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Kinematical Analysis of Crank Slider Mechanism with Graphical Method and by Computer Simulation

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Abstract The thesis focuses on kinematics analysis of a six-member planar mechanism using the MSC Adams software. The aim of the thesis is to create a model of a crank mechanism with rocking lever in the MSC Adams software and to perform a kinematics analysis on it. The first chapter is dedicated to mechanism theory. The second chapter contains theoretical basis for the issue of simultaneous movements and information about selected kinematics quantities. The next chapter contains a brief description of the solved mechanism. Next, graphic solution of the selected mechanism is performed for result comparison. The next chapter briefly describes the basic workspace of the MSC Adams and lists the process of modeling the selected mechanism. The results of the solutions are numerical values and graphs of selected kinematics quantities depicted in tables and graphically. Data acquired from the graphic solution and from computer modeling are compared and evaluated.

Keywords: *kinematics, mechanisms, MSC adam/views, simulation, modeling, graphic solution*

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1. Introduction

Modeling and simulation to increased the function mainly in the creation of new prototype and allows eliminate structural weaknesses of finished products. Using simulation programs we can significantly reduce the time and financial costs required for the development, improve the efficiency and quality of products and also to detect possible hidden structural weaknesses. The group of such programs include: SolidWorks, Matlab, Ansys, MSC Nastran, MSC Adams. In this work in the computer modeling program used MSC Adams. The program allows you to make kinematics and dynamic analysis and simulation of mechanical systems. It is among the most widely used simulation programs of its kind [5].

This article is dedicated to solving the kinematics analysis of the mechanism of six members. The aim of this work is to model the crank mechanism of the rocker arm in the program MSC Adams and perform kinematics analysis.

Attention is paid to the theory of mechanisms and issues of contemporary movements. In this article is given a brief description of the solution mechanism. The work contains a graphics solution that mechanism modeled in CorelDRAW. It contains a brief description of the basic working environment program and MSC Adams said the six-member process modeling mechanism. Finally, the simulation results are shown in the form of numerical values, the graph of kinematics variables and tables. At the end of the figures obtained from the graphical solutions and figures derived from computer simulations are compared and evaluated.

2. Theory of Mechanisms

The term means all the mechanisms associated relatively movable bodies, which serve to transfer the force effect, move or change the type of movement. For example, change the translational movement of the member of mechanism, the rotational motion of the second member of mechanism. And also allow management points and bodies after pathway [2].

The mechanisms which are moving in parallel planes to each other are called a planar mechanism. Addressing these systems is simpler and clearer than in cases of spatial mechanism, but the theory is very similar. Problems and solutions of plane mechanism is the theme of this work, so the following sections are devoted to this mechanism [1,2].

2.1. Three Member Mechanisms

They are the basic types of mechanisms. They must be composed of just one general kinematics pairs and with any combination of translational and rotational kinematics pairs. The typical example of the three members mechanisms are cam mechanisms (Figure 1).

2.2. Four Member Mechanisms

Crank slider mechanism (Figure 2) consisting of a rotary kinematics pairs of the one sliding kinematics pair, which is arranged between the frame and the piston [2,3].

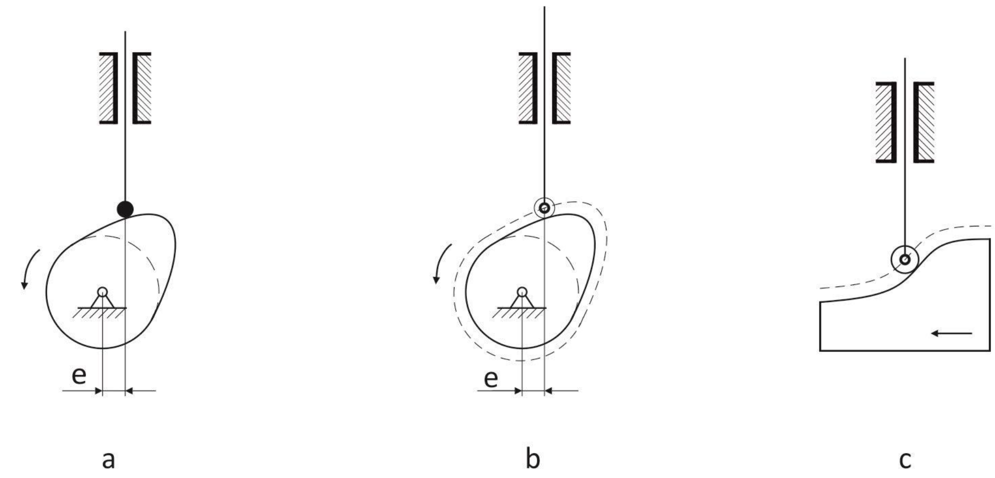

Figure 1. Cam mechanism a) lifter of the cam mechanism, b) lifter of the cam mechanism and pulley, c) thumb of cam

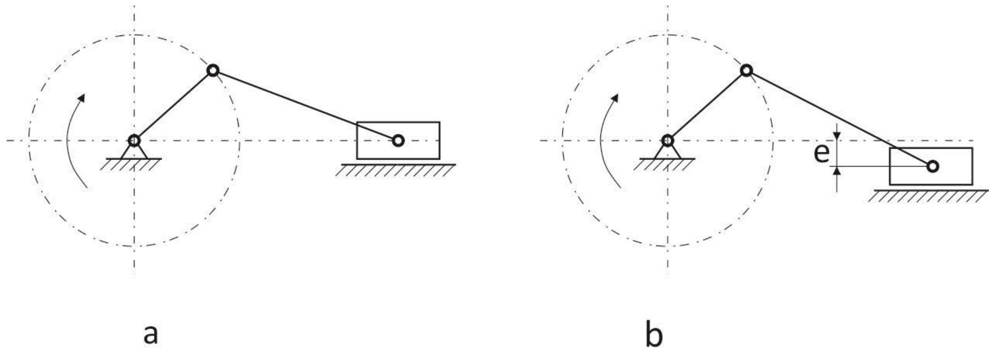

Figure 2. Crank slider mechanism a) without eccentricity (e=0), b) with eccentricity (e≠0)

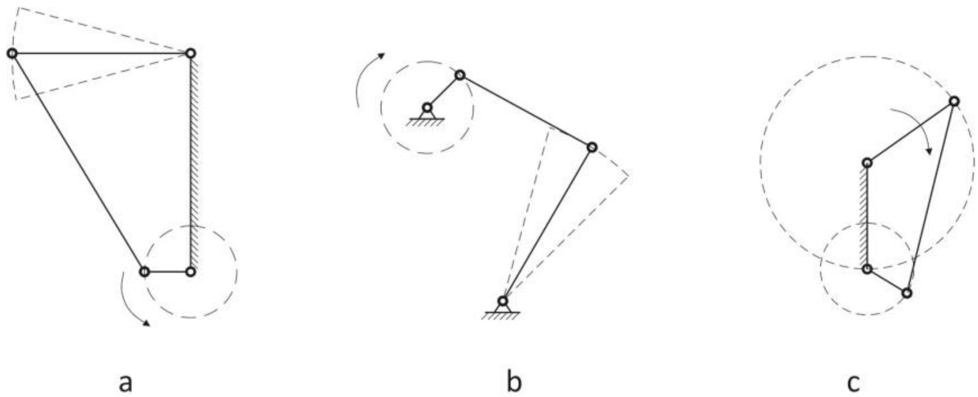

Figure 3. Articulated mechanisms a) centric crank rocker mechanism, b) crank rocker mechanism, c) double crank mechanism

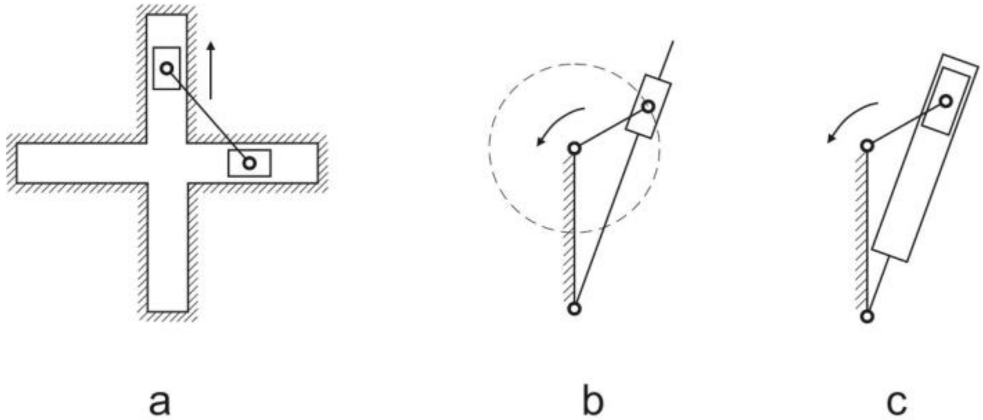

Figure 4. Kinds of crank mechanisms a) rectangular slider crank mechanism, b, c) crank slider mechanisms with rotating cylinder

