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Design and kinematic analysis of slider crank mechanism using Catia and Mat Lab

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Abstract
Slider-crank mechanism plays a significant role in the mechanical manufacturing areas. The slider-crank mechanism is a particular four-bar mechanism that exhibits both linear and rotational motion simultaneously. It is also called as four-bar linkage configurations. Analysis of four bar linkage configuration is very important. In this project four configurations are taken into account to simulate and analyze the mechanism. A CAD model is prepared in CATIA V5 to simulate the mechanism and also to specify the accurate path of the mechanism. And the analytical method is used to define the various position of the crank and respective position of slider in Slider Crank mechanism is studied.
MATLAB programs are provided for kinematic analysis of a Slider Crank mechanism that contains a coupler point. The MATLAB program performs position, velocity, and acceleration analysis for a given angle of the crank or for a given input. This program solves for all the unknown parameters and reports those results in excel sheet as an output in the numerical form.

Keywords: Design; Kinematic Analysis; Slider Crank Mechanism; Catia; Mat Lab.

Introduction

Once a tentative mechanism design has been synthesized, it must then be analyzed. A principal goal of kinematic analysis is to determine the accelerations of all the moving parts in the assembly. Dynamic forces are proportional to acceleration, from Newton's second law. We need to know the dynamic forces in order to calculate the stresses in the components. The design engineer must ensure that the proposed mechanism or machine will not fail under its operating conditions. Thus the stresses in the materials must be kept well below allowable levels. To calculate the stresses, we need to know the static and dynamic forces on the parts. To calculate the dynamic forces, we need to know the accelerations.

In order to calculate the accelerations, we must first find the positions of all the links or elements in the mechanism for each increment of input motion, and then differentiate the position equations versus time to find velocities, and then differentiate again to obtain the expressions for acceleration. For example, in a simple Grashof four-bar linkage, we would probably want to calculate the positions, velocities, and accelerations of the output links (coupler and rocker) for perhaps every two degrees (180 positions) of input crank position for one revolution of the crank.

This can be done by any of several methods. We could use a graphical approach to determine the position, velocity, and acceleration of the output links for all 180 positions of interest, or we could derive the general equations of motion for any position, differentiate for velocity and acceleration, and then solve these analytical expressions for our 180 (or more) crank locations. A computer will make this latter task much more palatable. If we choose to use the graphical approach to analysis, we will have to do an independent graphical solution for each of the positions of interest. None of the information obtained graphically for the first position will be applicable to the second position or to any others.

In contrast, once the analytical solution is derived for a particular mechanism, it can be quickly solved (with a computer) for all positions. If you want information for more than 180 positions, it only means you will have to wait longer for the computer to generate those data. The derived equations are the same. It is interesting to note that graphical position analysis of linkages is a truly trivial exercise, while the algebraic approach to position analysis is much

