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Comprehensive Dynamic Analysis and Simulation of the Slider-Crank Mechanism using ADAMS Software

P V Mallari[1], Sai Rohith G[2]

[1-2] UG Students, Department of Mechanical Engineering, RYM Engineering College, Ballari, Karnataka, India

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Abstract - *This research is to analyze the performance of the slider-crank mechanism by using MSC Adams/View software. Using the Lagrangian approach, a dynamic model was established by considering the effect of faults induced by heavy clearance. Furthermore, three-dimensional simulation of the model was verified. The study reveals that the gaps existing between the joints of the mechanism have a considerable impact on the response of mechanisms, hence increasing vibration, shock, and shifts in critical system parameters including but not limited to displacement, speed, and acceleration. The impacts are magnified with higher levels of clearance.*

Key Words: Slider-crank mechanism MSC Adams/View, Dynamic simulation, Kinematic analysis, Multibody dynamics

1. INTRODUCTION FOR MSC SOFTWARE

MSC Software is recognized as one of the pioneering companies in the software industry, standing out as a global leader in enabling manufacturers to enhance their engineering processes through simulation software and services. As a trusted collaborator, MSC Software assists organizations in improving product quality, reducing design and testing time, and cutting costs associated with product development. The company's technology is widely used by academic institutions, researchers, and students to broaden their understanding and further the capabilities of simulation.

MSC Software's simulation tools are utilized by top manufacturers for a wide range of applications, including linear and nonlinear finite element analysis (FEA), advanced material modeling, acoustics, fluid-structure interaction (FSI), multi-physics, optimization, fatigue and durability analysis, multi-body dynamics, controls, and manufacturing process simulations. The company's products provide accurate and dependable predictions of real-world product behavior, empowering engineers to design more innovative solutions.

1.1 ADAMS

MSC Adams (Automated Dynamic Analysis of Mechanical Systems) Adams is the world's most widely used multibody dynamics simulation software. It lets you build and test functional virtual prototypes, realistically simulating on your omputer, both visually and mathematically, the full–motion behavior of your complex mechanical system designs.

Adams provides a robust solution engine to solve your mechanical system model. The software checks your model and automatically formulates and solves the equations of motion for kinematic, static, quasi-static, or dynamic simulations. With Adams, you don't have to wait until the computations are complete to begin seeing the results of your simulation. You can view animations and plots – and continue to refine your design – even as your simulation is running, saving valuable time. For design optimization, you can define your variables, constraints, and design objectives, then have Adams iterate automatically to the design, providing optimal system performance.

1.2 Introduction to Slider Crank Mechanism

The slider-crank mechanism is a typical reciprocating mechanical system which consists of revolute and translational joints. In practice, motion clearance is inevitable mainly for three reasons: 1 First of all, the assembly clearance (normal clearance) is designed for rotation and sliding hinge movement. Second, fit and finish errors are designed into the joint components when they are manufactured. The third source of irregular clearance is due to wear and tear of the motion pair itself. Whether it is, a natural phenomenon, a design flaw or an assembly defect, the existence of clearance adversely affects dynamic behavior, especially rub-impact for the slider-crank mechanism. In recent years, a limited.

2. LITERATURE REVIEW

Flores et al. [2] introduced a general approach for modeling and analyzing multi-body dynamics in revolute joints with multiple clearances. In their study, they developed a continuous contact force model, based on elastic Hertz theory and dissipative terms, considering the actual joints as collision bodies affected by geometric and physical properties. Their findings emphasized that both the clearance size and operating conditions are critical for accurately predicting the system's dynamic response.

Zheng et al. [3, 4] examined the dynamic behavior of a rigid-flexible coupling slider-crank mechanism under non-lubricated revolute joints with clearance. They analyzed the impact of factors such as clearance size, crankshaft speed, and the number of clearances on the system's dynamic response, factoring in the elastic deformation of the rod.

Bauchau et al. [5] developed nonlinear dynamic equations for flexible multi-body systems with clearances, studying the effect of clearance and flexibility on the dynamic response of the mechanism.

For cases involving lubrication in frictional conditions, Alshaer et al. [6], Flores et al. [7-9], Tian et al. [10-12], and Zheng et al. [13] investigated dynamic analysis methods for lubricated revolute and ball joints with clearances. They used fluid dynamics theory to calculate the rub-impact contact force under lubrication. Their results showed that compared to the dynamic characteristics of the lubricated clearance model, the frictional contact force in the absence of lubrication leads to stronger fluctuations in the system.