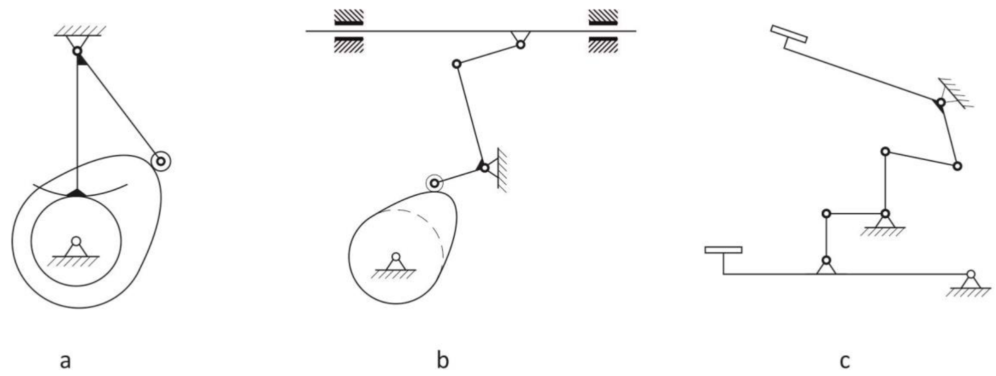

Figure 5. Multiple mechanisms with several degrees of freedom a) cam mechanism with lever, b) a mechanism packing machine, c) a lever mechanism typewriter

Four members articulated mechanisms comprise only a rotary kinematics pair, and either act as the Walking Beam and act as a rocking (Figure 3a, b), or they rotate completely (Figure 3c) [1,2]. A four bar linkage comprises four bar-shaped links and four turning pairs as shown (Figure 3). In a four bar linkage, if the shorter side link revolves and the other one rocks (i.e., oscillates), it is called a crank-rocker mechanism.

The slider-crank mechanism, which has a well-known application in engines, is a special case of the crank-rocker mechanism (Figure 3).

Notice that if rocker in Figure 4 is very long, it can be replaced by a block sliding in a curved slot or guide as shown.

If the length of the rocker is infinite, the guide and block are no longer curved. Rather, they are apparently straight, as shown in Figure 4, and the linkage takes the form of the ordinary slider-crank mechanism [2]. In Figure 5 are many cases mechanisms with combination simple groups.

3. Model of Crank Mechanism

In Figure 6 we can see the kinematics model of a mechanism which is the aim of addressing this work. Members of mechanism move in parallel planes to each other, so we say that it is a planar mechanism. We know that it is composed of six members, which means that it is a composite device. The basis of the mechanism consists of a crank mechanism composed of the members 1, 2, 3 and 4, which is derived from the motion of the arm 6. Member 4 perform the translational motion, the members 2 and 6 perform a rotary motion of the members 3 and 5 carry out a general plane motion. Individual members of the system are indicated as follows: 1 - frame 2 - crank, 3 - rod, 4 - piston, 5 - piston 6 - rotating cylinder.

3.1. Computation of Angular Velocity

Movement of the crank mechanism is defined by the number of crank revolutions n = 800 rev/min (further indicated rpm):

Angular velocity is determined [1]:

$$\omega_{21} = \frac{2\pi n}{60} = \frac{2\pi 800}{60} = 83.7758 \text{ rad.s}^{-1} \qquad (1)$$

where:

ω_{21} – angular velocity,

n – crank revolution, revolutions per minute.

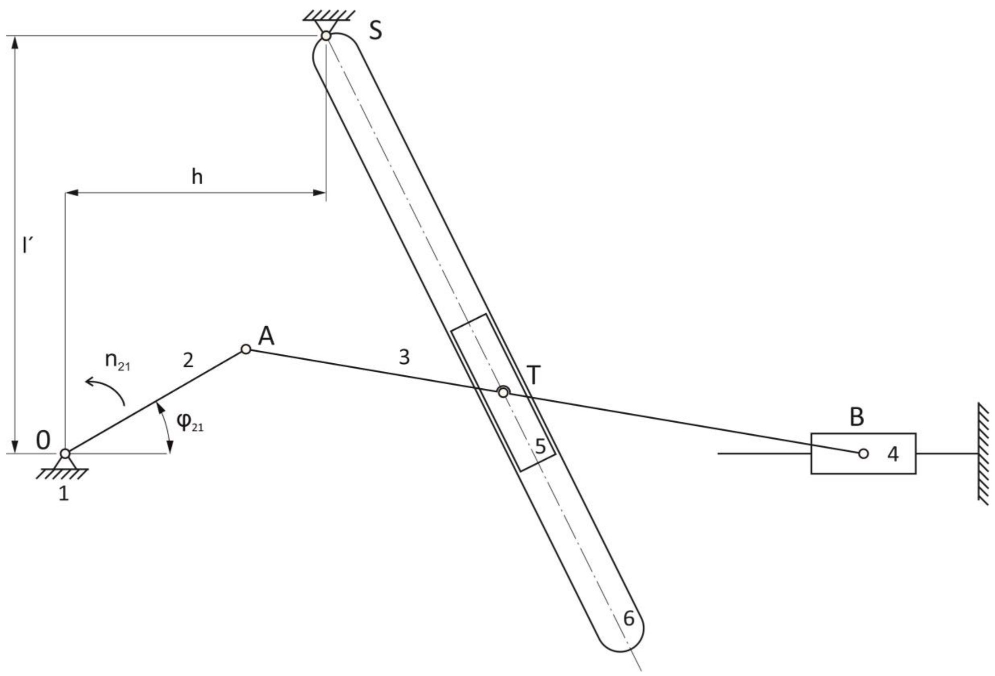

Figure 6. Crank slider mechanism with rotating cylinder

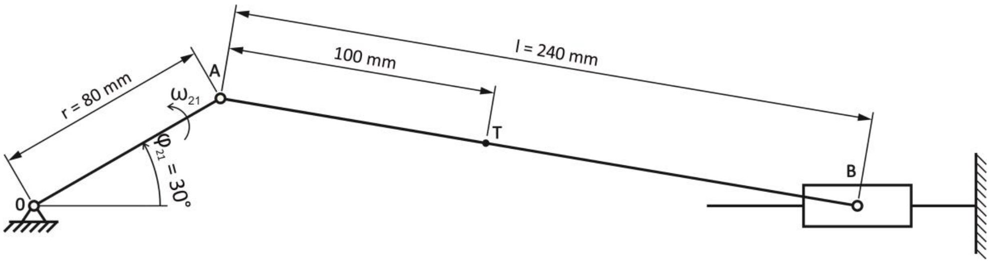

Figure 7. Crank slider mechanism

Velocity in point A is [2]:

$$v_A = \overline{OA}.\omega_{21} = 80.10^{-3}.\frac{2\pi 800}{60} = 6.70206 \text{ m.s}^{-1}. \quad (2)$$

For decomposition of movements: $31 = 32 + 21$, the velocity in point A:

$$v_{A31} = v_{A32} + v_{A21} \quad (3)$$

$$v_A = v_{A21} = v_{A31}. \quad (4)$$

4. Graphics Solution of the Mechanism

When graphics solution are selected following lengths scales, velocity and acceleration scale lengths, velocity and acceleration [3].

Scales lengths:

$$m_d = \frac{d_g}{d_s} = 500 \text{ mm.m}^{-1} \quad (5)$$

Scales velocity:

$$m_v = \frac{v_g}{v_s} = 5 \text{ mm. m}^{-1}\text{.s} \quad (6)$$

Scales acceleration:

$$m_d = \frac{(m_v)^2}{m_d} = 50.10^{-3} \text{ mm.m}^{-1}\text{.s}^2. \quad (7)$$

4.1. Computation of Velocity v_A

Using selected scales are designed in the Figure 8 individual parameters of the mechanism.

Acceleration in point A:

$$\overline{a_A} = \overline{a_{At}} + \overline{a_{An}} \quad (8)$$

where:
a_{At} - the tangential component of the acceleration,
a_{An} - normal component of the acceleration.

The tangential component of the acceleration is a_{At} =0, with Euclid's construction with graphic method is a_{Ang}=28.0735 mm and with scales acceleration is a_{An}=561.47 m.s^{-2}.

4.2. Computation of Velocity v_B

Determination of the velocity of mechanism in point B is shown in Figure 9.

For decomposition of the movement: $31 = 34 + 41$, the velocity in point B:

$$v_{B31} = v_{B34} + v_{B41} \quad (9)$$

$$v_B = v_{B31} = v_{B41} \quad (10)$$

For the wearer of velocity vectors t_{B31}=t_{B41}.

When moving member 3 with respect to the base 1 for velocity we write:

$$v_{B31} = v_{A31} + v_{BA31} \quad (11)$$

where:

$$v_{A31} = v_{A21} \quad (12)$$

The velocity value in graphic solution (Figure 10) is v_{B41g} = 21.6482 mm, v_{BA31g} = 29.4271mm and with scales values are determine v_{B41} = 4.3296m.s^{-2}, v_{BA31} = 5.8854 m.s^{-2}.