more complicated. If you can draw the linkage to scale, you have then solved the position analysis problem graphically.
It only remains to measure the link angles on the scale drawing to protractor accuracy. But, the converse is true for velocity and especially for acceleration analysis. Analytical solutions for these are less complicated to derive than is the analytical position solution. However, graphical velocity and acceleration analysis becomes quite complex and difficult. Moreover, the graphical vector diagrams must be redone de novo (meaning literally from new) for each of the linkage positions of interest. This is a very tedious exercise and was the only practical method available in the days B.c. (Before Computer), not so long ago. The proliferation of inexpensive microcomputers in recent years has truly revolutionized the practice of engineering.
B.Venu, Dr. M. nagaphani sastry study dynamic reactions investigation was successfully done by using MATLAB software. The obtained data have been statistically processed using Response Surface Method. The empirical models of output parameters are established and tested through the analysis of variance to validate the adequacy of he models. A response surface optimization is attempted using DESIGN Expert software for output responses in slider crank mechanism. The optimization of slider crank mechanism is done by using GA.
Prof. Raghu Echempati said that demonstrated an increased depth of understanding of planar mechanism theory via the creation and verification of their graphical and analytical models using math and CAE tools such as Excel program and NX while also retaining a solid grasp of the physical system via either the data acquisition apparatus or the virtual CAE model. In doing so, they have explored and defined the various limiting link conditions (dead centre position) of the Whitworth Quick Return system and the ramifications of the said conditions. Although in this paper only a quick return mechanism is presented, other planar mechanisms using higher pairs (cams and gears) are also studied using both graphical and analytical methods, as well as, analysis using a simulation tool such as UG-NX.
Vjekoslav Dami the analysis of behaviour of the planar multibody system based on communication between dynamic and virtual model of the system is presented. The virtual model is created using Bond Sim Visual. The dynamical model is developed by bond graphs using object oriented software Bond Sim. During simulation two-way communication is obtained between two models based on named pipe technology, which supports the exchange of information. Two software packages – Bond Sim and Bond Sim Visual can run on different computers connected in a local net. The proposed procedure is applied to the slider crank mechanism. Flexibility of its components is neglected because deformation is really small. We plan also to extend our investigation to the multibody systems with flexible links. Also, the approach explained in the paper, can be extended to the analysis of spatial multibody systems with closed kinematic structure.
Erener, Kaan study, visual and interactive computer software package which works with CATIA V5 in fully parametric form is created for solving aerospace mechanism synthesis problems. The created software is named as Syn CAT and Syn CAT is capable of synthesizing planar four-bar mechanisms for four multiply separated positions for motion, path and function generation synthesis types. Syn CAT is written in Visual Basic (VB) with graphical user interface since commands of CATIA V5 is available in VB. Thanks to compatibility with CATIA and VB, Syn CAT performs synthesis of mechanism in CATIA in fully parametric form. Therefore, designer can use geometrical element in CATIA and get output in the same design environment *Katarína Monková, Peter Monka, Sergej Hloch, Jan Valíček* 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 three factors can matters such as strengths, materials, fabrication techniques, and costs be seriously addressed. Failure to devote the proper attention to kinematics up front can, and often does, result in the design of a system with substandard or no optimum performance and/or with unsatisfactory reliability. Even though the virtual simulation of a mechanism has a firm place in engineering practice, it seldom conforms to real conditions, due to outside and inside influences, which can be difficult to predict and define. Therefore it is necessary to consider random influences and to multiply the results by surety factor.

2. Slider Crank Mechanism Modeling

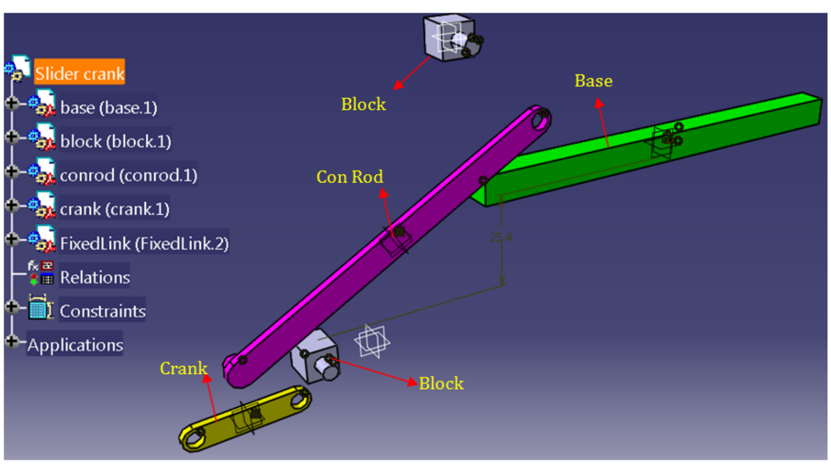

Fig 1:

3. Kinematic Analysis in MATLAB

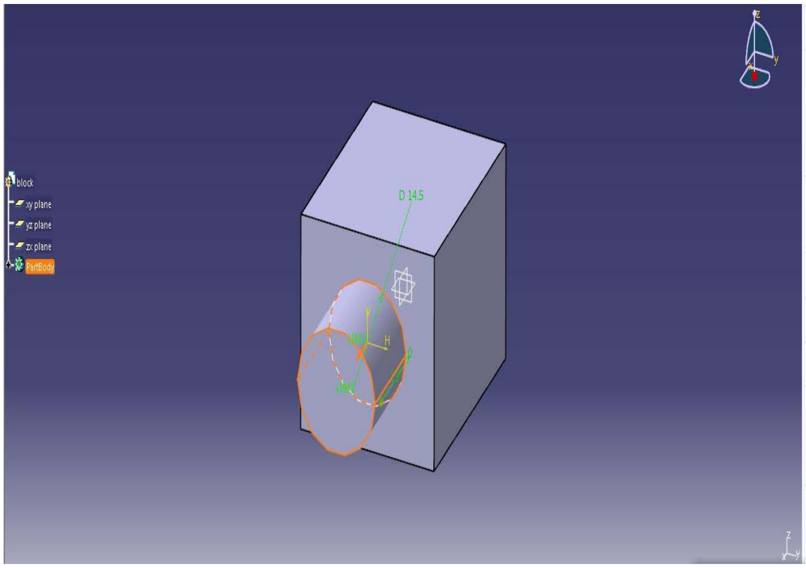

Fig 2: block

4. Results and Discussions

4.1 Analytical Results

The results are estimated for the four configurations of Slider crank mechanism. For the below 4 configurations the analytical Results are calculated.

Table 1: Slider crank mechanism Configurations

Configuration	a (mm)	b(mm)	c(mm) offset	θ_2 (Deg)	ω_2 (rad/Sec)	α_2 (rad/Sec^2)
1	35.66	101.6	25.4	45	10	0
2	76.2	203.2	50.8	-30	-15	-10
3	127	508	-127	225	-50	10
4	177.8	635	254	330	100	18

Table 2: Slider crank mechanism Analytical Results

Analytical Results								
Configuration	θ3 Open (Deg)	Slider Open	θ3 crossed (Deg)	Slider crossed	ω3 (rad/Sec)	Slider Vel in m/s	α3 (rad/Sec2)	Slider Acc in m/s2
1	180.1	127	-0.14	-76.2	2.47	-0.252	-25	-1.9
2	205.9	248.9	-25.9	-116.8	-5.42	-0.09	29	-12.4
3	175	416.6	4.2	-596.9	8.86	-4.161	447	281.8
4	212.7	688.3	-32.7	-378.5	28.8	-0.988	1136	-1484.1

4.2 MATLAB Results

For the four configurations mentioned in Table 5.1, four Input files prepared and MATLAB Program run for those Configurations. The MATLAB Results are as follows:

Table 3: Slider crank mechanism Analytical Results

MATLAB Out Put								
Configuration	θ3 Open (Deg)	Slider Open	θ3 crossed (Deg)	Slider crossed	ω3 (rad/Sec)	Slider Vel in m/s	α3 (rad/Sec2)	Slider Acc in m/s2
1	180.144	126.744	-.1439631	-76.45496	2.4748815	-0.252079	-24.764205	-1.88584787
2	205.944	248.712	-25.94448	-116.73	-5.417363	-0.089896	30.24	-12.3270379
3	175.801	416.834	4.1991444	-596.4389	8.8626259	-4.160461	447.125656	281.830683
4	212.684	688.437	-32.683639	-380.478	28.810407	-0.989088	1136.01422	-1484.11157

