USBTU
INTERNATIONAL JOURNAL OF SIVAS UNIVERSITY OF SCIENCE AND TECHNOLOGY
ULUSLARARASI SİVAS BİLİM VE TEKNOLOJİ ÜNİVERSİTESİ DERGİSİ
ISSN:
dergipark.org.tr
DOI:
Araştırma Makalesi / Research Article

Kinematic and Kinetic Analysis of Flexible Four Bar Mechanisms

Ufuk DEMİRCİOĞLU[1*] (Orcid ID: 0000-0002-9707-8271)

Mutlu Tarık ÇAKIR[1] (Orcid ID: 0000-0002-0107-594X)

[1]Sivas University of Science and Technology, Faculty of Engineering and Natural Sciences, Mechanical Engineering Department, Sivas

*Sorumlu yazar (Corresponding author): udemircioglu@sivas.edu.tr

Geliş Tarihi (Received): 17.06.2022 **Kabul Tarihi (Accepted)**: 18.07.2022

Abstract

The aim of the study is to investigate the effect of flexibility on the dynamic analysis of the mechanism. Four bar mechanism is used for the study in order to demonstrate the results. Four bar mechanism is modeled, simulated and post-processed by using MSC Adams software. Different mechanisms composed of rigid bodies, flexible bodies and interconnection of these are modeled and simulated by using this software. Angular velocity, acceleration of mass center of coupler and force at the joint between coupler and rocker is simulated for different four bar mechanisms. Results are comparatively evaluated. The effect of flexibility on dynamics of four bar mechanism is investigated and results are graphically presented.

Keywords: Four bar mechanisms, MSC Adams, flexible members

INTRODUCTION

Kinematic and kinetic analysis is the study of the motion and forces of the mechanisms respectively. Kinematic and kinetic analysis of mechanisms involves the measurement of position, velocity, acceleration and forces of one or more body parts. Measurement can be linear measurements of specific parts or angular measurements at joints, or a combination of these two performed in order to quantify the special and temporal properties of movements of multiple body parts simultaneously. Kinematic and kinetic analysis of mechanisms can be done either analytically or graphically. Analytical method is suitable for computer programing as much as time consuming. However once the analytical model is implemented to computer it can be reused in the future time. On the other hand, graphical method is very useful especially when quick and rough results are desired. As a result, graphical method is used in conceptual design stage of product design. Yet these days there are great demands to reduce time and speed up product design process. Also, integration of the different mechanisms of product needed is necessary to connect individual parts into one comprehensive model. These problems can be solved by employing suitable computer software.