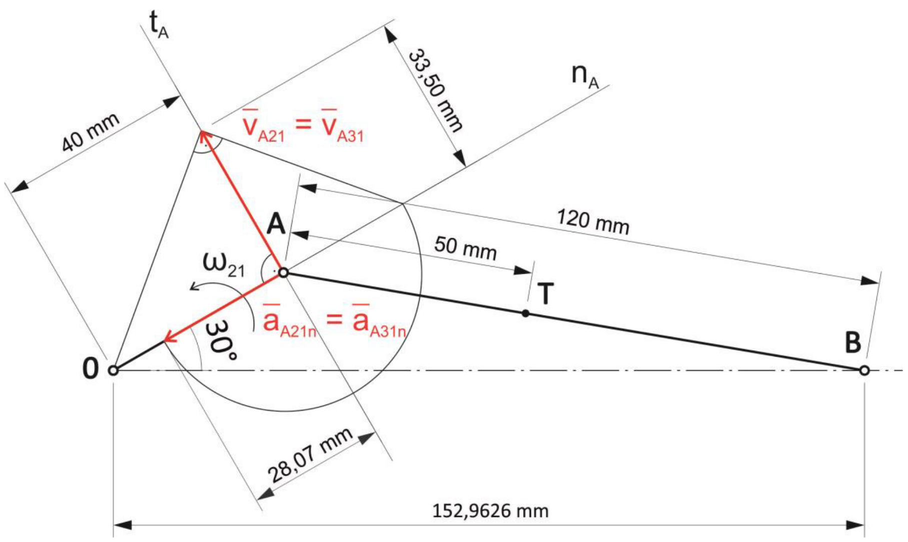

Figure 8. Mechanism in scale and Euclid's construction of the acceleration a_{A21n}

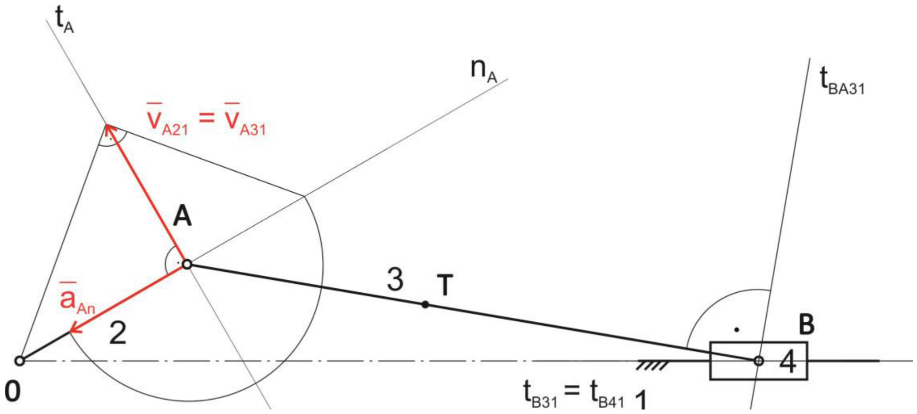

Figure 9. Graphical solution of the velocity in the point A

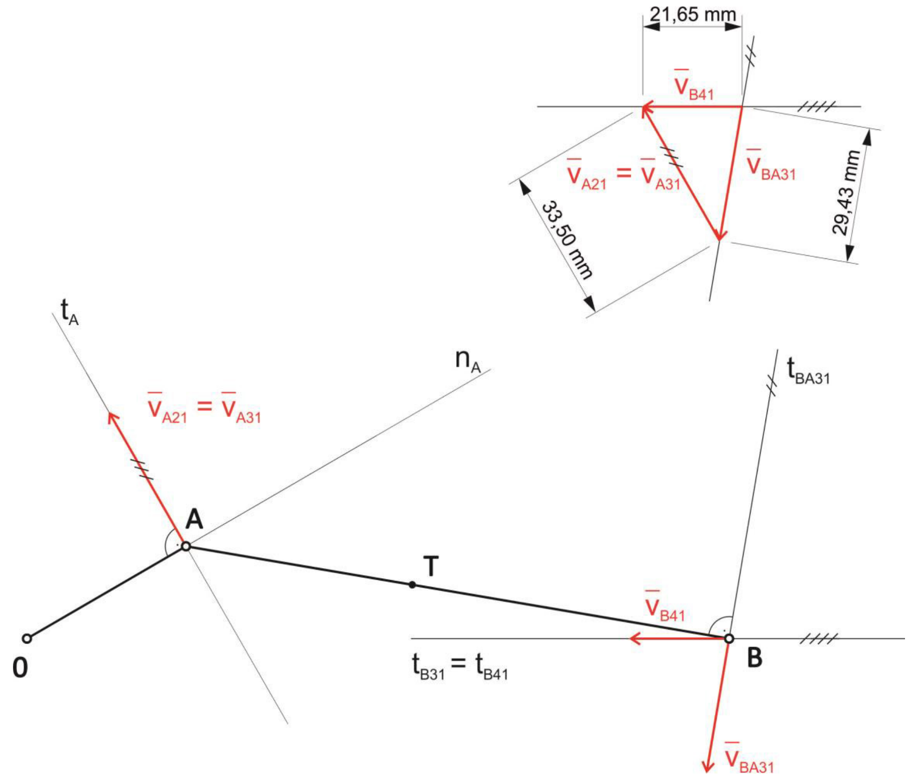

Figure 10. Graphical solution of the velocity for the point A and B

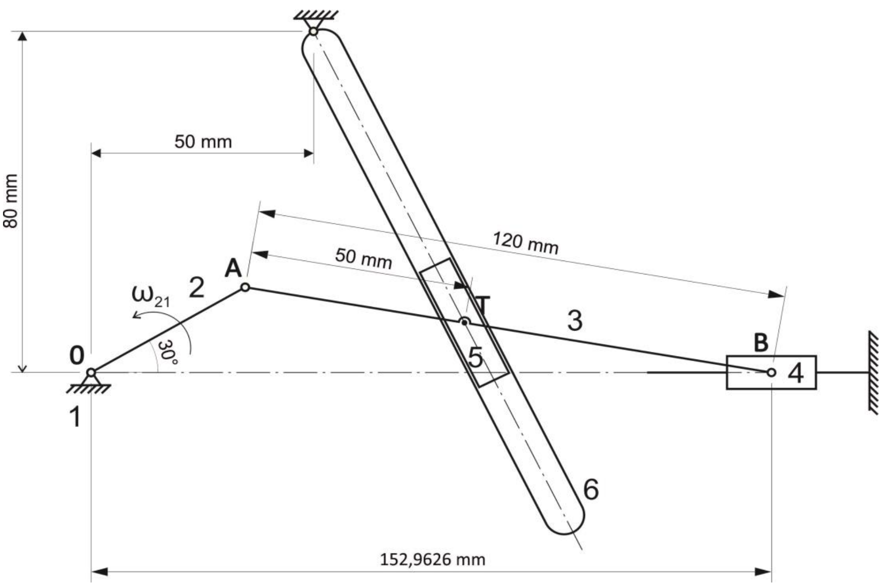

Figure 11. Mechanism in scale for graphics solution

4.3. Computation of Velocity v_T

After determining the dimensions of the piston and the rocker arm in Figure 11 determine the speed at point T.

For velocity and acceleration of point T:

$$v_{T31} = v_{T51} \tag{13}$$

$$a_{T31} = a_{T51} \tag{14}$$

For decomposition of movements: $51 = 56 + 61$, velocity of center of mass T:

$$\bar{v}_{T51} = \bar{v}_{T56} + \bar{v}_{T61} \tag{15}$$

$$\bar{a}_{T51} = \bar{a}_{T56} + \bar{a}_{T61} + \bar{a}_{Cor} \tag{16}$$

$$\bar{a}_{Cor} = 2\omega_{61} \times v_{56} \tag{17}$$

The velocity value of center of mass in graphic solution (Figure 12) is v_{T31g} = 25.2866 mm, velocity of T is v_{T61g} = 9.2495 mm, v_{T56g} = 23.6232 mm and with scales values are determine v_{T31} = 5.0573 m.s^{-1}, v_{T61} = 1.8499 m.s^{-1}, v_{T56} = 4.7246 m.s^{-1} .

Value of the normal component of the acceleration in graphic solution with Euclid's construction (Figure 13) is a_{61ng} = 1.1199mm and with scale is a_{61ng} = 22.398m.s^{-2}.

4.4. Computation of the Acceleration a_T

Determination of Coriolis's acceleration plotted in Figure 14. Direction of Coriolis's acceleration (a_{Cor}) we determined the manner of rotation relative velocity vector (v_r) 90° in the direction of the angular velocity vector (ω_u).

Value of the Coriolis's acceleration in graphic solution with Coriolis's construction (Figure 14) is a_{Corg} = 5.7207 mm and with scale is value a_{Cor} = 114.414 m.s^{-2}.

