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Dynamic Analysis of Quick Return Mechanism Using MATLAB

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***Abstract*— Quick return mechanism is generally use in machining process, such as in shaper, slotter and in IC engine, it gives the higher velocity ratio, reduce total machining time and cost. Using constrain geometric methodology mathematical model of kinematic analysis is generated and using D'Alembert principle of static dynamic analysis 13*13 matrices of force is generated which gives the force at each joint of mechanism. The analysis based on the mathematical model performed with the help of MATLAB.**

***Index Terms*— Kinematic Analysis, Dynamic analysis.**

I. INTRODUCTION

A mechanism is mostly used in machine equipment; it generated from the linkage arrangement in such a passion by which desired output for the given input can derived, Quick return mechanism is six-bar mechanism in which time of return stroke is comparatively smaller then the time of cutting stroke so it is called quick return mechanism For complete understanding of any mechanism kinematic and dynamic analysis play significant role, kinematic analysis gives the position, velocity and acceleration of each link.

II. LITERATURE REVIEW

Katarina Monkova used three methods for kinematic analysis of Quick return mechanism, After compression author conclude that computer aided method is more accurate and faster compare to other.[1]; **Himanshu Chaudhary** use maximum reclusive ness of a dynamic equation for the evaluation of bearing force, In this work author optimize vibration and improve the balancing of four bar mechanism.[2]**; Selcuk Erkaya** carried out dynamic analysis of slider crank mechanism with eccentric connector and planetary gears, in this study there are two type of slider-crank mechanism one is simple slider-crank and second one is modified slider-crank mechanism in modified has an additional extra link between connecting rod and crank pin as distinct from conventional mechanism, using dynamic analysis author conclude force output is grater in modified slider-crank mechanism [3]; **Kevin Russell et. al.** created method for designing slider crank mechanism to achieve multi-phase motion generation application typically accomplished by adjustable planer four bar motion generator.[4]; **Iradj G. Tadjbakhsh has** generated Dynamic stability of the flexible connecting rod of a slider crank mechanism, slider crank-mechanism is operated at high speed and rapid response, it is necessary to reduce mass to the smallest feasible value, in order to minimize inertia effect, in result some member in mechanism is subjected to elastic deformation if we reduce mass of inertia without considering elastic behavior then working of mechanism develop instability of parameter result of that reduce the efficiency and reliability of mechanism to an undesirable of degree. Author concludes that the large amplitudes of axial load is responsible for the occurrence of the infinite regions of instabilities and it is also due to the larger axial load. [5];

From the above literature, mathematical model of kinematic analysis has been used for designing the mechanism. Kinematic analysis mainly divides into position, velocity and acceleration analysis. Dynamic analysis is the essential requirement to understand the dynamic behavior of mechanism which is also called force analysis in which we have to consider all the forces, mass of each link. Dynamic behavior can be easily understood with the use of static equilibrium analysis. Mathematical model can be used for the Design, weight optimization, improve the balancing and force output. For find out maximum velocity ratio and force output of Quick return mechanism mathematical model of kinematic analysis and dynamic analysis is generated. After analyzing that mathematical model using MATLAB find the position of link at which force and velocity is maximum.

III. KINEMATIC OF QUICK RETURN MECHANISM

Kinematic analysis is important for find out position, velocity and acceleration of each link in quick return mechanism, mathematical model of kinematic analysis is generated using constrain geometrical method in which whole quick return mechanism is divided into two close loop system.

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From the fig 2.1 for the close loop-1