Hroncová et al. (2014) studied the simulation of kinematic analysis of a press mechanism. Simulation is performed by using MSC Adams software. The study consists of modeling press mechanisms, running simulation and plotting the kinematic parameters. Rotational motion, translational motion and general plane motion of the members are determined during the study. From simulation it was obtained that MSC Adams can be used for modeling systems of more degrees of freedom, their static, kinematics and dynamic analysis conveniently and efficiently (Hroncová et al., 2014). Hroncová et al. (2014) studied the kinematic analysis of slider crank mechanism by using MSC Adams. Table of parameters is created to parametrize the geometry of slider crank mechanisms. A functional dynamic model of slider crank mechanism is modeled and later on complete kinematic analysis is performed. Different slider crank mechanisms are created from functional model and simulated comparatively (Hroncová et al., 2012). Hroncová et al. (2014) simulated the kinematic analysis of a six-member mechanism using MSC Adams. A virtual product is modeled in MSC Adams view simulated. From simulation trajectory of members, angular rotation, angular velocity and angular acceleration were obtained. Subsequently, result from simulation was further processed by the postprocessor of Adams view. Overly, it was concluded that using computer software ease the design process (Hroncová and Frankovský, 2014). Hroncová and Delyová (2019) studied the motion analysis of single point of mechanism. The trajectory of point is analyzed both numerical and with simulation using MSC Adams. When comparison made it is clear that utilizing computer software is useful to analysis (Hroncová and Delyová, 2019). Çakan and Botsali (2017) studied the inverse kinematic of PUMA robot. Multi-body dynamics of robot are modeled using MSC Adams joints angles are derived from inverse kinematics. To do so, circle shaped trajectory is given to end effector and joint angles are derived from this motion. From simulation it was concluded that inverse kinematics analysis gives visual animations and using MSC Adams is a successful and effective method for solving inverse kinematics. It was also pointed out that complicated model whose mathematical model is hard to obtain can be modeled and simulated (Çakan and Botsali, 2017). Talli and Kotturshettar (2015) studied the forward kinematics of anthropomorphic robot manipulator by using MSC Adams. multibody dynamic model of the robot was developed using MSC Adams software. Kinematic equations are also developed to compare computer simulation results. Joint angles are found from simulation and kinematic equation. When results are compared it is clear that there is nearly any error between kinematic model and MSC Adams Modal (Talli and Kotturshettar, 2015). Sharma and Ranjan (2013) studied the kinematic analysis of four bar planar mechanism using MSC Adams. Four bar mechanism is modeled and simulated by using MSC Adams. During the study the position of links, speed of links and angular acceleration of links are studied. From results it was concluded that MSC Adams is very fast and needs less labor and it is very efficient than graphical and analytical methods. It was also pointed out that using simulation software gives better results than graphical and analytical methods since graphical and analytical methods have inherent errors (Sharma and Ranjan, 2013). Beyaz and Dağtekin (2018) investigated kinematic analysis of crank rod of tractor motor using MSC Adams. Different crank rod mechanism with different lengths are modeled. Parameters like displacement, velocity, and acceleration of crank rod mechanisms are investigated. From simulation it was observed that any changes of mechanism can be simulated using software in a short time. Also it was point that performance of mechanism can be increased by using software (Beyaz and Dağtekin, 2018). Hroncová and Delyová (2015) investigated the kinematic analysis of valve mechanisms. Mechanical parts are modeled using MSC Adams. Mathematical model of valve mechanism is obtained using Lagrange's equation. From study spring force, spring deformation and valve positions are obtained. It is concluded from results that MSC Adams makes it easier to analysis dynamic of mechanisms especially when mechanisms are complex and have multi degree of freedom (Hroncová and Delyová, 2015). Hroncová and Šarga (2015) studied the dynamic analysis of crank mechanisms of a conveyor. MSC Adams view is used to model mechanisms and subsequently to analysis it. Velocity, acceleration, angular acceleration and displacement of individual members are investigated thoroughly. From results it was pointed out that using MSC Adams gives the benefit of graphical results representation (Hroncová and Šarga, 2015). Sapietová and Dekýš (2016) investigated the misalignment of rotating machine by using MSC Adams. Two different misalignment namely, parallel and angular misalignment are studied. By considering these misalignment parameters like deflection, velocity and acceleration are investigated (Sapietová and Dekýš, 2016). Alexandru (2017) studied the multi-criteria optimization of the hood mechanism of a container by using MSC Adams. The objective function, design variables and design constraints are set. Lengths and the position angles of the links (2,5) are set as design variables. Three design constraints are set as follows 1) The hood does not interfere with the filter throughout the entire range of motion; 2) The inclination angle is of 50 degrees when the hood is fully open; 3) The filter is accessible from above when the hood is open. The objective function of the study is to minimize the material cost. The optimal value of design parameters of the mechanism is defined. From result improved mechanism of hood mechanism with slight changes was obtained (Alexandru, 2017). Hroncová and Grieš (2014) investigated the projectile of a point mass. The simulation is performed using MSC Adams. Simulation is performed under two different condition namely, when air resistance is included and air resistance is not included. During study speed, distance and acceleration of point mass is plotted (Hroncová and Grieš, 2014)

Both analytical and graphical methods are performed based on assumptions. It is assumed that all the members of mechanism are rigid. However, real life mechanisms are deformable. So, the deformation of members of mechanism should be considered in the analyzing stage if one needs results that are close to truth. However, when above mentioned situation is considered it is hard when analyzing mechanism by analytical or graphical method. Therefore, the purpose of this study is kinematic and kinetic analysis of four bar mechanism by including the flexibility.

MATERIAL AND METHOD

In this section modeling, kinematic and kinetic analysis of four mechanisms is described. Four bar mechanisms is modeled by using MSC Adams. All the links and joints are modeled in MSC Adams. Crank, coupler and rocker are modeled and dimension of them are 0.130 m, 0.223 m and 0.170 m respectively. Ground pins are located 0.25 m apart from each other. Four bar mechanism is modeled as shown in figure 1. Two different four bar mechanism is modeled and analyzed in this study. Firstly, all the members of the mechanisms are modeled as rigid bodies. Later on members are made flexible and analyzed again.