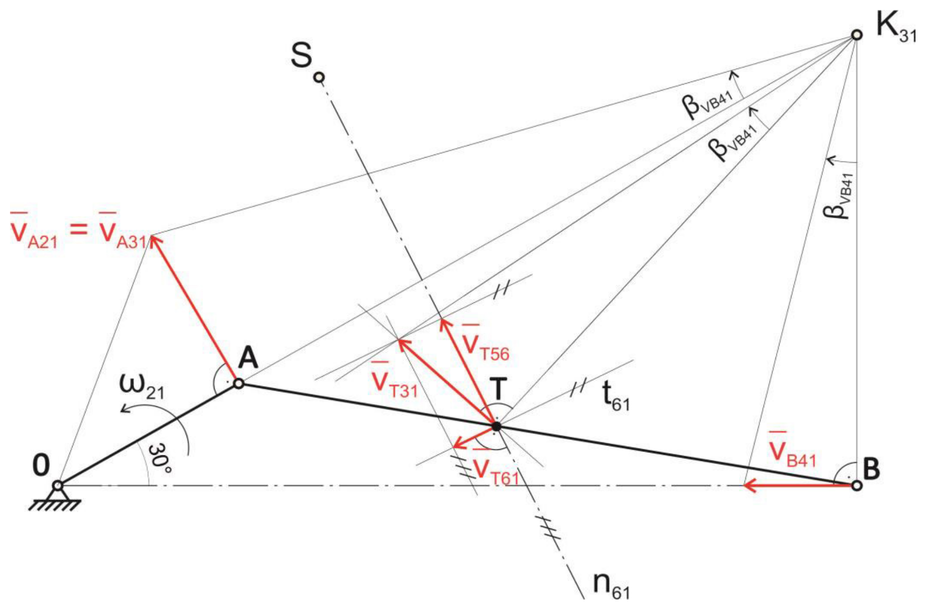

Figure 12. Graphical solution of velocity of the point A, B and T

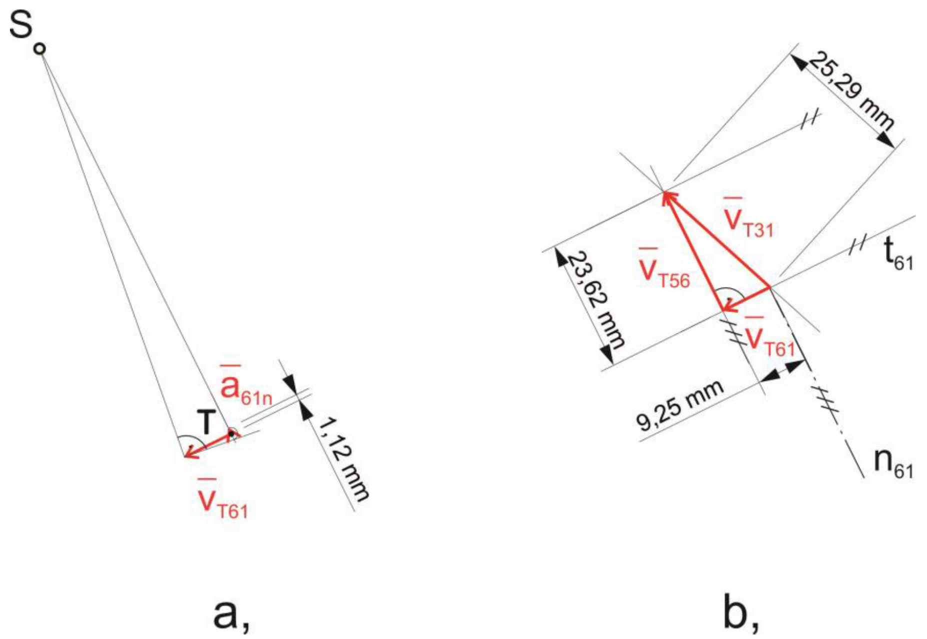

Figure 13. a) Euclid's construction of acceleration a_{61n}, b) velocity vector diagram

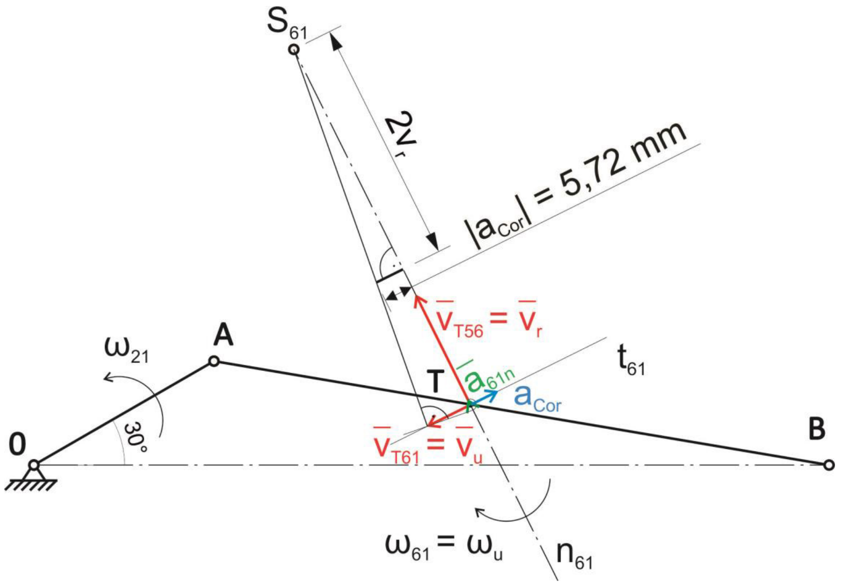

Figure 14. Graphical solution of acceleration a_{Cor}

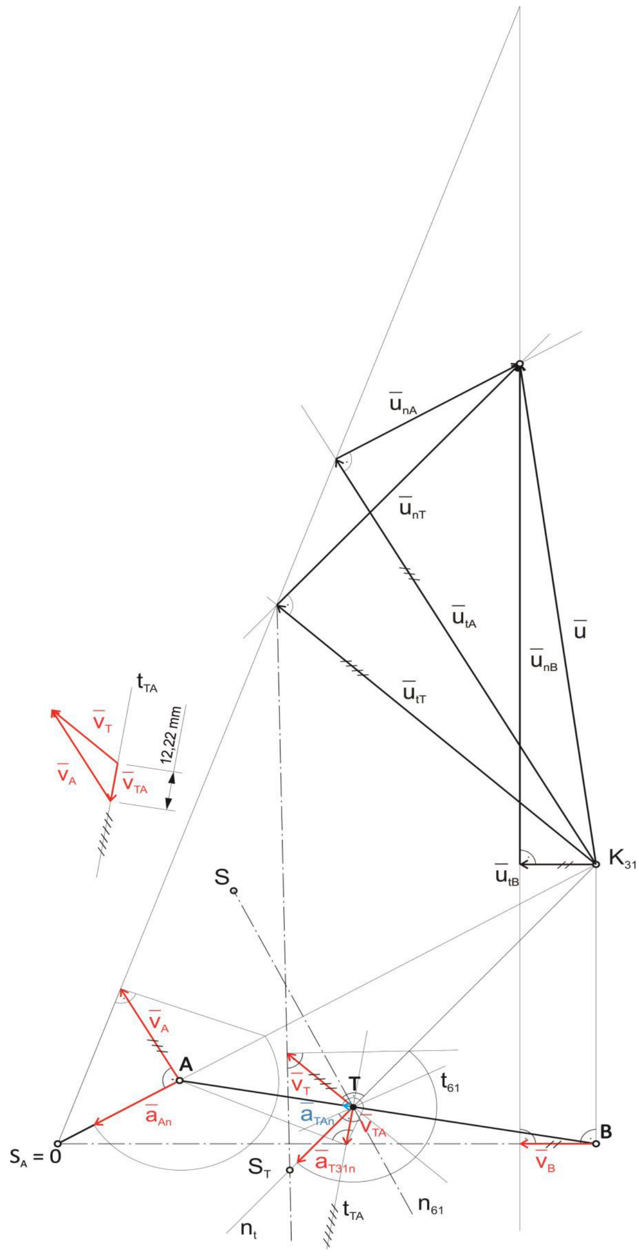

Figure 15. Hartmann's construction

4.5. Hartmann's Construction

To determine the axis of curvature of the track of point T in Figure 15 Hartmann's constructed structure. After determining the point S_T is constructed with Euclid's construction normal component of the acceleration a_{T31n}.

Value of the velocity v_{TA} in graphic solution with Euclid's construction (Figure 15) is v_{TAg} = 12.2186mm and with scale is value of velocity $v_{TA} = 2.4437 m.s^{-1}$.

In Figure 16 shows the scheme of vectors acceleration.

The values of the velocity and acceleration of the Figure 16 are shown in Table 1.

Table 1. Acceleration of the points of mechanism

Acceleration of the points		
Acceleration of the point	Value of graphic solution (mm)	Acceleration ($m.s^{-2}$)
a_{TAn}	3.0118	60.236
a_{TAt}	5.3611	107.222
a_{T31n}	23.7771	475.542
a_{T3t}	14.0872	281.744
a_{T31}	27.6359	552.718
a_{56}	3.2331	64.662
a_{61t}	33.0117	660.234

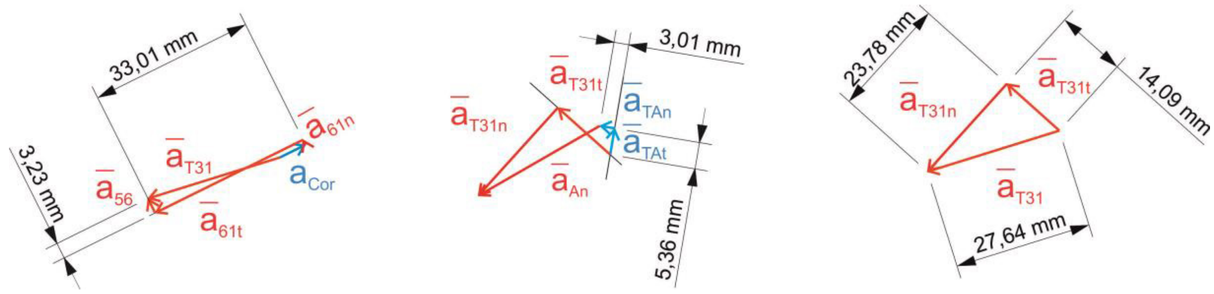

Figure 16. Scheme of acceleration vectors from graphic solutions

5. Computer Simulation Using MSC Adams/View Program

The computer simulation provide significantly increase the efficiency of the working process, reduce development costs and optimizing product and we can achieve a much better level of safety and quality of products. Properties and behavior of creating the prototype can be evaluated even before the actual prototype. It is able to detect any hidden structural defects and remove them still at the prototype stage [4,6].

