American Journal of Mechanical Engineering, 2013, Vol. 1, No. 7, 370-373
Available online at http://pubs.sciepub.com/ajme/1/7/43

DOI:10.12691/ajme-1-7-43

Dynamic Analysis of the Shaping Machine Mechanism

Darina Hroncová[*], Ingrid Delyová, Peter Frankovský, Anna Puzderová

Department of applied mechanics and mechatronics, Technical University of Košice / Faculty of mechanical engineering, Košice, Slovakia
*Corresponding author: darina.hroncova@tuke.sk

Received October 10, 2013; Revised October 14, 2013; Accepted November 21, 2013

Abstract This paper considers the problem of dynamic analysis of a shaping machine mechanism. Mathematical model for the mechanism was compiled and computer simulation was done in the program MSC Adams/View. The results of the computer simulation are kinematical parameters of individual members of the mechanism.

Keywords: *mechanism, Equation of Motion, dynamic analysis, simulation, MSC Adams*

Cite This Article: Darina Hroncová, Ingrid Delyová, Peter Frankovský, and Anna Puzderová, "Dynamic Analysis of the Shaping Machine Mechanism." *American Journal of Mechanical Engineering* 1, no. 7 (2013): 370-373. doi: 10.12691/ajme-1-7-43.

1. Introduction

Development of mechanization and automation of production processes requires the construction of new machines and mechanisms. Today's time forces us to technological development still improve and expedite the creation of new mechanical systems. Computer simulations bring ease to and accelerate the innovation of mechanical systems.

One of the most widely used software for dynamic analysis is MSC ADAMS (Automatic Dynamic Analysis of Mechanical Systems). MSC Adams includes a number of modules. MSC Adams/View module is used to for simulation and visualization of the model and it facilitate the evaluation of the analytical results. With Adams/Solver it forms a tool that allows us to deal with all types of MBS (multi-body systems) [4].

With the development of society also arises the need in progress in automation and mechanization of production processes. This creates the need for constructing new machinery and equipment. Instruments and machines consist of different mechanisms having substantially different functions and structure. Despite this fact a number of mechanisms have common basic functions and structure.

2. Mathematical Model of the Mechanism

The basic and also most universal method for the dynamic analysis of mechanical systems is the method which uses the second Newton's law. The mathematical model of a four member mechanism in Figure 1 was derived by using this method. The driving torque M_h is exerted on the driving member 2. The resistive force F acts on the driven member 4 with the known geometric and mass properties. In the dynamical analysis the friction between respective members was neglected [1,2,3].

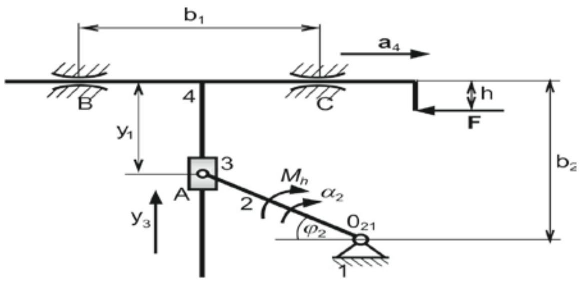

Figure 1. Four-bar mechanism

To compile equations of motion we analyze the individual members of the mechanism. The links are represented by forces acting on them.

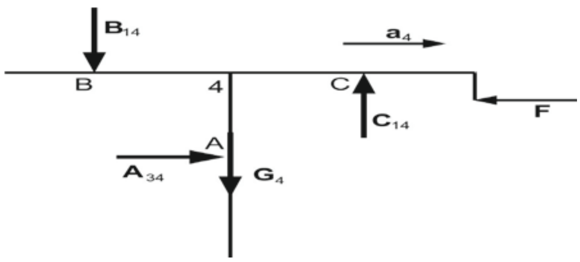

Figure 2. Analysis of member 4

Member 4 as shown in Figure 2 performs translational movement in the horizontal direction. The equations of motion are in form

$$m_4.a_4 = -F + A_{34}, \tag{1}$$

$$I_4.\alpha_4 = C_{14}.b_1 - F.h + A_{34}.y_1, \tag{2}$$

where m_4 is the weight, a_4 the acceleration, I_4 the moment of inertia and α_4 the angular acceleration of the member 4.