To mitigate the negative effects of revolute joints with clearance, Varedi [14] proposed a method using particle swarm optimization to optimize the mass distribution of the mechanism, aiming to reduce or eliminate the impact force at the joint with clearance. The effectiveness of this algorithm was verified through a practical example.

3. PROCEDURE AND RESULTS FOR SLIDER CRANK MECHANISM

Problem Description

In the slider crank mechanism linkage shown in below.

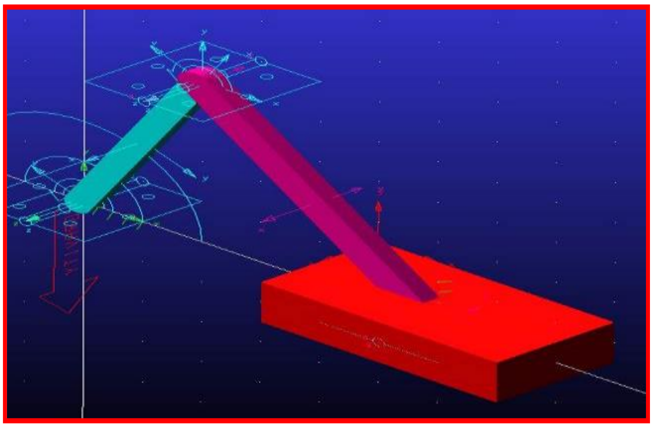

Figure 1: Slider Crank mechanism

Step 1. Create a new Adams Database

- a Click on Create a new model.
- b In the Working Directory section, navigate to the folder where you wish to save your model.
- c Enter "slider crank mechanism" as the name for the new model and click OK. Ensure that the gravity setting is configured to Earth Normal (Global Y) and the units are set to MMKS (mm, kg, N, s, deg).

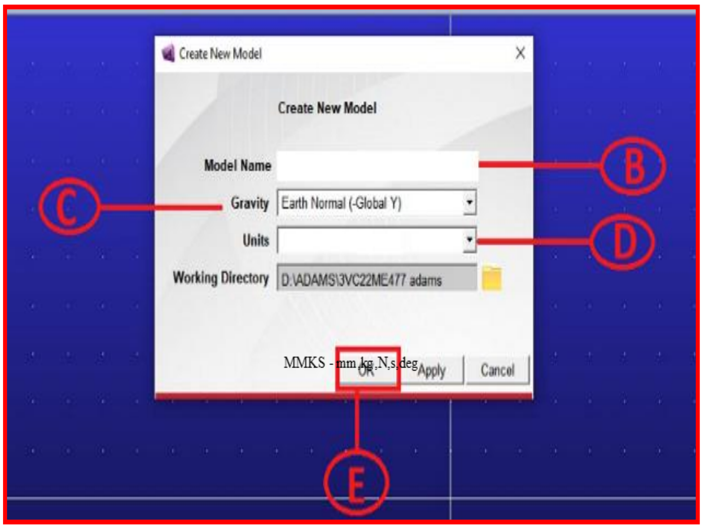

Figure 2: Create a New Adams database.

Step 2. Create Links and Joints

- a From Bodies ribbon, double click Rigid Body: Link
- b Create the link using the specified length, with the markers serving as the endpoints.
- C From Connectors ribbon, double click Create a Revolute joint
- d Establish revolute joints between the two links at the designated points.
- e From Bodies ribbon, double click Rigid Body: box
- f Create the box using the specified length, with the markers as the endpoints.

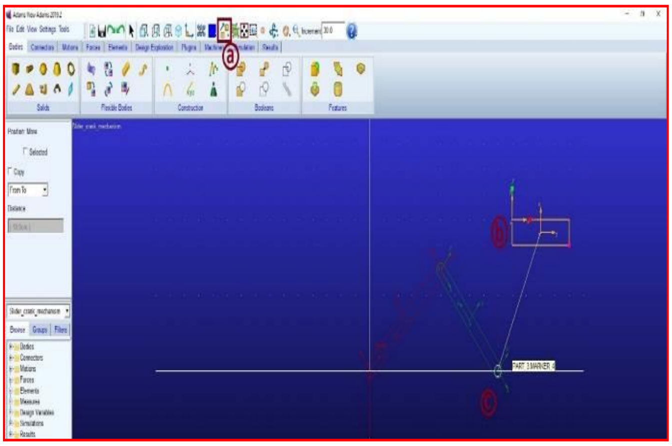

Figure 2: Create links.