5.1. Construction of the Model of Mechanism

Introduction to modeling after setting the working environment to create further hints modeled members. On the crank and on the connecting rod are defined the points. After placing the auxiliary points are then created various bodies that represent the mechanism crank and connecting rod. The modeling is followed by step modeling of the shaft and the hollow cylinder [5]. Both are rotary symmetrical body, so that will be created using the creation of rotating bodies (Figure 17).

The piston is designed with tool for box geometry (Box). After creating the piston body is moved to the location of the center of gravity and is inclined in a certain direction (Figure 18).

Walking Beam is designed tool to create extrusion (Extrusion). Walking Beam is then moved into position as before the piston (Figure 19).

After constructing the model of the mechanism still need to add the corresponding kinematics linkage between individual members and add the drive member [6].

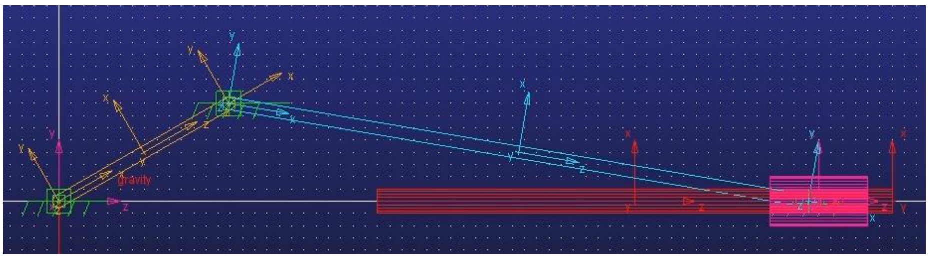

Figure 17. Created crank, connecting rod, piston and shaft mechanism

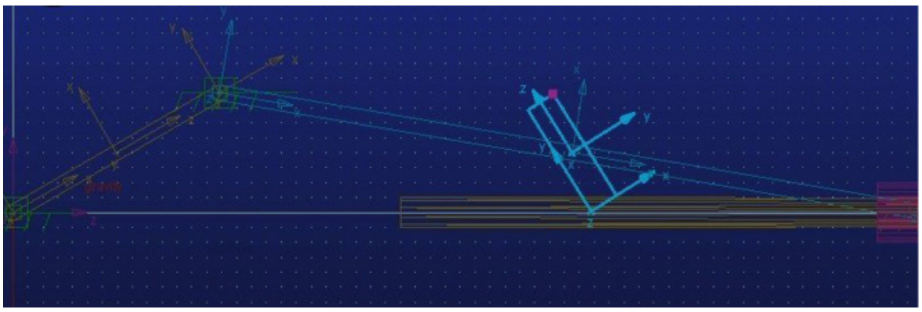

Figure 18. Created piston of the mechanism

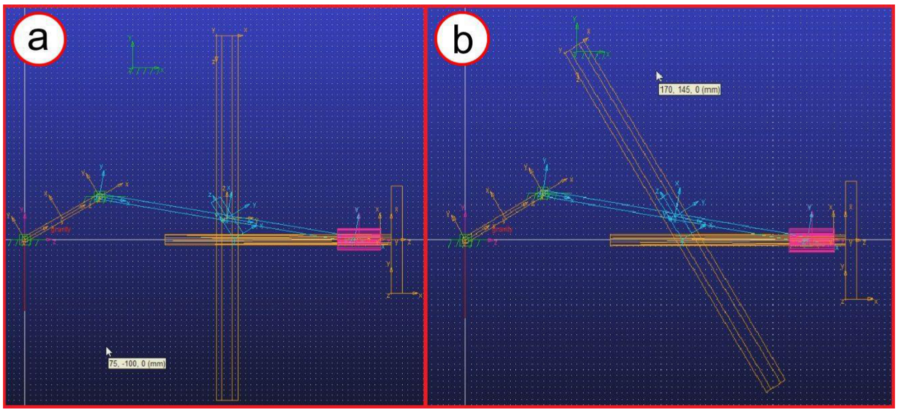

Figure 19. Creating a piston and rotating cylinder

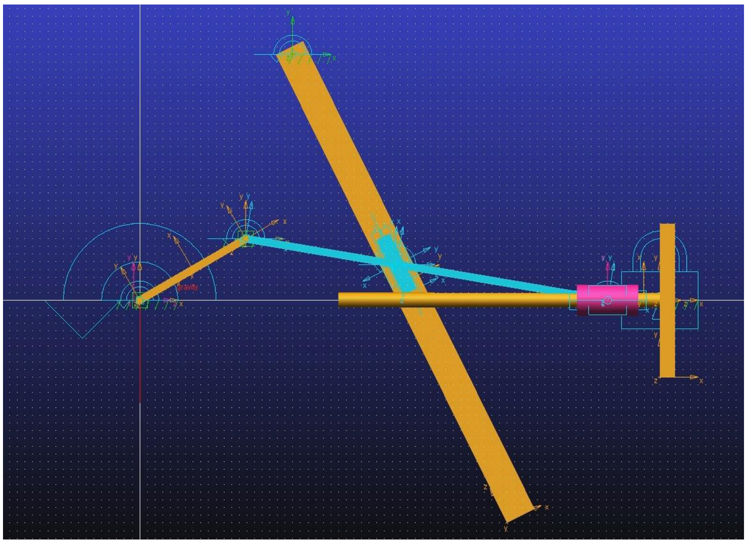

Figure 20. Model of the mechanism with joints

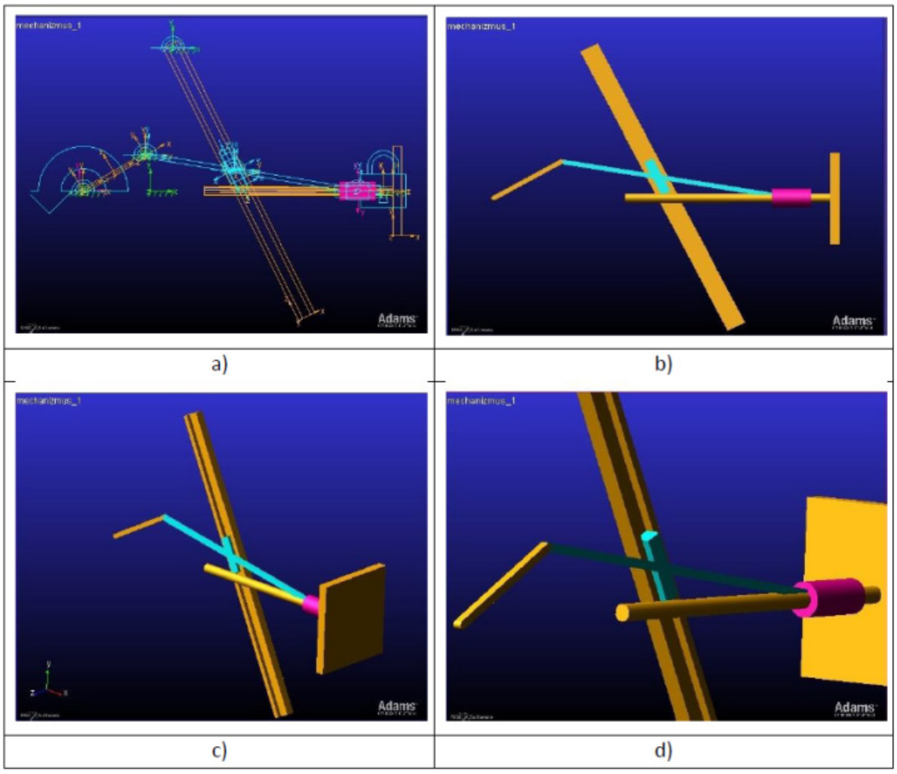

Figure 21. View of the resulting model a) from the front with visible links, b) rendered model from the front. c) rendered model from the right, d) model rendered from the left

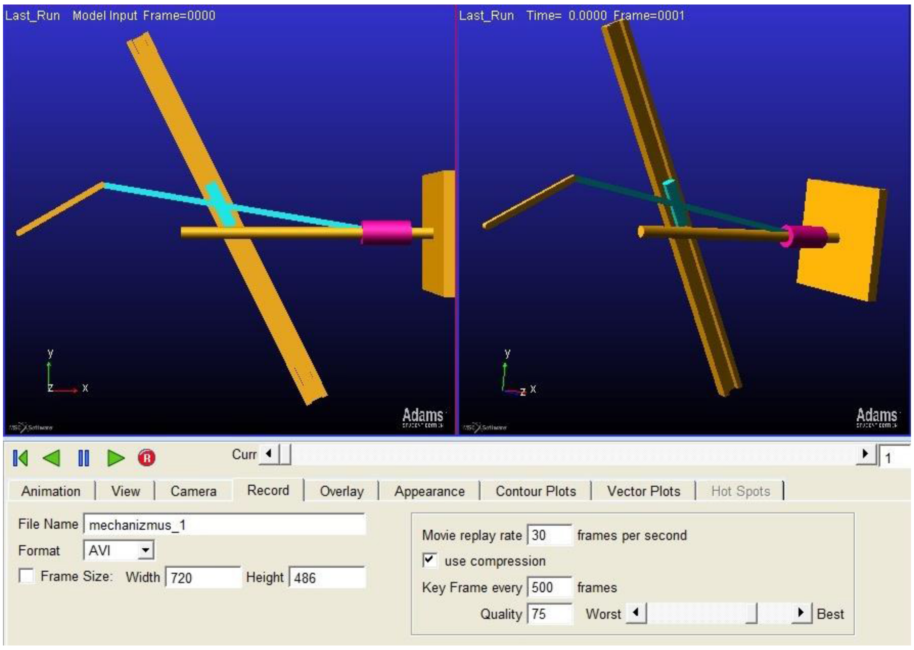

Figure 22. Selected step of the forming the video output

After performing these procedures still need to check the dimensions of the members and the setting of individual bonds (Figure 20). View of the resulting model shows the Figure 21.