For member 4 stays that $a_{4y} = 0$ and $\alpha_4 = 0$. Thus the equations of motion have the form

$$0 = -B_{14} + C_{14} - G_4, \tag{3}$$

$$0 = C_{14}.b_1 - F.h + A_{34}.y_1, \tag{4}$$

while

$$y_1 = b_2 - y_2 = b_2 - b.\sin\varphi_2, \tag{5}$$

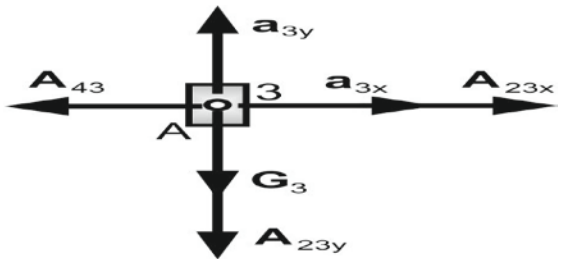

Figure 3. Analysis of member 3

Member 3 describe in Figure 3 of the mechanism performs curvilinear translational movement considering it as a particle. The equations of motion the member 3 are

$$m_3.a_{3x} = A_{23x} - A_{43}, \tag{6}$$

$$m_3.a_{3y} = -A_{23y} - G_3, \tag{7}$$

where m_3 is the mass of the member 3 and a_{3x}, a_{3y} are components of the acceleration of member 3

By application of the principle of action and reaction stands $A_{43} = A_{34}$.

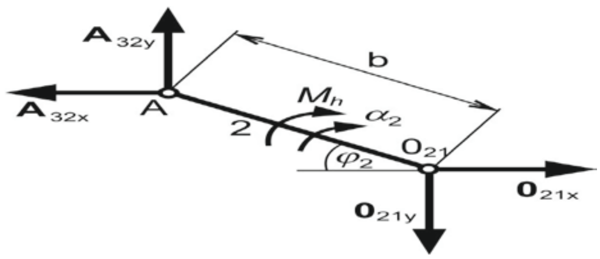

Figure 4. Analysis of member 2

The member 2 performs rotational motion around a fixed axis of rotation perpendicular to the plane of movement and going through point O_{21}. The sliding action of forces acting on member 2 is zero, therefore the equations of motion are

$$O_{21x} - A_{32x} = 0, \tag{8}$$

$$-O_{21y} + A_{32y} - G_2 = 0, \tag{9}$$

$$I_{20}.\alpha_2 = M_h + A_{32y}.b.\cos\varphi_2 - A_{32x}.b.\sin\varphi_2 - G_2.b/2.\cos\varphi_2, \tag{10}$$

where $A_{32x} = A_{23x}$, $A_{32y} = A_{23y}$, I_{20} is the moment of inertia of member 2, α_2 is the angular acceleration of member 2 and m_2 is mass of the member 2, while

$$I_{20} = 1/3.m_2.b_2^2, \tag{11}$$

$$x_A = x_3 = x_4 = -b.\cos\varphi_2, \tag{12}$$

$$a_{3x} = a_4 = b.\alpha_2.\sin\varphi_2 + b.\varphi_2^2.\cos\varphi_2, \tag{13}$$

$$y_A = y_3 = b.\sin\varphi_2, \tag{14}$$

$$a_{Ay} = a_{3y} = b.\alpha_2.\cos\varphi_2 - b.\omega_2^2.\sin\varphi_2, \tag{15}$$

The movement of the system is described by a system of equations. Given the complexity of solving this system of equations the simulation in MS Adams is chosen as the further step in the analysis [8,9].

3. Simulation in MSC Adams/View

For dynamic analysis of individual members of a four-member mechanism we compiled its model in MSC Adams in Figure 5. After running the simulation we can measure the movements of individual members exerted by the driving force and observe the time diagrams of respective kinematical variables [5,6].