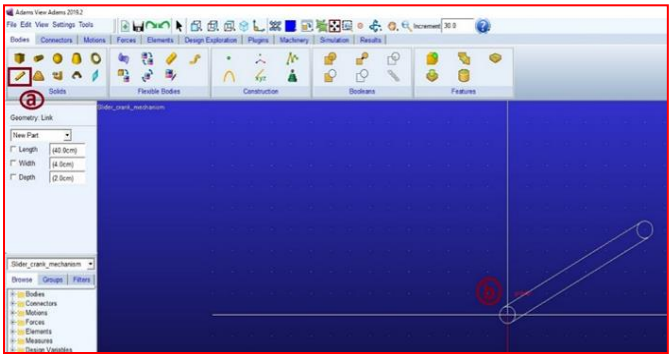

Figure 4: Creating the box.

Step 4. Move the Box
a from mover ribbon, Right click Rigid Mover
b Select the Box and choose the Center Points.
c Click link End Point
d Solidify the part by creating the final form

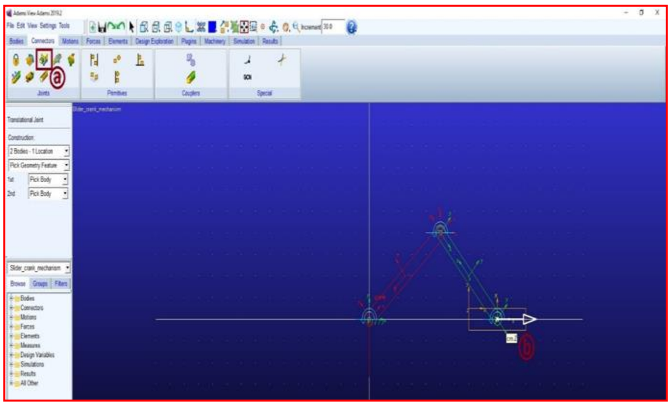

Figure 5: Move the Box.

Step 6. Create a Revolute Joints
a From Connectors ribbon, double click Create a Revolute joint
b Establish revolute joints between the two links at the specified points.

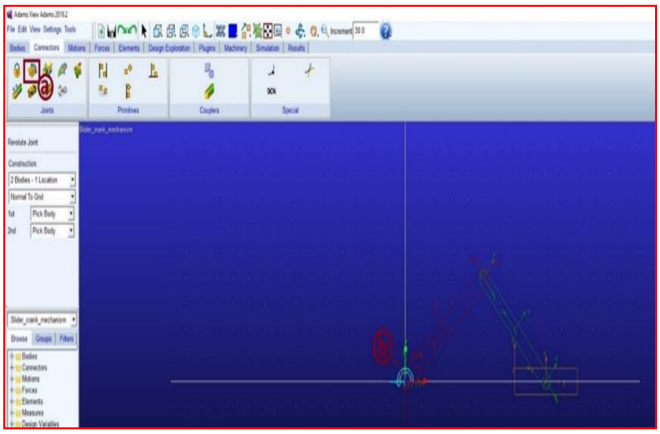

Figure 6: Assigning a Revolute joint.

Step 7. Create Translational Joints
a From Connectors ribbon, double click Create a Translational joint
b Select Rigid Body: Box when the prompt at the bottom of the screen says "Select the first body."
C Select Ground when the prompt at the bottom of the screen asks for "Select the second body."
d Choose PART_2.cm when the prompt at the bottom of the screen says "Select the location."
e Select cm. X when the prompt at the bottom of the screen asks for "Select the direction vector."

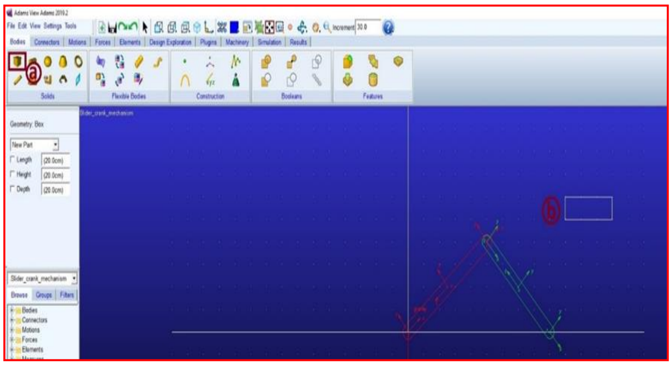

Figure 7: Assigning a Translational joint.