$r_1 + r_2 = r_3$ … … … … … 3.1

For the close loop-2

$r_3 + r_8 + r_5 = r_7 + r_6$ … … … … … .3.2

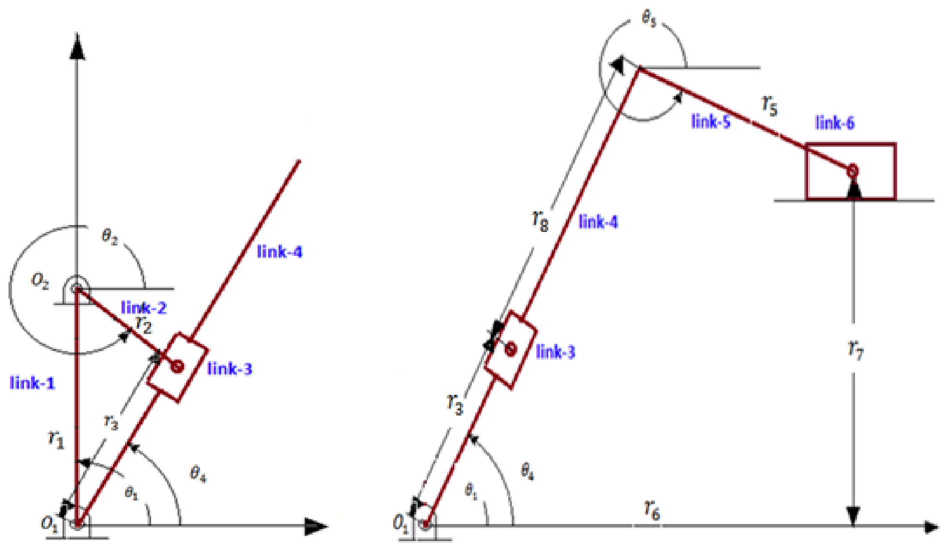

Fig- 1 Close loop of quick return mechanism

After taking the component of Eq-3.1 and Eq-3.2 and simplifying Equation gives the position of each linkage.

$$r_6 = \frac{r_4 \cos\theta_4 + r_5 \cos\theta_5 - r_7 \cos\theta_7}{\cos\theta_6} \text{ … … … … … … … .3.3}$$

Eq-3.3 shows the position of link-6

Velocity analysis is conducted using time derivation of position analysis equation

$$\dot{r}_6 = r_4 \sin\theta_4\, \omega_4 + r_5 \sin\theta_5\, \omega_5 \text{ … … … … . … … … … 3.4}$$

$$\omega_4 = \frac{r_2 \cos\theta_2 \cos\theta_4\, \omega_2 + r_2 \sin\theta_2 \sin\theta_4\, \omega_2}{r_3} \text{ … … … 3.5}$$

Acceleration analysis can be done using time derivation of velocity analysis.

$$\ddot{r}_6 = -r_4\omega_4^2 \cos\theta_4 - r_4\alpha_4 \sin\theta_4 - r_5\omega_5^2 \cos\theta_5 - r_5\alpha_5 \sin\theta_5 \text{ … … … … … .3.6}$$

IV. DYNAMIC ANALYSIS OF QUICK RETURN MECHANISM

Mathematical model of dynamic analysis of quick return mechanism is generated using D'Alembert principle, The principle states that the sum of the differences between the forces acting on a system of mass particles and the time derivatives of the moment of the system itself along any virtual displacement consistent with the constraints of the system is zero. Thus, in symbols d'Alembert's principle is written as following,

$$\sum_i (\mathbf{F}_i - m_i \mathbf{a}_i) \cdot \delta \mathbf{r}_i = 0,$$

By taking individual component of quick return mechanism at equilibrium condition all equation of momentum is generated at the end of dynamic analysis of quick return mechanism there is 13*13 matrices which gives the joint force at each joint of mechanism.

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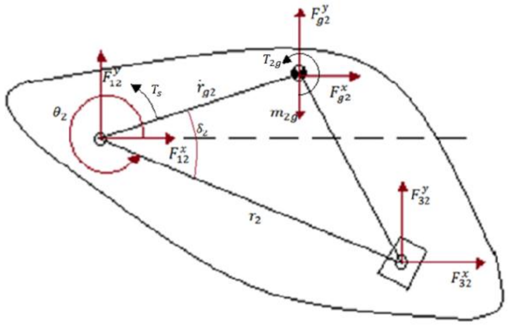

Fig-2 Link-2 with all forces during equilibrium condition

$$F_{12}^{x}+F_{32}^{x}+F_{g2}^{x}=0 \quad \dots\dots\dots\dots 4.1$$

$$-m_2 g+F_{12}^{y}+F_{32}^{y}+F_{g2}^{y}=0 \quad \dots\dots\dots 4.2$$

$$T_s+F_{12}^{x}r_{g2}sin(\theta_2+\delta_2)-F_{12}^{y}r_{g2}cos(\theta_2+\delta_2)-F_{32}^{x}[r_2 sin\theta_2-r_{g2}sin(\theta_2+\delta_2)]+F_{32}^{y}[r_2 cos\theta_2-r_{g2}cos(\theta_2+\delta_2)] + T_{g2}=0 \quad \dots\dots\dots 4.3$$