Between members 1 and 2 is rotational joint as well as between members 2 and 3. Member 3 also performs translational movement relative to member 4 therefore these members have also a translational joint. Measures are used to observe the forces in the joint A and 0_{21} and are placed in the respective locations [7].

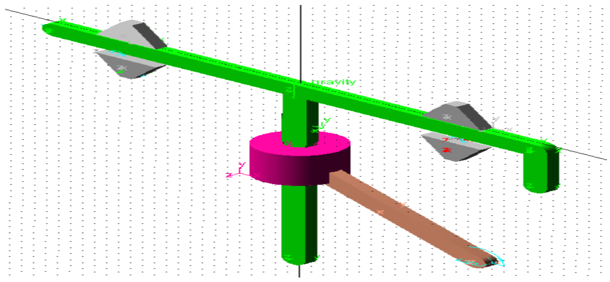

Figure 5. Model of the mechanism in MSC Adams/View

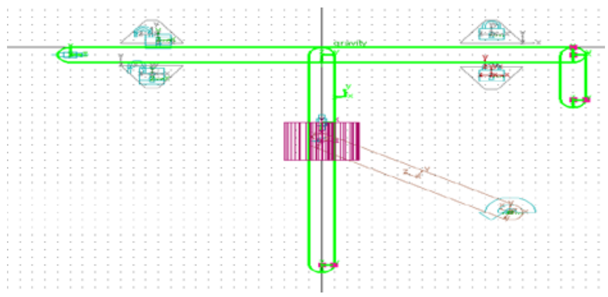

Figure 6. Model with links and joints

The next step is entering the boundary conditions and running the simulation in MSC Adams/View. The result of the simulation is the kinematical parameters of individual members of the mechanism. The individual measures in joints give the respective forces in a defined time interval. In time t = 0,25s the force A = 10,02N in Figure 7 and in Figure 8. The translational joint between member 3 and 4 was measured force $A_{34} = A_{43}$ = 9,97N in Figure 9.

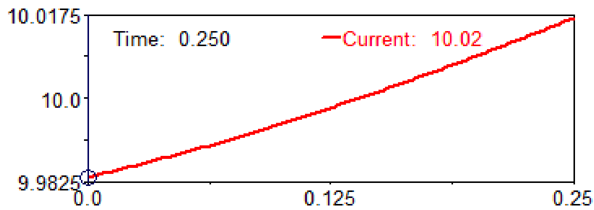

Figure 7. Time diagram of force in joint A

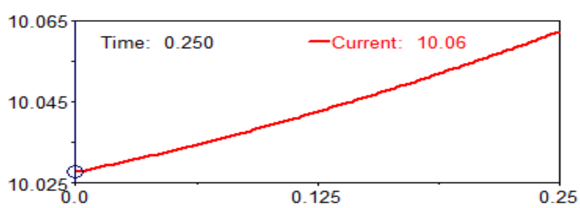

Figure 8. Time diagram of force in joint O_{21}

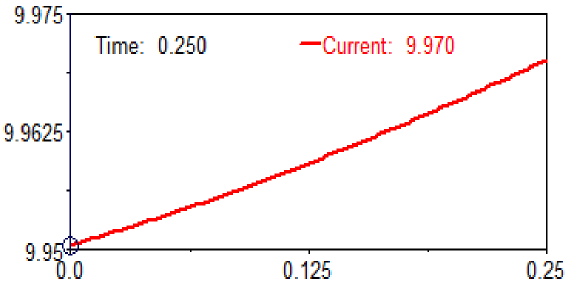

Figure 9. Time diagram of force in joint between members 3 and 4

Movement of member 3 is given by the displacement y_3, velocity v_3 and acceleration a_3. Their time diagrams are in Figure 10.

Member 2 performs rotational movement around the pivot and is rotated by angle φ_{21} relative to the base i.e. the member 1. In the Figure 11 there is the time diagram of the rotation angle φ_{21}. The time diagram of the angular velocity ω_{21} of member 2 is in Figure 12.

Movement of member 4 is given by displacement x_4, velocity v_4 and acceleration a_4.

