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A Review on Kinematic and Dynamic Analysis of Mechanism

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Abstract *- The research work on the kinematic and dynamic analysis has been reviewed in this paper. 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 it's effort and due to that dynamic study is required to understand force and it's 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*

Index Terms - **Kinematic analysis, Dynamic analysis, Optimization.**

I. INTRODUCTION

A mechanism is used in most of machine equipment; it is generated from the linkage arrangement in such a passion by which, desired output for the given input can be derived. For complete understanding kinematics and dynamic analysis play significant role. There are vibration in the mechanism for reduce present vibration it is important to understand the dynamic behavior of each link, then vibration will optimize by method of optimization.[2] With the use of kinematics and dynamic analysis of slider-crank, we can find the output torque and improve it for same input.[3], The design of slider-crank mechanism is achieved by multi-phase motion generation and software is use for study of motion.[4], In slider crank mechanism we convert sliding motion of piston into rotary motion, stability of crank and connecting rod is understand with study of dynamic behavior.[5], So research on dynamic and kinematic analysis is very wild for design and synthesis.

II. KINEMATIC ANALYSIS OF MECHANISM

In kinematic, we generate mathematical model for the position, velocity and acceleration analysis, the basic methodology for the kinematic study is complex geometric, position analysis is used to understand the position of any link or any point and it is done by use of close loop of system, derive the time-derivation of position analysis give the velocity and second derivation of equation give the acceleration of each link, So kinematic analysis give the position, velocity and acceleration behavior of mechanism. There are three different methods for the kinematic analysis.

- Analytical solution (mathematical model)
- Graphical solution
- Computer aided solution

By analytical method we can find position, velocity and acceleration by use of close loop of mechanism [3].
The position of piston in simple slider crank mechanism is given by

$$S_{pi}^{*} = l^{*} + r^{*}\left[\cos\theta^{*} - \frac{1}{2}\lambda^{*}sin^{2}\theta^{*}\right]$$

Velocity of simple slider crank mechanism

$$V_{pi}^{*} = -r^{*}\omega_{21}\left[\sin\theta^{*} + \frac{1}{2}\lambda^{*}\sin 2\theta^{*}\right]$$

Acceleration of simple slider crank mechanism $a_{pi}^{*} = r^{*}\omega_{21}^{2}[\cos\theta^{*} + \lambda^{*}\cos 2\theta^{*}]$
With following disadvantages in the prescribed method

- The expression of mathematical equation is time consuming,
- It required an excellent mathematical knowledge of the operator,
- This method does not solve the collisions of component,[1]

In second method the solution is carried out by graphical method, graph of position, velocity and acceleration is generate and from them we can compute speed and acceleration,

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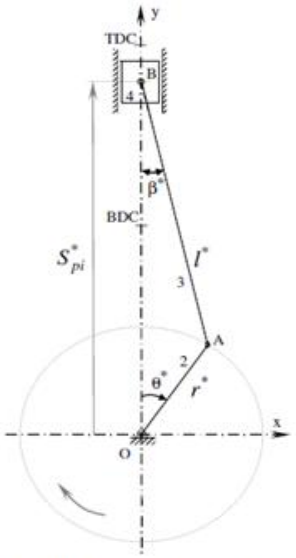