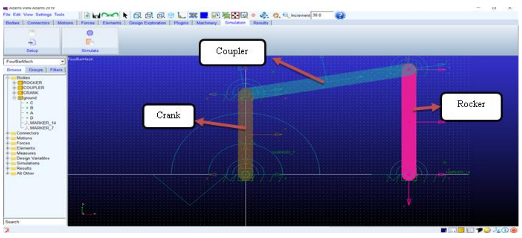

Figure 1. MSC Adams model of four bar mechanisms

RESULTS AND DISCUSSION

Rigid Body Simulation

In this part of the study all the links are assumed to be rigid. Angular velocity and acceleration of mass center of coupler is simulated. Also force at the joint between coupler and rocker is simulated. 30 degrees/second motion is given to crank and the simulation is run. After that result of simulation is processed by using MSC Adams postprocessor. Angular velocity, acceleration and force obtained and illustrated in figure 2, figure 3 and figure 4 respectively.

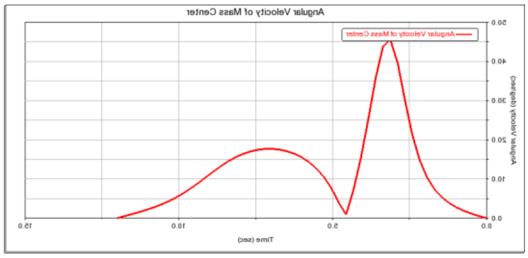

Figure 2. Angular velocity of coupler

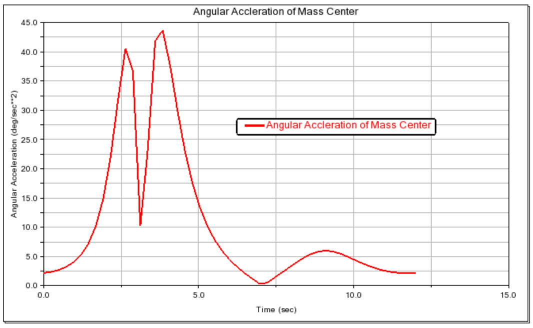

Figure 3. Angular acceleration of coupler

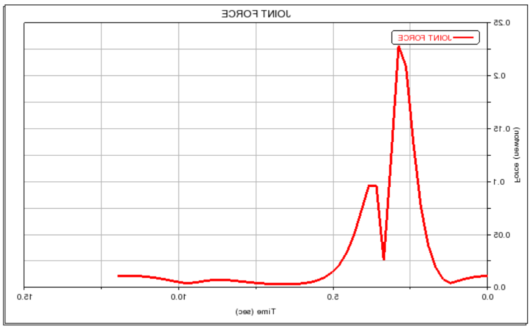

Figure 4. Force developed at joint between coupler and rocker

Flexible Body Simulation

After rigid body simulation, flex body simulation is performed in order to see effect of flexibility on the results of the analysis. Simulation is performed at 2 different speed as shown in figure 5 and figure 6. To do so, links are made flexible and simulated again. Three different simulation is run at each speed. Firstly, crank is made flexible and simulation is run and result is recorded. After that in addition to crank coupler is made flexible and simulated. Finally, all the links are made flexible and simulation run. Figure 5 and figure 6 clearly shows the effect of the flexibility on force developed at the joint. When the links are made flexible the force developed at joint changes which clearly indicates that the flexibility greatly effects the results. Simulation results clearly indicates that the flexibility has to be considered during kinematics and kinetics analysis.

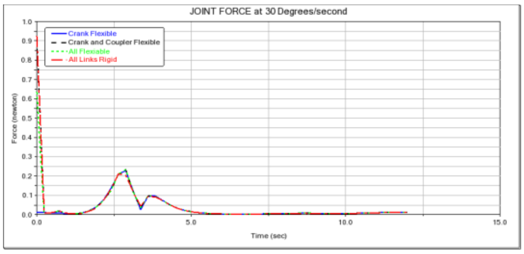

Figure 5. Force developed at joint between coupler and rocker under 30 degrees/ second

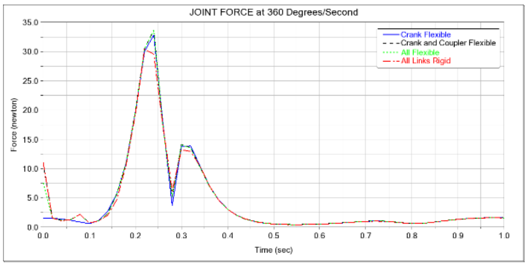

Figure 6. Force developed at joint between coupler and rocker under 360 degrees/ second.