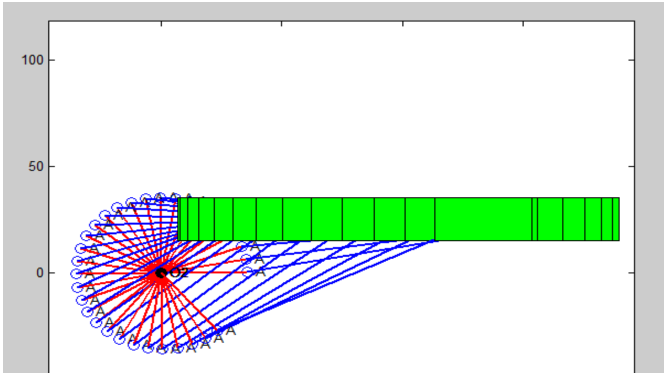

Fig 3: Slider Crank Animation in MATLAB

6. Comparison Between Analytical & MATLAB Results

The MATLAB Results and Analytical Results are compared. The Comparison for four configurations of slider crank mechanism are plotted in the following.

Configuration 1

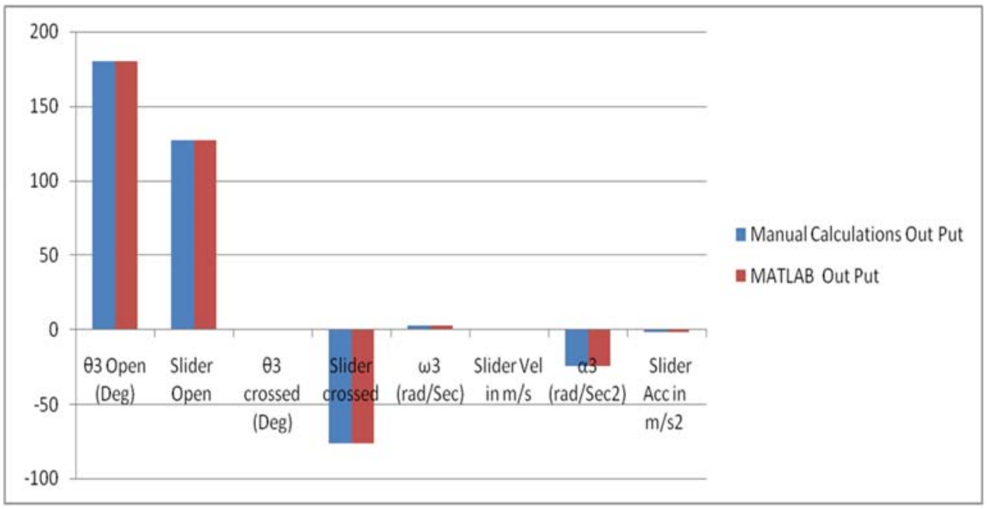

Fig 4: Analytical vs MATLAB Results for Configuration -1

Configuration 2

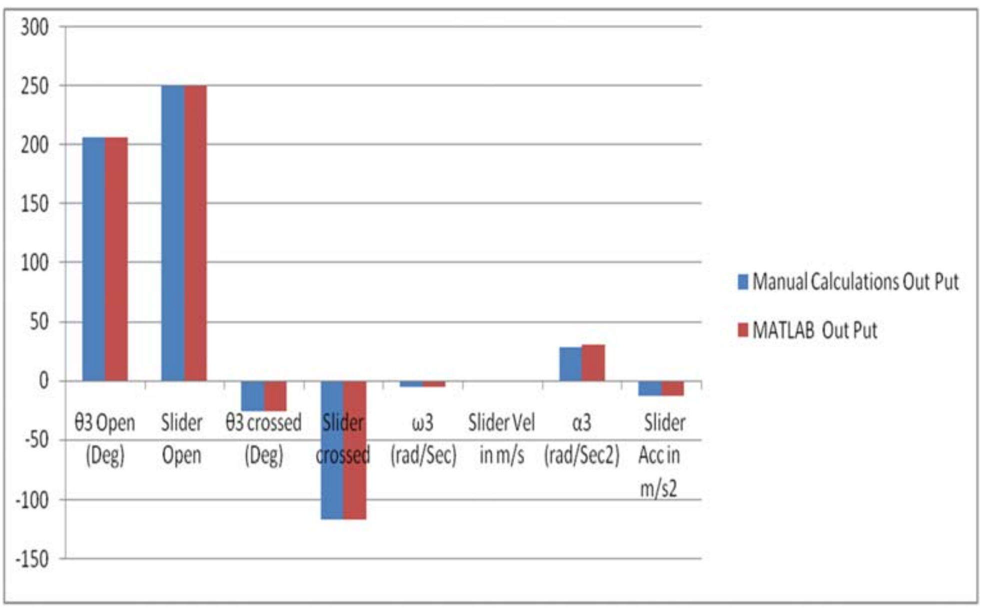

Fig 5: Analytical vs MATLAB Results for Configuration -2

Configuration 3

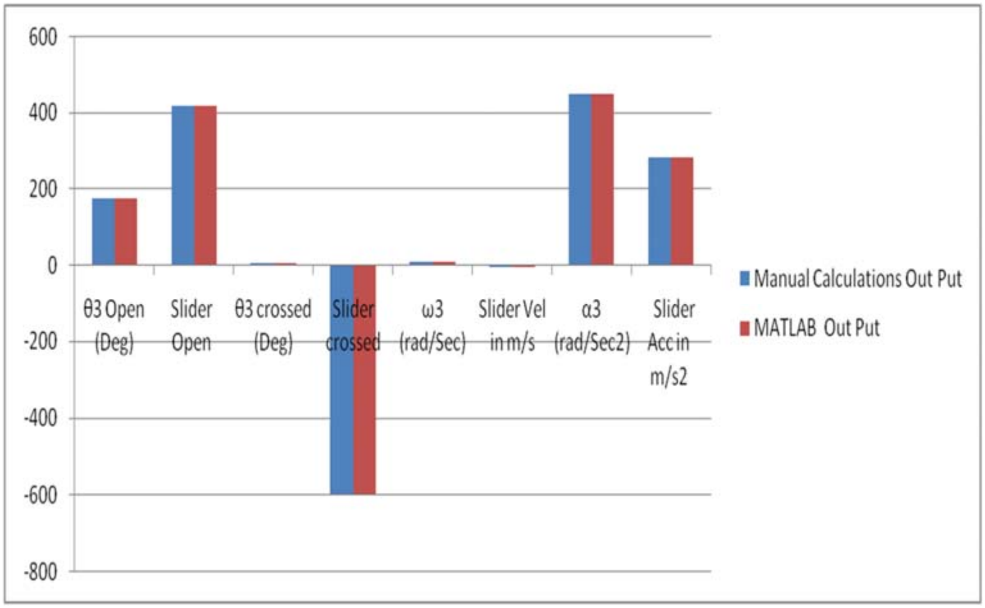

Fig 6: Analytical vs MATLAB Results for Configuration -3

7. Conclusion

In this work I have studied, simulate and analyses of slider crank mechanism, and I have used two software packages CATIA and MAT LAB. By using CATIA software I will design and model the slider crank mechanism with in specified limits. By using MATLAB Software we can simulate and analyze the slider crank mechanism. In this project the MATLAB gives the results in numerical form, the mat lab code gives the all the calculated values in an excel file as output and it generates an animation in 2D Plot. During mock-up design review, users do not only need to view simulated kinematics but also analyze the mechanism's consistency with the functional specifications.

Kinematics Simulator computes the minimum distances and also performs both clearance and interference functions. A 'stop on collision' option freezes the motion for detailed analysis. Finally the obtained output from CATIA and MAT LAB are compared together and the corresponding variations are shown in graphs. Finally we conclude that The Software’s CATIA and MATLAB are very Quick in response, low labor cost and very efficient than graphical methods.

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