Step 8. Add Motion
a From Motions ribbon, select Rotational Joint Motion
b Enter (30 rad) in Rot. Speed text field
c Select joint at point O

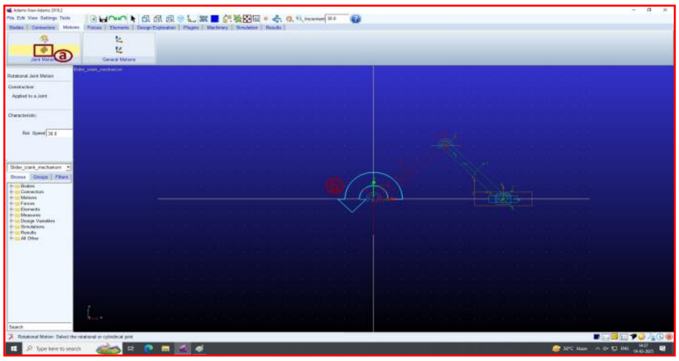

Figure 8: Adding Motion to the Slider Crank Add Motion.

Step 9. Testing the Model
a From Simulation ribbon, Select Run an Interactive Simulation
b Set the Duration to 10 and the Step Size to 500.
C Click Start.
d Click on Plotting.
e Generate a CM Position Plot for link OA in the X component.

f Create a CM Angular Velocity Plot for Link AB and Link BC in the magnitude component.
g Follow the plot curve to determine the angular velocity

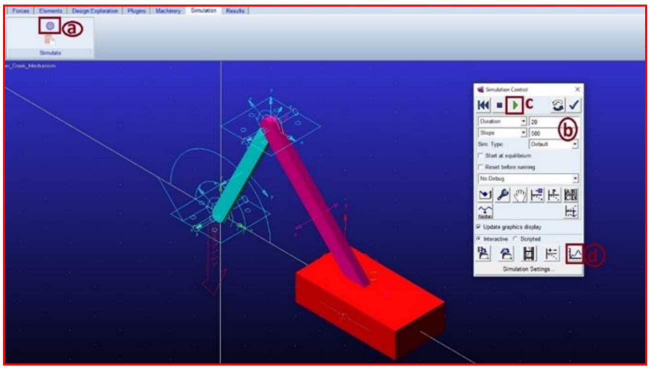

Figure 9: Simulating the Slider Crank Mechanism.

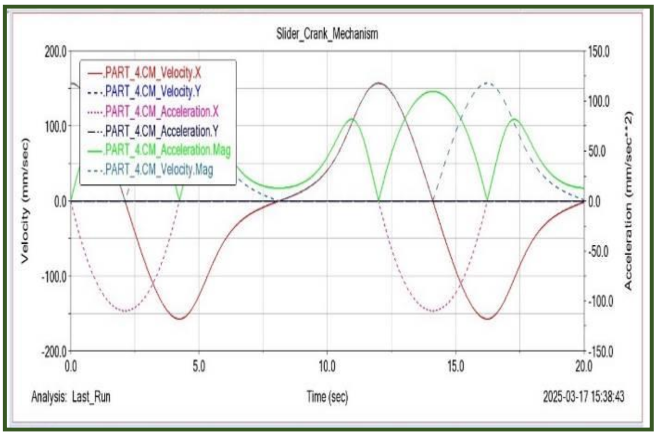

Chart - 1: Various factors of Slider Crank mechanism.

4. CONCLUSION

Slider-Crank Mechanism with Clearance Fault Slider-Crank Mechanism with Clearance Fault Using the Lagrange approach, a dynamic model accounting for clearance tolerances in continuous contact conditions was developed and simulated in MSC Adams akin to the View. Calculating the clearance, or the gap, in the border's framework will definitely alter dynamic displacement, speed, acceleration, and other vibration. Simulation shows maximum clearance results decrease in terral performance and locus measurable changes using Adams. With the aid of Adams/View, a more precise numerical simulation sought to clarify, and possibly lessen, the impediments and breakdowns stemmed clearance defect apology.

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BIOGRAPHIES

P V Mallari
UG Student Mechanical Engineering, RYM Engineering College, Ballari

Sai Rohith G
UG Student Mechanical Engineering, RYM Engineering College, Ballari