Fig 2.1 Slider crank mechanism

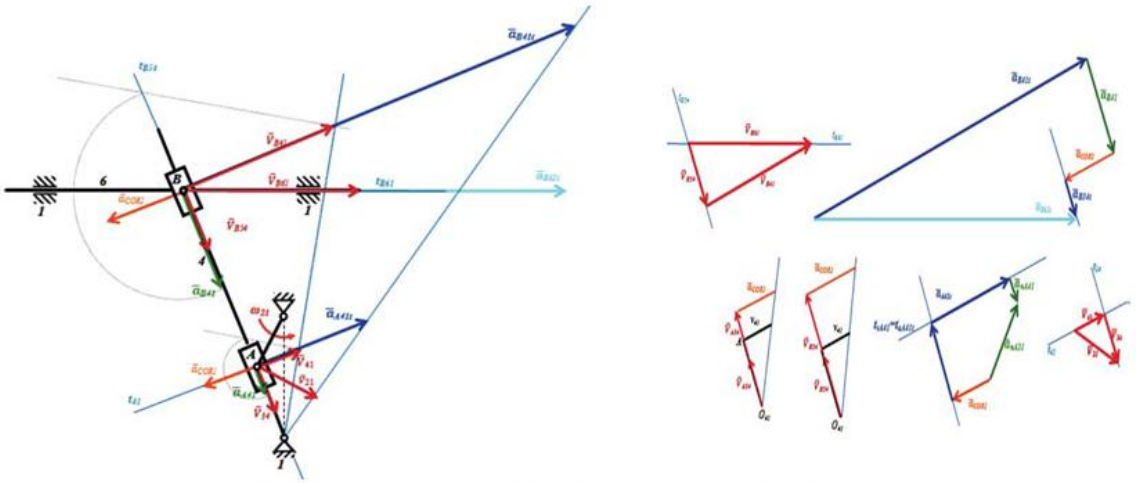

Fig 2.2 Velocity and acceleration analysis by graphical method

For computer aided solution lots of commercial software are available in market by use of them author develop motion of mechanism, position of each link, velocity, force, momentum, and parameter. From each method author find velocity and acceleration and conclude that computer aided method is accurate comparatively two other, it is also perform quickly. [1]

III. DYNAMIC ANALYSIS OF MECHANISM

During the working of any mechanism there is force on each member which is due to the operating force and mass of inertia of each link, to understand the effect of that force on mechanism dynamic analysis is important. There are several methods adopted for dynamic analysis as below

a. Hamilton principle method
b. Lagrange multiplier method
c. Geometric constraint method
d. Partitioning method
e. Newtonian solution method

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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. The new extra link, may be called eccentric connector, transmits gas forces to the crank and also drives a planetary gear. In this work author develop mathematical model of kinematic analysis and dynamic analysis for simple slider crank and modified slider crank mechanism.

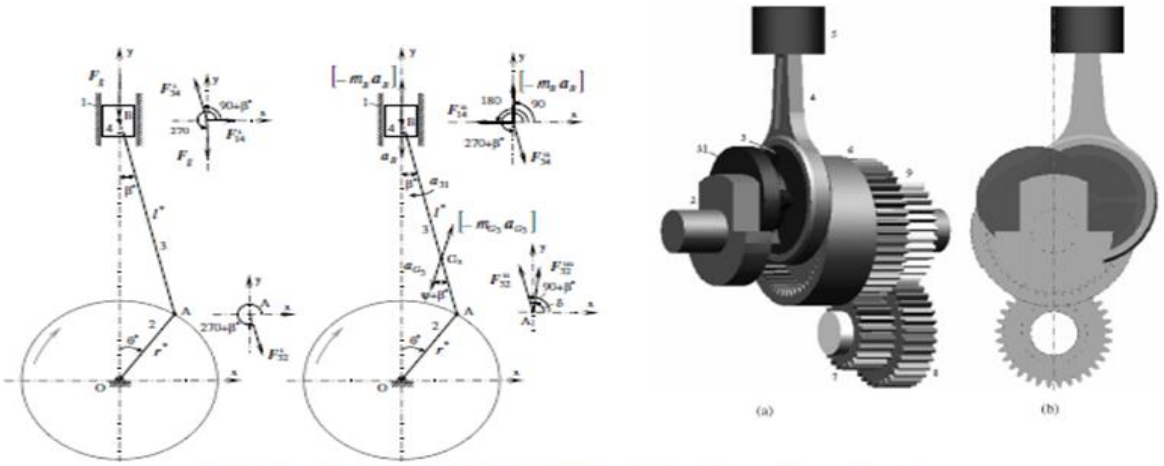

Fig 3.1 Dynamic analysis of simple and modified slider crank mechanism

Total torque $M_{total} = M_{gas} + M_{inertia} = rxF_{32}^{i} + rx\sum F_{inertia}$