The results obtained from the simulation we can easily work in postprocessor, where among other things we can create and edit graphs, export the results in various formats or create an animation of the simulation model. Postprocessor can be used to create detailed animation [7].

With the recording of the animation we just do video output to “avi” or “mpg” format (Figure 22). This function is very useful for presenting activities on the model.

5.2. Using Postprocessor

The resulting values of kinematics parameters obtained from simulations are processed in Postprocessor. The graphs of kinematics quantities displacement, velocity and acceleration of the points A and B of mechanism and center of mass of member 5 and member 6 dependent on time are shows next.

The resulting values of kinematics parameters obtained from simulations are recorded at the time when the angle $\varphi_{21} = 30°$ in order to obtain values that are comparable with those obtained from the graphical solutions.

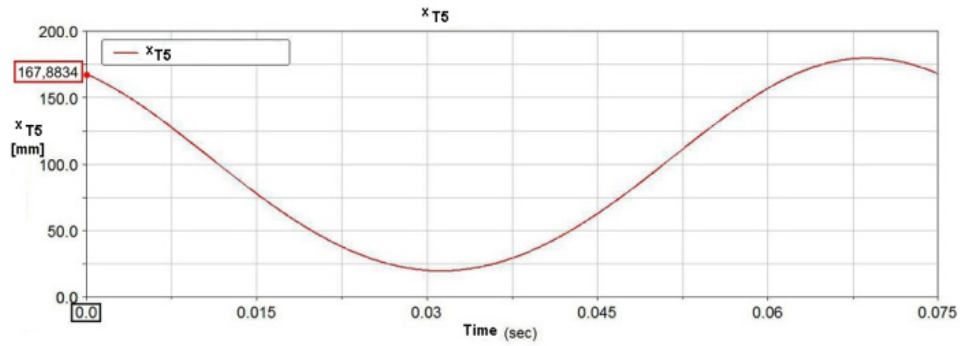

Figure 23. The graph of the displacement of the center of mass of member 5 in the axis x dependent on time

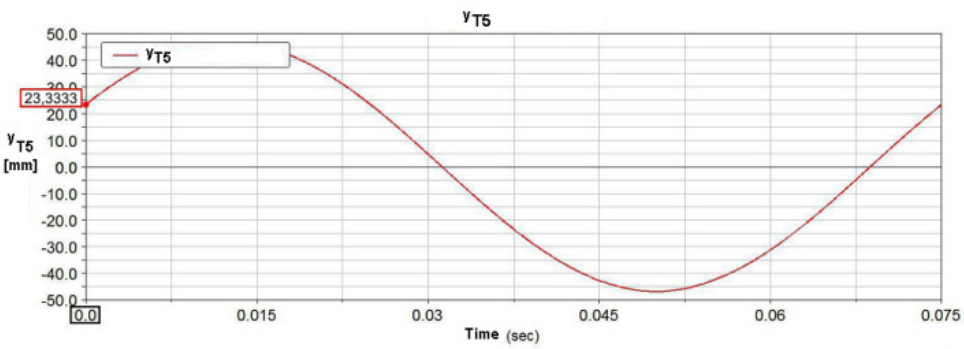

Figure 24. The graph of the displacement of the center of mass of member 5 in the axis y dependent on time

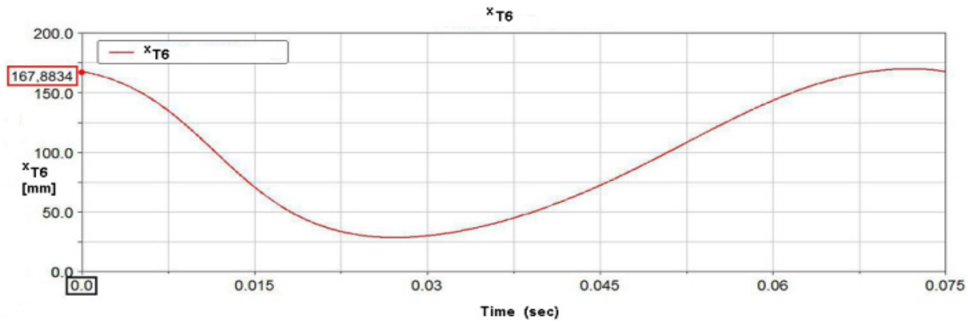

Figure 25. The graph of the displacement of the center of mass of member 6 in the axis x dependent on time

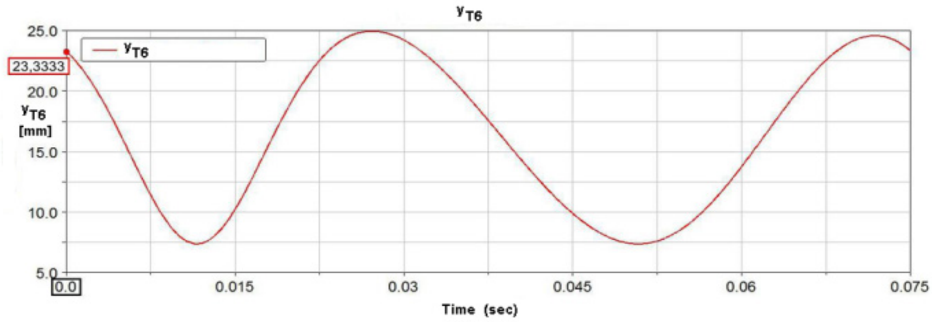

Figure 26. The graph of the displacement of the center of mass of member 6 in the axis y dependent on time

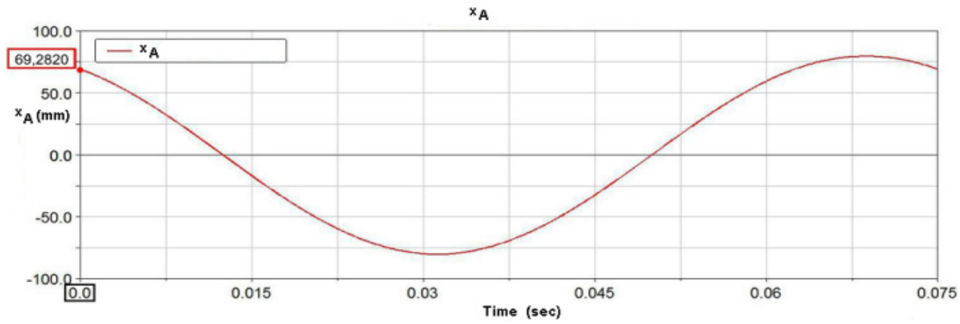

Figure 27. The graph of the displacement of the point A in the axis x dependent on time

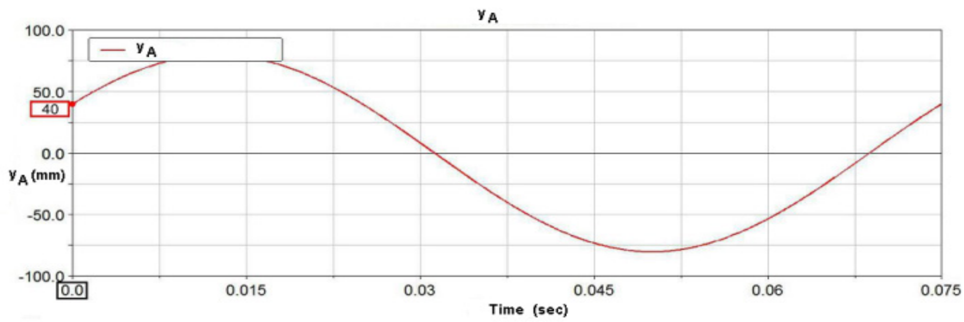

Figure 28. The graph of the displacement of the point A in the axis y dependent on time

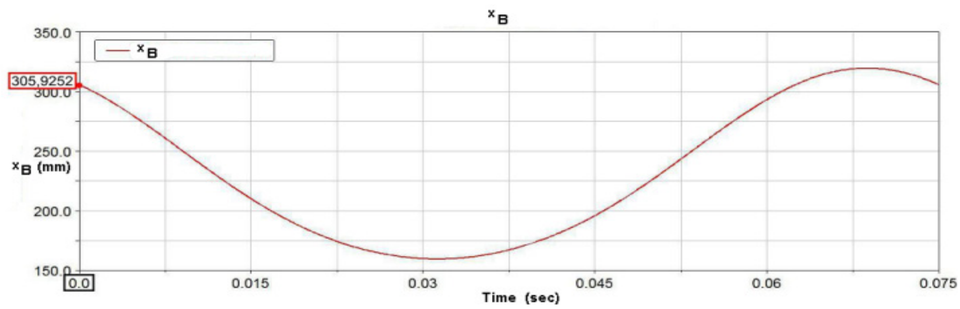

Figure 29. The graph of the displacement of the point B in the axis x dependent on time