The time diagram of these parameters is in Figure 13, Figure 14, Figure 15 and Figure 16.

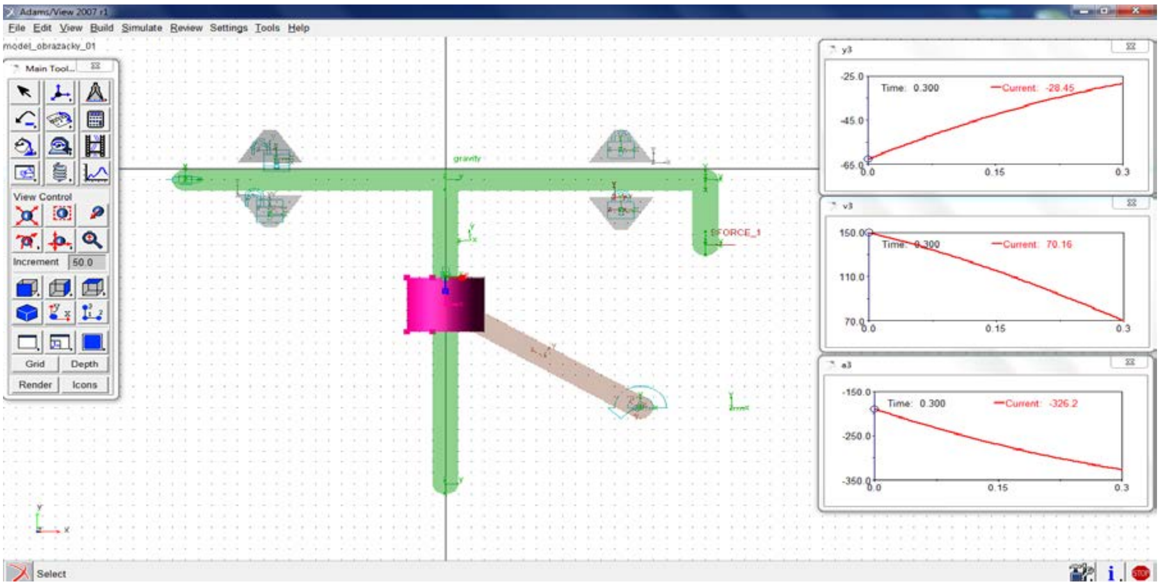

Figure 10. Model of the mechanism with time diagrams of kinematical parameters of member No. 3

