shirgire [4], have developed such a Analytical method using Trigonometry for Analyzing the simple & compound mechanisms which will be helpful for the design engineer to carry out the research work in the Industry by reducing the maximum graphical work. Initially this method requires initial position of mechanism or angle of each links with horizontal Axis which also needed in Graphical Method. The focus of those paper is to draw manually velocity diagram on X and Y axis without using any drawing instruments for determining the Linear or Angular Velocities of links for analysis purpose of four bar, five bar, Six bar, Seven bar linkages etc.

Prof. N.G.Alvi, Dr.S.V.Deshmukh and Ram.R.Wayzode[5] have elaborate in the paper "Computer Aided Analysis of Four bar Chain Mechanism" the modeling of the four bar chain in CATIAV5, the paper deals with analysis of a four bar mechanism to determine values of velocity and acceleration at different positions of the crank using digital computer this method is very fast and less laborious and very efficient than graphical method. Also errors due to the graphical method are eliminated by this present method which gives better result.

KINEMATIC ANALYSIS APPROACHES:

A simple representation of real mechanism that serves as the basis for the next processing is the kinematic scheme. The kinematic scheme of a quick-return mechanism, drawn up on the basis of real mechanism, is shown in Fig.1. The input values of the studied mechanism, shown in are taken from the literature. The comparison of the numerical, graphical and computer aided solution of kinematic analysis was realized on the planar quick-return mechanism that is usually used as the base for shaping machine in technical practice. The goal of the kinematic analysis of this mechanism is to define the motion of the component ram whose all points describe the line path. At the end of the ram the tool can be located for machining. The kinematic analysis can be done in several ways, such as: analytical solution, graphical solution, and computer aided solution.

A. Analytical solution:

There are several types of analytical solution that is usually focused on the task of the solution position. Most often the numerical method uses the trigonometric rules and mathematical definitions such as functions, differentiation, equations, etc.

The advantages of this method include minimal cost for its realization and the possibility to use the table applications for obtaining mathematical function.

The disadvantages of this method are: the expression of mathematical equations is time consuming; it requires an excellent mathematical knowledge of the operator, this method does not solve the collisions of components. For analytical solution the coordinate system of mechanism is located into the point, the position of the important points is described by coordinates. The parameter that changes with time is the crank angle. If angular velocity of crank is constant then kinematic dependency of angle on time is constant.

More over the calculation of the parameter can be done by the different methods or by using the programming for calculation in application like MATLAB, C programming, etc which is advantages for finding the kinematic parameter at the several different position.

B. Graphical solution:

Graphical solution is suitable only for the solving of planar mechanism and proceeds from the kinematic scheme of mechanism sketched in the selected scale with the scaled input parameters (velocity, acceleration) in vector form.

The advantages of this method are: minimal cost for its realization, possibility to use graphical

software, relatively quick solution of obtaining output values for one concrete combination of defined input parameters. The disadvantages are: for every change of input value it is necessary to process a new graphical solution, inaccuracy, it does not solve the collisions of components. This solution consists of investigation of velocity and acceleration of important mechanism points. It provides information about kinematic parameters for a concrete time moment, which means it provides information on the values corresponding to the concrete immediate mechanism position. Graphical solution is suitable for investigation of planar mechanism. this method based on the application of the knowledge of kinematics. Input parameters are drawn in the needed scale, of course it influences the output values which have to be changed after solution according to the scale.

C. Computer aided solution:

Computer aided solution uses special software designed for it. Today there are very interactive and user friendly 3D software in the market, which can simulate not only the motion of the mechanism, but they can define the position, velocity, acceleration, forces, moments and other parameters at every moment of time in a graph or vector version. Inside the computer application it is necessary primarily to create the 3D models of individual components of mechanism, secondary to join them by kinematic linkage which removes needed number of the degree of freedom. The degree of approximation to the real situation is higher at the more difficult systems than at the simpler software. Therefore it is important to choose the simulation tool correctly. This approach requires not only the software control, but it demands the knowledge of the mechanics field, too.

The advantages of this method are: visualization of the mechanism motion in virtual environment with its details, fast data processing and fast output data acquirement for variable combination of input values, possibility to use the output data for other applications, the material characteristics definition and consequently the possibility of dynamic characteristics generation, the chance for direct transmission to dynamic analysis, the ability of components impact determination in virtual background.

The disadvantages are: expensive software and hardware equipment, necessity for the operator to be able to work with the software and hardware. The virtual model of wing mechanism needs to create by software like CATIA, Pro-Engineer on the basis of kinematic scheme of mechanism. The software includes the simulation and kinematic tools, which are suitable for the analysis and the control rationalization of complicated processes. It provides the engineers within the product development process to perform the kinematic motion simulation and behavioral insight into the assembly through easy definition and animation of connections, such as pin joints, ball joints, sliders and other. These connections and the resulting assembly constraints facilitate the assembly. They can be used compatibly and in combination with packaging and traditional like mate, align insert, offset and so on. Once the mechanism is assembled, engineers can observe how their mechanism designs will behave geometrically through interactive part dragging and user defined motion simulations. Predefined motion simulations, using drivers to simulate motors or actuators, also provide animation. There is a powerful design tool enabling engineers to create industry-best mechanism designs by clearly building and communicating design intent into mechanism assemblies and subassemblies in this software. After the modeling mechanism, joints and input parameter definition, it is possible to provide the kinematic analysis. Output data can be designed direct in CAD/CAM system as graphs or as vectors or it can be sent to the other software for the next processing.

RESULT AND DISCUSSION:

The design of a machine or a mechanism or any moving mechanical system always starts with a consideration of kinematics because kinematics is the study of the geometry of motion. That is, kinematics deals with the functional relationships between the parts interconnected, and how those parts move relative to each other. Only after choices have been made regarding those factors can matters such as strengths, materials, fabrication techniques, and costs be seriously addressed. Fortunately, today, the availability of very powerful personal computers and the associated software allows kinematic synthesis and analysis, which were formerly laborious, to be performed quickly and cheaply. There is no longer an excuse for avoiding doing careful kinematic design. Actually before engineers can start to use a computer for synthesis or analysis of a machine, they must develop some initial concept of how the machine will operate. The analytical method using computer programming [7] is useful in determining the values of velocity and acceleration analysis at different positions of the crank. This method is very fast and less laborious and very efficient than graphical method. Also errors due to the graphical method can be eliminated by this method which gives better result. On the other hand in the Computer aided method we can simulate their link at different positions and find the velocity and acceleration graph. On the basis of result and analysis, DMU Kinematics Simulator provides users the ability to define the mechanisms. During mock-up design review, users do not only need to

view simulated kinematics but also analyze the consistency of mechanism with the functional specifications. DMU Kinematics Simulator performs the fit checking as well as computing the minimum distance. The simulating software DMU CATIA Kinematics Simulator[6] is very fast and less laborious and very efficient than graphical and analytical methods. Also errors due to the graphical and analytical methods are eliminated by this present method which gives better result.

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