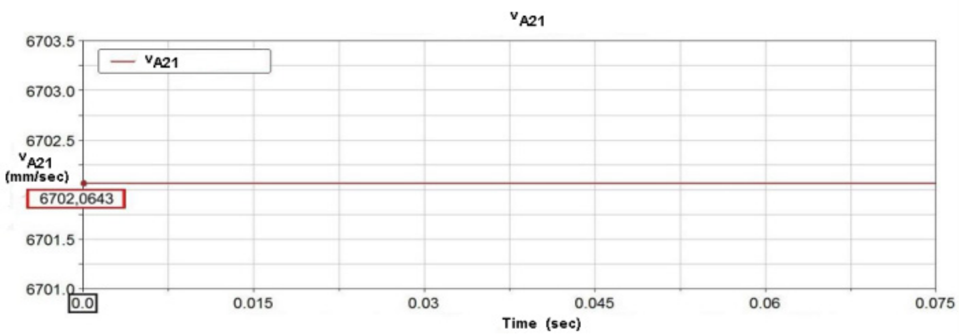

Figure 30. The graph of the velocity of the point A dependent on time

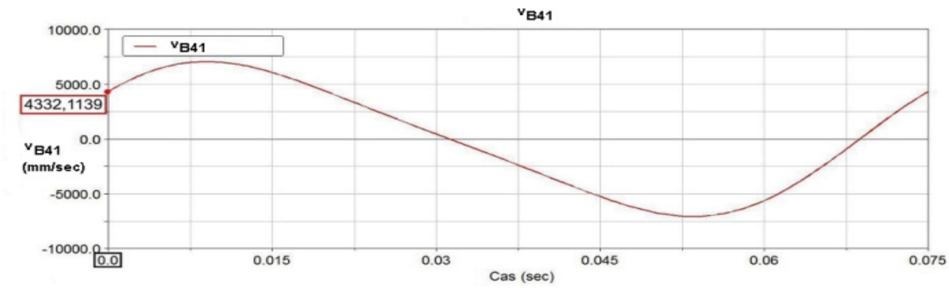

Figure 31. The graph of the velocity of the point B in the axis x dependent on time

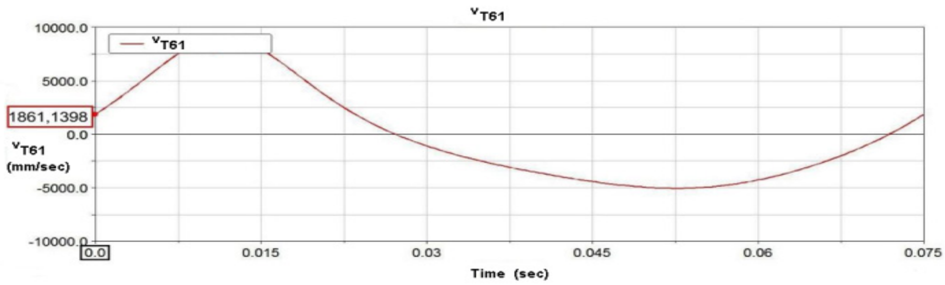

Figure 32. The graph of the velocity of the center of mass of member 6 dependent on time

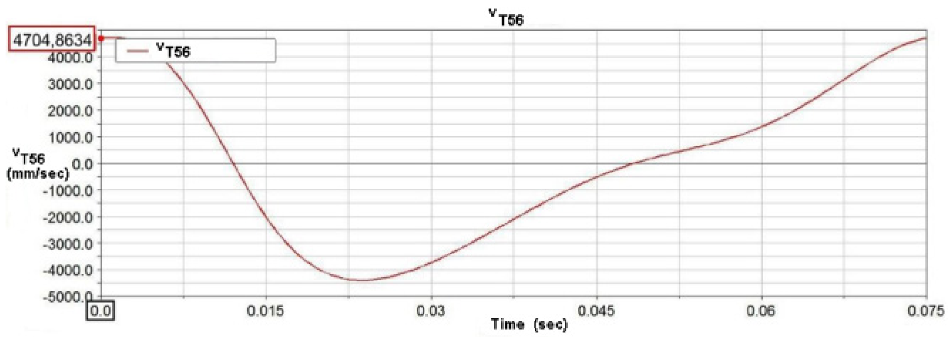

Figure 33. The graph of the velocity v_{T56} of the center of mass of member 5 dependent on time

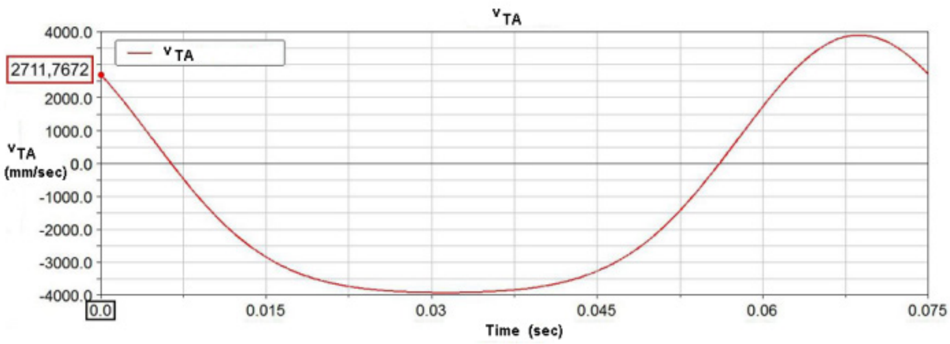

Figure 34. The graph of the velocity v_{TA} dependent on time

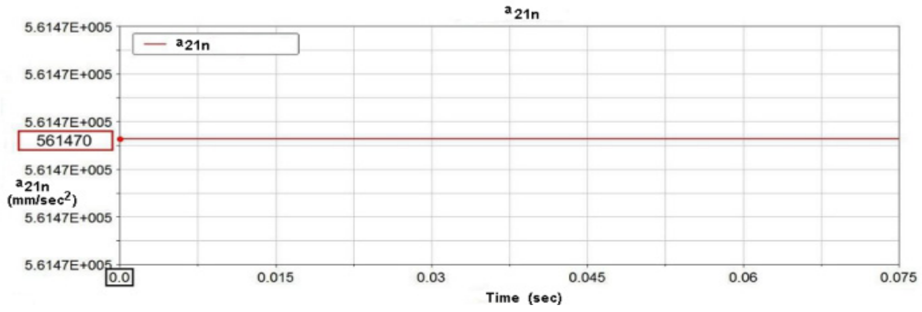

Figure 35. The graph of the normal component of acceleration a_{A21n} of the point A dependent on time

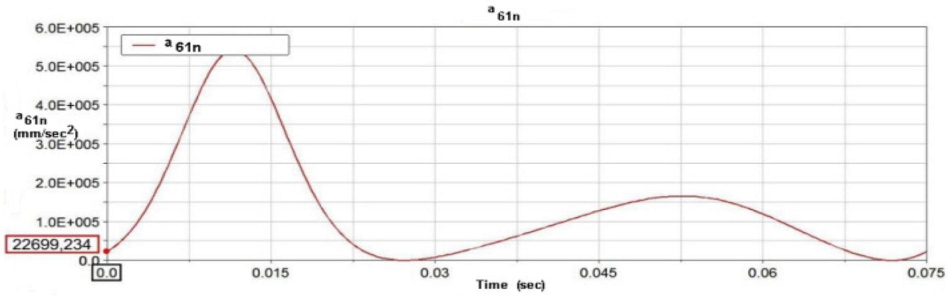

Figure 36. The graph of the normal component of acceleration a_{61n} of member 6 dependent on time

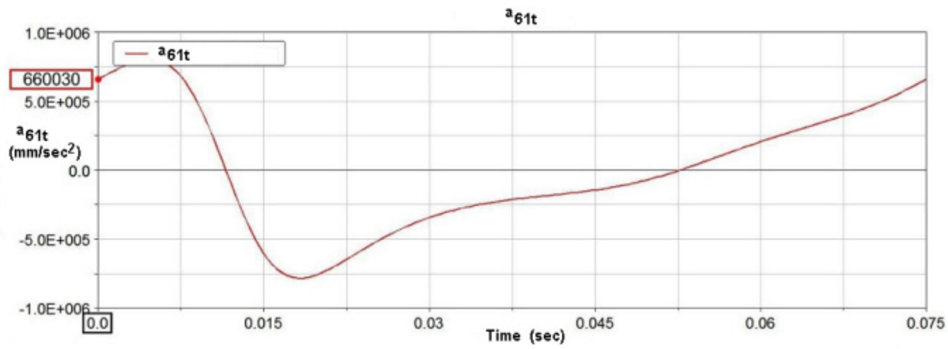

Figure 37. The graph of the tangential component of acceleration a_{61t} of member 6 dependent on time

The duration of the simulation was set to 0.075sec because in that time model performance over a cycle.