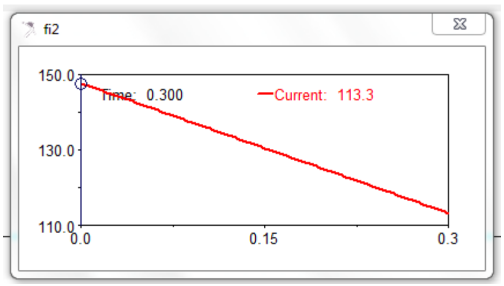

Figure 11. Time diagram of rotation angle φ_{21}

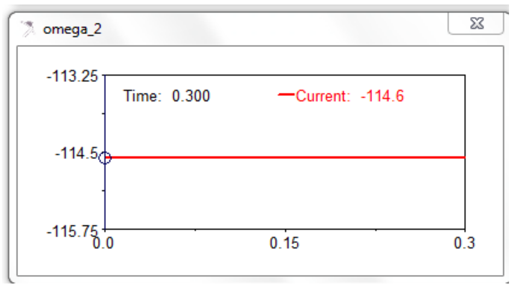

Figure 12. Time diagram of angular velocity ω_{21}

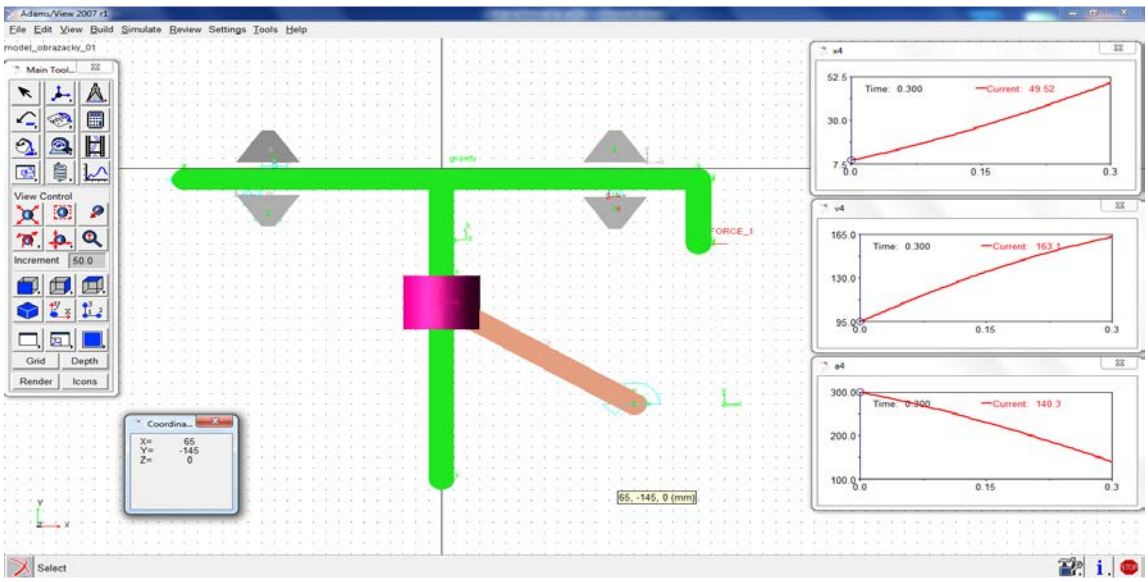

Figure 13. Model of the mechanism with time diagrams of kinematical parameters of member No. 4