Torque of modified slider crank mechanism $M_{total} = M_{gas} + M_{inertia} = rxF_{32}^{1} + rx\sum F_{inertia}$

Same way after dynamic study of modified slider-crank author conclude that output torque of modified slider-crank is higher compare to simple slider crank for same gas force.[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.

Here in this paper the slider crank mechanism is generated with use of adjustable planer four bar motion generator, the benefit of this method is twofold, first multiple phase of prescribed rigid body position are achievable using mechanism with fever moving parts then the planer four bar mechanism. Second slider crank motion generator can achieve phase of prescribed rigid body position without any physical and automatic adjustments of it's moving pivots between phases. A slider path that enable the slider crank motion generator to achieve two phase of prescribed rigid body position is designed by 7^{th} order polynomials to connect the moving pivot path of the follower link of the adjustable planar 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.

This work is concerned with the stability of the flexible coupler of a slider crank driven by a rigid crank, here small deformation of each link are analysis by taking them separate.

- Here partial differential equation of motion of the flexible connecting of a slider crank is derive, under assumption of small deflection ,
- Galerkin procedure leads to linear ordinary differential equations with respect to the modal coordinate of vibration of the rod.
- Application of Floquet theory determines those values of the parameters, speed, input torque, geometry and material properties that constitute the boundary between the regions of stability and instability.

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]

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IV. OPTIMIZATION

After kinematic and dynamic study work can extant in optimization field, it is very important to optimize the weight and vibration of mechanism. **Himanshu Chaudhary** use maximum reclusive ness of a dynamic equation for the evaluation of bearing force, In this work author follow the following steps

1. Formulation of the dynamic problem to calculate the joint reaction and other dynamic characteristics,
2. Formulation of the objective function that can be used as an index of merit for the dynamic performance of a linkage,
3. Constrain on the design variable of the problem at hand that define bounds on the space on the feasible solution,
4. Optimization is done with the use of 'fmincon' function.

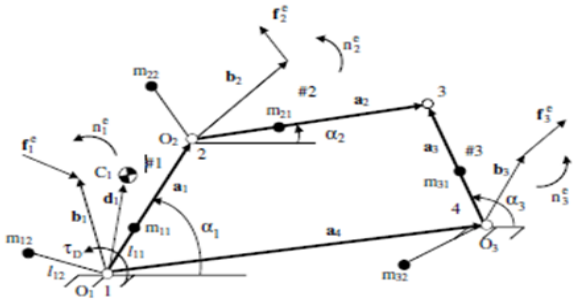

Fig 4.1 Dynamic analysis of four bar mechanism

In this work author optimize vibration and improve the balancing of four bar mechanism. [2]

V. FUTURE SCOPE

Dynamic analysis is one of the very 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.

VI. CONCLUSION

- From the presented three methodology of kinematic analysis computer aided method is accurate.
- Dynamic balancing of four bar linkage is carried out using the maximum recursive dynamic algorithm for the evaluation of bearing force.
- In order to compare two different mechanisms in kinematic and dynamic respects, the same stroke and gas force are considered and rotational speed of 2500 rpm used for both, observation show total torque of modified slider crank is more than conventional mechanism.
- Multiple phase o prescribed rigid body position are achievable using a mechanism with fever moving part then the planner four bar mechanism.
- Axial force in the coupler is a combination of the inertia forces and the driving moment at the input crank, the frequency of inertial force is same as the rotational speed of the mechanism, loading is causes large amplitude of axial load is responsible for the occurrence of the infinite region of instability.
- From above review we can conclude that Dynamic study is very important for design and optimization of mechanism.

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