And after taking static dynamic analysis of quick return mechanism 13*13 matric is

$$\begin{bmatrix} -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a & b & c & d & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & -1 & 0 & 0 & 0 & e & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & f & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & g & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & h & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & i & j & k & l & m & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & -1 & 0 \end{bmatrix} \begin{bmatrix} F_{12}^{x} \\ F_{12}^{y} \\ F_{23}^{x} \\ F_{23}^{y} \\ F_{14}^{x} \\ F_{14}^{y} \\ F_{34} \\ F_{45}^{x} \\ F_{45}^{y} \\ F_{56}^{x} \\ F_{56}^{y} \\ F_{16}^{y} \\ T_s \end{bmatrix} = \begin{bmatrix} F_{g2}^{x} \\ F_{g2}^{y}-m_2 g \\ T_{g2} \\ F_{g3}^{x} \\ F_{g3}^{y}-m_3 g \\ F_{g4}^{x} \\ F_{g4}^{y}-m_4 g \\ T_{g4} \\ F_{g5}^{x} \\ F_{g5}^{y}-m_5 g \\ T_{g5} \\ F_{g6}^{x}+F_L \\ m_6 g \end{bmatrix}$$

Solve above matric by manually it is very complicated so, using MATLAB this matric is solved which gives the force at each joint.

V. RESULT AND DISCUSSION

Using Mathematical model of kinematic analysis and MATLAB data is analyze for the variable length of each link, in that analysis velocity of slider (link-6) which is output of quick return mechanism is change with change of length of each link but total output ratio of velocity is remain constant, in that analysis only with change of height of slider (link-6) velocity ratio is change.

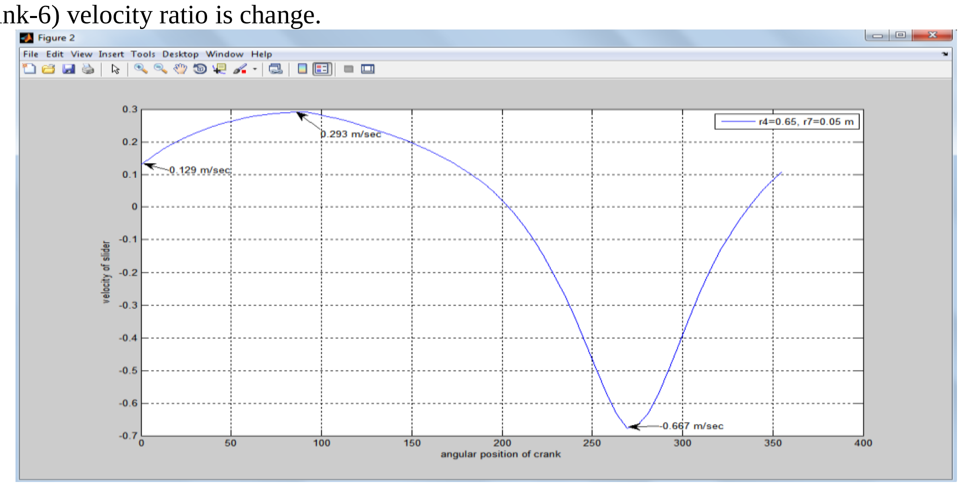

Fig- 3 angular position vs. velocity of slider (link-6) at height r7=0.05 m

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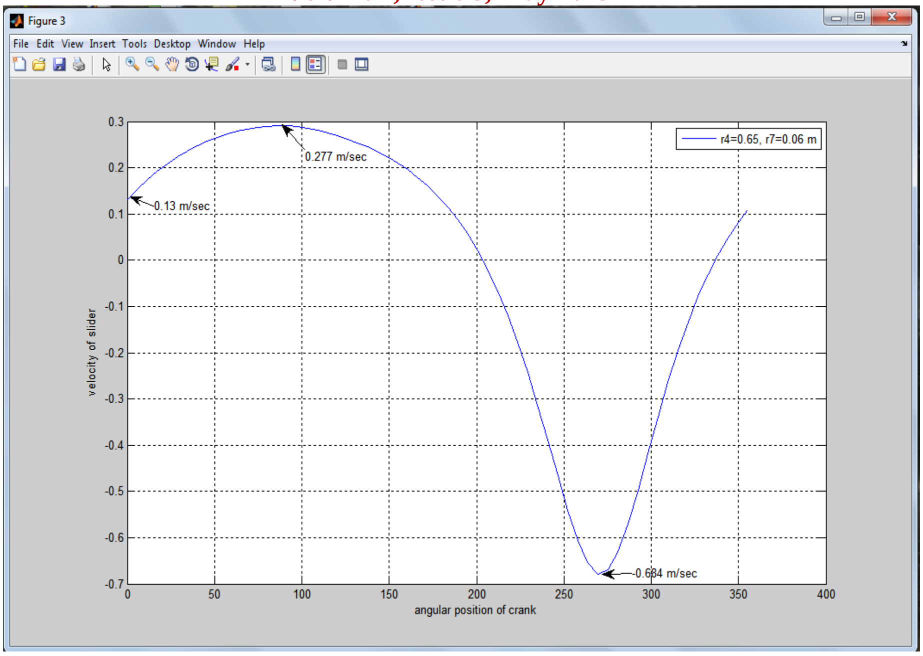