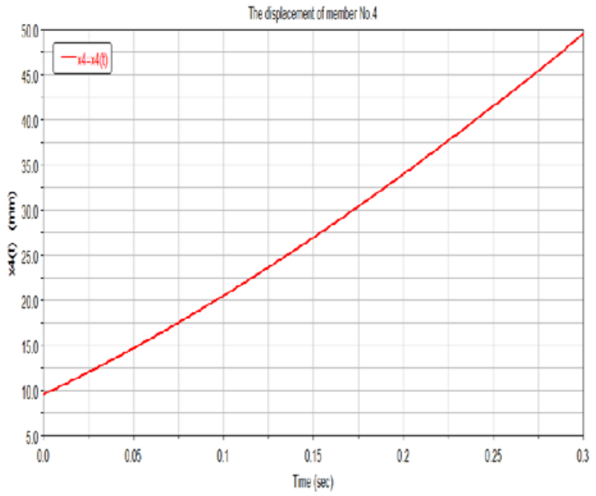

Figure 14. Displacement x_4(t) of the member No. 4

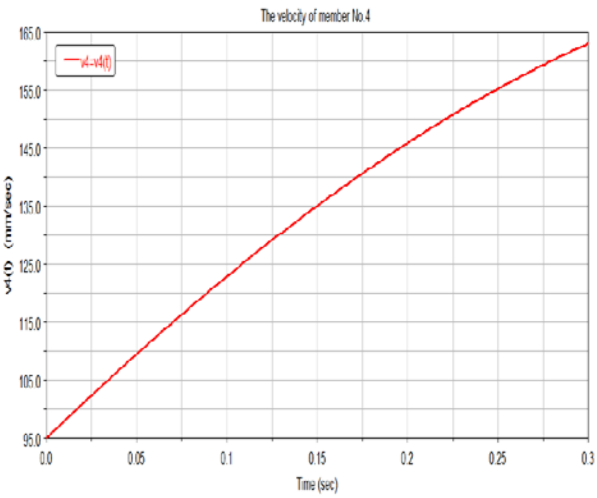

Figure 15. Velocity v_4(t) of the member No. 4

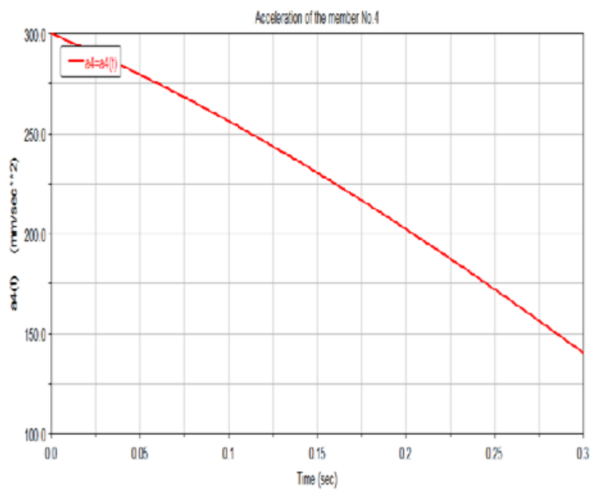

Figure 16. Acceleration a4(t) of the member No. 4

4. Conclusion

Program MSC Adams/View makes it easy to analyze complex mechanical systems with multiple degrees of freedom. In the paper one module of the number of modules namely MSC Adams/View was used as a tool which allows a better simulation and visualization of the model and easier evaluation of the results obtained. With the module Adams/Solver they represent a tool that is able to addresses various types of mechanisms with many degrees of freedom. The results obtained by the simulation of four-member mechanism of the shaping machine were processed by the postprocessor program of MSC Adams/View.

Acknowledgement

This work was supported by grant projects VEGA No. 1/0289/11, VEGA No. 1/1205/12 and grant projects VEGA No. 1/0937/12 and APVV-0091-11.

References

[1] Drahoš, P., Kutiš, V., Dúbravský, J., Sedlár, T., 2011. *Design and Simulation of SMA Actuator*, International Review of Automatic Control. Vol. 4, No. 4 (2011), p. 588-593.

[2] Hanzel, J., Jurišica, L., Kľúčik, M., Duchoň, F., 2011. *Identification of the Experimental Ultrasonic System Parameters, in"AD ALTA"* Journal of Interdisciplinary Research. Vol. 1, Iss. 2 (2011), p. 138-141.

[3] Hanzel, J., Kľúčik, M., Jurišica, L., Vitko, A., 2011. *Identification Based Model of Ultrasonic Sensor*, in "Research and Education in Robotics - EUROBOT 2011". Prague, Czech Republic, Heidelberg, Springer, pp. 144-157.

[4] Novotný, L., Tsunori, M., 2011. *Creation of Imperfections for Welding Simulations*, in "CMES: Computer Modeling in Engineering & Sciences," Vol.82, Nos.3&4, p. 253-264.

[5] Pásztó, P., Hubinský, P., 2010. "*Application of a Visual System for a Mobile Robot Navigation (OpenCV)*," in Process Control 2010," 9th International Conference. University of Pardubice, Kouty nad Desnou, Česko, paper C015a.

[6] Delyová, I., Frankovský, P., Hroncová, D., 2011. *Kinematic analysis of movement of a point of a simple mechanism*," 4th International Conference Modelling of mechanical and mechatronics systems, KAMaM, TU Košice, Herľany, Slovakia.

[7] Segľa, Š., Segľa, J., 2011. *Modelling and Optimization of Vehicle suspension with Magnetorheological Dampers*, 7th International Conference Dynamics of Rigid and Deformable Bodies 2008, FVTM UJEP Ústí nad Labem , Česko.

[8] Skočilas, J., Skočilasová, B., Soukup, J., 2011. *Investigation and vibration of vehicle mechanical model*. In: Dynamika tuhých a deformovatelných těles 2011 - Sborník přednášek z 9. mezinárodní konference v Ústí nad Labem, FVTM UJEP, Ústí nad Labem, Česko.

[9] Svoboda, M., Soukup, J., 2011. „*Analytical solutions of motion equations of railway car, determination of bazic geometric, mass and stiffness parameters*," Dynamika tuhých a deformovatelných těles 2011 - Sborník přednášek z 9. mezinárodní konference. FVTM UJEP, Ústí nad Labem, Česko.