CONCLUSION AND SUGGESTIONS

Virtual modals of four bar mechanisms are modeled and analyzed in this study. Simulation of modals were performed by using MSC Adams software. All desired results are obtained using this software and processed further using MSC Adams postprocessor. The influence of flexibility on the dynamics of four bar mechanism is investigated thoroughly. From results, it was observed that using the software is of the great benefit. In addition to analytical method and graphical method using software like MSC Adams gives more details about the dynamic of the mechanisms. It was also observed that the flexibility has great effect on kinematics and kinetics of the mechanisms.

ACKNOWLEDGE

We thank to reviewers and editors for their valuable time they spent evaluating our article.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest between the authors.

STATEMENT OF RESEARCH AND PUBLICATION ETHICS

The study is not complied with research and publication ethics

REFERENCES

Alexandru, C. 2017. "Multi-Criteria Optimization of the Mechanical Systems by Virtual Prototyping Tools." *International Journal of Modeling and Optimization* 7 (3): 134–38. https://doi.org/10.7763/ijmo.2017.v7.572.

Beyaz, A., Dağtekin, M. 2018. "Kinematic Analysis of Tractor Engine Crank-

Rod Mechanism Traktör Krank-Biyel Mekanizmasının Kinematik Analizi." *Çukurova University Journal of the Faculty of Engineering and Architecture* 33 (September): 93–100.

Çakan, A., Botsali, F.M. 2017. "Inverse Kinematics Analysis of A Puma Robot By Using Msc Adams." *ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering*, no. January: 24–28.

Hroncová, D., Michal B., Šarga, P., Kičák, F. 2012. "Kinematical Analysis of Crank Slider Mechanism Using MSC ADAMS/View." *Procedia Engineering* 48 (June 2015): 213–22. https://doi.org/10.1016/j.proeng.2012.09.507.

Hroncová, D., Delyová, I. 2019. "Motion Analysis Of Point Of A Simple Mechanism." *Acta Tecnología - International Scientific Journal about Technologies* 5 (4): 97–102. https://doi.org/10.22306/atec.v5i4.66.

Hroncová, D., Delyová, I., Frankovský, P. 2014. "Kinematic Analysis of Mechanisms Using MSC Adams." *Applied Mechanics and Materials* 611 (November 2016): 83–89. https://doi.org/10.4028/www.scientific.net/AMM.611.83.

Hroncová, D., Frankovský, P., Virgala, I., Delyová, I. 2014. "Kinematic Analysis of the Press Mechanism Using MSC Adams Kinematic Analysis of the Press Mechanism Using MSC." *American Journal of Mechanical Engineering* 2 (November): 312–15. https://doi.org/10.12691/ajme-2-7-30.

Hroncová, D., Maroš Grieš. 2014. "Trajectories of Projectiles Launched at Different Elevation Angles and Modify Design Variable in MSC Adams/View." *Applied Mechanics and Materials* 611 (November): 198–207. https://doi.org/10.4028/www.scientific.net/AMM.611.198.

Hroncová, D., Šarga, P. 2015. "Kinematics Analysis of the Crank Mechanism Conveyor Using MSC Adams." *Applied Mechanics and Materials* 816 (November): 140–49. https://doi.org/10.4028/www.scientific.net/amm.816.140.

Hroncová, D., Sivák, P., Delyová, I. 2015. "Kinematical Analysis of Valve Mechanism Using MSC Adams/View." *Applied Mechanics and Materials* 816 (November 2016): 108–17. https://doi.org/10.4028/www.scientific.net/amm.816.108.

Sapietová, A., Dekýš, V. 2016. "Dynamic Analysis of Rotating Machines in MSC.ADAMS." *Procedia Engineering* 136 (December): 143–49. https://doi.org/10.1016/j.proeng.2016.01.188.

Sharma, R.P., Ranjan, C. 2013. "Modeling And Simulation Of Four-Bar Planar Mechanisms Using Adams." *International Journal Of Mechanical Engineering And Technology (IJMET)* 4 (2): 429–35.

Talli, A.L., Kottürshettar, B.B. 2015. "Forward Kinematic Analysis, Simulation & Workspace Tracing of Anthropomorphic Robot Manipulator By Using MSC. ADAMS." *International Journal of Innovative Research in Science, Engineering and Technology* 04 (01): 18462–69. https://doi.org/10.15680/ijirset.2015.0401009.