Fig-4 angular position vs. velocity of slider (link-6) at height r7=0.06 m

Sr. No	Height of link-6	Velocity during cutting stroke	Velocity during return stroke	Velocity Ratio
1.	0.04	0.1690	0.7930	4.6900
2.	0.05	0.1640	0.7960	4.8536
3.	0.06	0.1470	0.8140	5.5370
4.	0.07	0.1634	0.810	4.9571

From the above table the velocity ratio is maximum at a height 0.06 of Slider (Link-6) Now as per the design of quick return mechanism the velocity ratio and output force is required to maximum, So from the dynamic analysis of quick return mechanism force output is analyze for the different height of the slider (link-6).

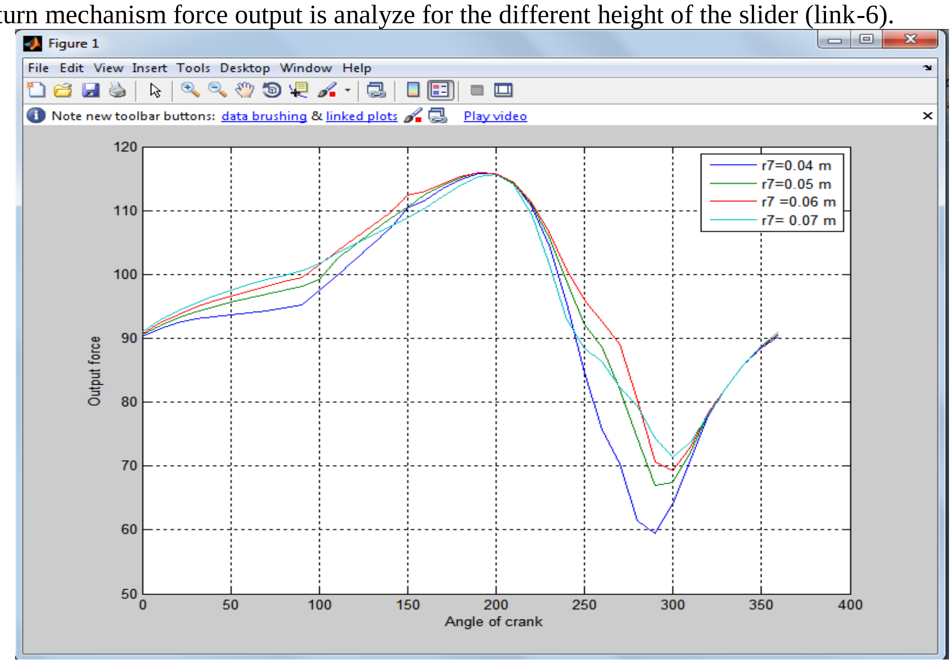

Fig- 5 Compression graph of Angle of crank vs. output force for various height of link-6

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From the Fig-3.3 force output is maximum when the height of link-2 is 0.06 m .So from the above result velocity ratio and Force output is maximum at height 0.06 m

VI. CONCLUSION

In quick return mechanism, velocity of cutting stroke and return stroke both change with the change in length of slotter link but total velocity ratio remains constant. the velocity ratio and force output changes with the change in height of slider. The ratio of length of slotter link to height of slider is 1.083 and at this instant the velocity ratio and force found to be with their maximum value during the stroke.

VII. FUTURE SCOPE

Dynamic analysis is one of the important phase in design the systems. A computer base modeling and simulation gives better understanding regarding rigid system parameters. There is much scope in development of an accurate mathematical model and subsequent simulations for the kinematic and dynamic analysis of the mechanical systems for the precise application in the industry. From the present work it is easy to compute velocity and force at each joint for any real application of quick return mechanism, this work can be extend in the direction of optimization of weight of each link for the same dynamic behavior.

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