For subtracting the kinematics variables was chosen point in time t = 0sec. They created the gauges at selected locations, and after the simulation to obtain time courses of the principal vectors of speed and acceleration [8]. A graph showing the time courses of these vectors exported to the postprocessor, which were read the exact values of these parameters.

5.3. Computation of Kinematics Parameters in Numerical Form

The values of parameters in numerical form, obtained in postprocessor are provided in the tables (Table 2, Table 3). Individual values in the table have been recorded at approximately 20 ° until the mechanism has not carried out a single cycle.

With the help of these tables we can easily determine the value of the relevant kinematics variables at different times and different angles (Table 4, Table 5).

We obtained values of kinematics quantities displacement, velocity and acceleration of the points A and B of mechanism and center of mass of member 5 and member 6 on a certain angle of rotation crank OA.

Table 2. Displacement of the points A and B depending on the angle of crank

Angle of crank OA (°)	Displacement of the points A and B		
	x_A (mm)	y_A (mm)	x_B (mm)
30.0	69.2820	40.0000	305.9252
50.4	51.2517	61.4269	283.2576
70.8	26.9413	75.3271	254.8137
90.0	-0.6702	79.9972	225.6050
110.4	-28.1996	74.8651	199.8250
130.8	-52.2736	60.5596	179.9601
150.0	-69.4490	39.7094	167.2431
170.4	-78.8797	13.3415	160.7492
190.8	-78.6451	-14.6612	160.9067
210.0	-69.2820	-40.0000	167.3612
230.4	-51.2517	-61.4269	180.7542
250.8	-26.9413	-75.3271	200.9311
270.0	0.6702	-79.9972	226.9454
290.4	28.1996	-74.8651	256.2242
310.8	51.5085	-61.2117	283.5713
330.0	69.4490	-39.7094	306.1411
350.4	78.8797	-13.3415	318.5086
370.8	78.6451	14.6612	318.1968
390.0	69.2820	40.0000	305.9252

Table 3. Displacement of the points T_5 and T_6 depending on the angle of crank

Angle of crank OA (°)	Displacement of the points T_5 and T_6			
	x_{T5} (mm)	y_{T5} (mm)	x_{T6} (mm)	y_{T6} (mm)
30.0	167.8834	23.3333	167.8834	23.3333
50.4	147.9208	35.8324	154.9430	17.6371
70.8	121.8882	43.9408	128.2805	10.0462
90.0	93.6111	46.6650	91.4115	7.6446
110.4	66.8106	43.6713	58.1336	13.2583
130.8	44.4904	35.3264	37.9319	20.5960
150.0	29.1727	23.1638	29.8543	24.4806
170.4	20.9657	7.7825	29.6820	24.5699
190.8	21.1682	-8.5524	35.3516	21.7737
210.0	29.3193	-23.3333	45.1072	17.6177
230.4	45.4174	-35.8324	59.0296	13.0056
250.8	68.0055	-43.9408	76.3496	9.2466
270.0	94.9515	-46.6650	96.2734	7.4482
290.4	123.2099	-43.6713	117.2778	8.3840
310.8	148.2013	-35.7068	136.4932	11.8306
330.0	168.0707	-23.1638	153.1587	16.9612
350.4	178.7251	-7.7825	164.8194	21.8538
370.8	178.4583	8.5524	170.1937	24.5055
390.0	167.8834	23.3333	167.8834	23.3333

Table 4. Velocity of the points depending on the angle of crank

Angle of crank OA (°)	Velocity of the points			
	v_{T56} ($m.s^{-1}$)	v_{T61} ($m.s^{-1}$)	v_{TA} ($m.s^{-1}$)	v_{B41} ($m.s^{-1}$)
30.0	4.7049	1.8611	2.7118	4.3321
50.4	4.3474	5.0173	0.9606	6.2993
70.8	2.4594	8.1491	-0.8679	7.0603
90.0	-0.3378	9.0011	-2.2340	6.7021
110.4	-2.9342	6.7764	-3.1571	5.5134
130.8	-4.2038	3.5345	-3.6320	3.9315
150.0	-4.3589	1.0494	-3.8288	2.3699
170.4	-3.8655	-0.8189	-3.9024	0.7498
190.8	-3.0211	-2.1361	-3.9005	-0.8438
210.0	-2.1007	-3.0779	-3.8288	-2.3699
230.4	-1.1477	-3.8919	-3.6133	-4.0287
250.8	-0.3547	-4.5454	-3.1169	-5.5983
270.0	0.1854	-4.9448	-2.2340	-6.7021
290.4	0.6175	-4.9963	-0.7681	-7.0501
310.8	1.1265	-4.5496	1.0717	-6.2154
330.0	1.8696	-3.6698	2.7118	-4.3321
350.4	2.9499	-2.2956	3.7782	-1.4856
370.8	4.0665	-0.4475	3.7436	1.6679
390.0	4.7049	1.8611	2.7118	4.3321

Table 5. Acceleration of the points depending on the angle of crank

Angle of crank OA (°)	The components of the acceleration of the member 6	
	a_{61n} ($m.s^{-2}$)	a_{61t} ($m.s^{-2}$)
30.0	22.6992	660.0300
50.4	164.9600	802.1700
70.8	435.1800	566.6500
90.0	530.9300	-186.8700
110.4	300.9200	-746.7300
130.8	81.8684	-714.9000
150.0	7.2165	-526.1000
170.4	4.3946	-364.1900
190.8	29.9029	-264.7600
210.0	62.0841	-210.9100
230.4	99.2581	-173.5100
250.8	135.3900	-130.8300
270.0	160.2400	-63.2071
290.4	163.5900	43.9988
310.8	135.6400	166.0500
330.0	88.2556	271.5400
350.4	34.5332	375.6300
370.8	1.3124	500.5600
390.0	22.6992	660.0300

Table 6. Results of the velocity and acceleration of the points

Velocity and acceleration	Results of the velocity and acceleration		
	Result of simulation	Result of graphic solution	Diference of the solutions
v_{A21}	6.7021 ($m.s^{-1}$)	6.7021 ($m.s^{-1}$)	0.0000 ($m.s^{-1}$)
v_{B41}	4.3321 ($m.s^{-1}$)	4.3296 ($m.s^{-1}$)	0.0025 ($m.s^{-1}$)
v_{T61}	1.8611 ($m.s^{-1}$)	1.8499 ($m.s^{-1}$)	0.0112 ($m.s^{-1}$)
v_{T56}	4.7049 ($m.s^{-1}$)	4.7246 ($m.s^{-1}$)	-0.0197 ($m.s^{-1}$)
v_{TA}	2.7118 ($m.s^{-1}$)	2.4437 ($m.s^{-1}$)	0.2681 ($m.s^{-1}$)
a_{21n}	561.4700 ($m.s^{-2}$)	561.4700 ($m.s^{-2}$)	0.0000 ($m.s^{-2}$)
a_{61n}	22.6992 $m.s^{-2}$)	22.3980 ($m.s^{-2}$)	0.3012 ($m.s^{-2}$)
a_{61t}	660.0300 ($m.s^{-2}$)	660.2340 ($m.s^{-2}$)	-0.2040 ($m.s^{-2}$)

5.4. Results of the Simulation and Graphic Solution

Comparing the results obtained from the simulation with the results obtained from the graphic solutions we can verify the accuracy of the two methods of dispute (Table 6). Small variations may arise from rounding simulation results and the uncertainty of graphic solutions.

6. Conclusion

The paper aimed to perform a kinematics analysis of the rocker arm crank mechanism created using MSC Adams.

In this work, the kinematics analysis of the mechanism of six-member was performed using the program MSC Adams and second-hand graphic solutions constructed in CorelDRAW. Kinematics variables selected points mechanism graphics solutions obtained were compared with those obtained by simulation in the program MSC Adams/View.

The results obtained from the graphical solution to verify the accuracy of the results obtained from simulation. It showed the benefits of the program MSC Adams in speed, accuracy and the number of options kinematics dependencies between kinematics quantities. The program allows you to obtain the results in graphical solutions, numerical form and as a video simulated movement mechanism. It allows convenient processing of the values obtained. Work on the form can serve the educational purpose of finding out more information about the possibilities of mechanical systems with simulation and kinematical analysis.

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References

[1] Záhorec, O., Caban, S., *Dynamika*, TUKE, Košice, Slovakia, 2002.

[2] Juliš, K., Brepta, R., *Mechanika II.díl, Dynamika*, SNTL, Praha, 1987.

[3] Bocko, J., Frankovský, P., Delyová, I., Pástor, M., *Kinematika v príkladoch*, SjF TU v Košiciach, 2011.

[4] Virgala, I., Frankovský, P., Kenderová, M., "*Friction Effect Analysis of a DC Motor*," In: American Journal of Mechanical Engineering, Vol. 1, No. 1, p. 1-5, 2013.

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

[6] Frankovský, P., Delyová, I., Hroncová, D., "*Modelovanie mechanického systému s jedným stupňom voľnosti pohybu v programe MATLAB*," In: Transfer inovácií. č. 21, 2011, s. 71-73.

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

[8] Ostertagová, E., "*Modelling using polynomial regression*," Modelling of Mechanical and Mechatronics Systems 2012, November 6th-8th 2012, Zemplínska Šírava, Slovakia, In: Procedia Engineering, Vol. 48 (2012), p. 500-506.