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MODELING IN MSC ADAMS/VIEW AS MODERN APPROACH TO MECHANISM DESIGN

The paper deals with the kinematic analysis of a pressure mechanism. It is a four-member mechanism. The mechanism transforms rotational motion into translational motion. It has one degree of freedom of movement. The position and speed of the piston, the magnitude of the force in the spring and the angle of the arm of the drive member at different values of the load of the drive member are determined. The task is solved using the program MSC Adams / View. The result of the simulation is the calculated trajectory of the movement of the selected point of the mechanism. The trajectory is shown in graphical form

Keywords: *mechanism; simulation; kinematic and dynamic analysis; trajectory.*
Fig.: 8. Table: 1. References: 12.

Urgency of the research. In today's world of technology, we encounter a wide application of spatial mechanisms and bound mechanical systems. Movement from simple to more complex is examined. We then examine the given movements on the basis of the characteristics that we need to find out. The kinematic and dynamic properties of the mechanism are determined. There are several methods to solve them. The oldest possible solutions are analytical and graphical solutions. At present, software solutions using available computer programs are being used.

This paper shows the use of one of the software products in the kinematic and dynamic analysis of a mechanical system. Software solutions are preferred, but knowledge of graphical and analytical methods is still needed. The graphical method of solving improves our imagination about the system during its movement. However, the graphical method gives information about the quantities only in the specific investigated position. It is therefore time consuming. A number of the computer products are currently available for kinematic analysis. One of them is the MSC Adams program. In it, a mechanical system with one degree of freedom is modeled and its kinematic analysis is performed as an example of its use. After building the model and starting the simulation, the program offers to process clearly searched kinematic quantities in its postprocessor. It allows their processing in graphical and numerical form. It also allows to get an animation of the movement of the mechanism, which gives you an insight into the behavior of the mechanism during the workload. This paper is devoted to this issue.

Target setting. Computer modeling is currently being developed in various areas of industrial production. It is significantly used in the automotive industry but also in other areas. It focuses on reducing the development time of new product models and making the development and production less expensive.

Computer modeling is commonly used in engineering tasks to obtain information about system behavior at low cost. It allows you to change the parameters of the models and monitor their impact on the final solution. The advantage of computer modeling is the speed and flexibility in solving problems in the process of product design, development and innovation.

Computer modeling can be divided according to the process of creating and processing a model for mathematical modeling, in which we work with a mathematical model of the solved mechanical system. Here we can include, for example, Matlab/Simulink, Mathematics and Maple. Or when using multibody modeling software, we only need to know the overall design of the model and its load during the movement. These programs, where we define the mechanical system directly through the direct definition of the geometry of its elements, constraints and loads, also include the MSC Adams program used, and here we speak of "multibody" modeling. Here we could also include the Toolbox SimMechanics of the Matlab/Simulink.

Actual scientific researches and issues analysis. In mathematical modeling, we describe the whole model and its behavior using mathematical equations. To define the properties of the solved model, mathematical equations are used, which define the motion and call their equations of motion of the system, as well as equations describing the kinematic dependencies between the individual members of the mechanical system. The compilation of equations of motion is time consuming and therefore this procedure is only suitable for systems with a lower number of degrees of freedom. Here we can use, for example, Matlab/Simulink, Maple and Mathematics.

Matlab is a program that allows numerical calculations, modeling and simulation.

Maple is a comprehensive calculation software that allows analytical calculations, numerical calculations, graphical display of results and the creation of a document describing the workflow.

Mathematica is a program focused on numerical and matrix problems in various areas of technical problems.

The difference in "multibody" modeling from mathematical modeling is that this "multibody" modeling does not describe the model by mathematical equations. Only the shape of the geometry of the individual bodies from which the model is built is defined. There is no time to compile the equations of motion, which leads to time savings. However, computer programs in this area of modeling are more demanding on hardware and knowledge of the use of software. Theoretical knowledge and skill of the designer is required.

SimMechanics as an extension of Matlab was developed to address the kinematics and dynamics of a rigid body.

Simulink as a Matlab graphical environment was developed to create and solve dynamic systems using block diagrams.

MSC Adams uses an object-oriented programming environment with graphical output. Systems are defined directly by the geometry of bodies, kinematic constraints, force effects and motion generators.

Analysis of existing research and publications. Much attention has been paid to the spatial mechanisms in the literature since the last century. The first works include the work of Burmester, Reuleaux and Assur. The work of Artobolevsky and Franke, Šrejtra on newer authors. The methods of describing mechanisms are the work of Denavit and Hartenberg [1] and the work of Kalicin, Kislicyna, Lebedeva, Litvin [2]. The matrix methods in kinematics has been studied by Hartenberg, Denavit and Uicker. The vector methods of kinematics analysis was devoted to Zinoviev, Novotný, Chace [2].

Methods of mechanisms description are described in works of Denavit and Hartenberg [1] and others. General methods of dynamic analysis of planar mechanisms are attributed to authors as Brát [2], Kozlov, Makaričev, Timofejev, Jurevič [3], Bejczy, Koplik, Leu, Haug [2], Stejskal [4], Valášek [4] and others.

Fourth order matrices were introduced by J. Denavit and R. S. Hartenberg. Similarly, G. S. Kalicin solved some problems of planar and spherical mechanisms by matrix calculus. The possibility of using quaternions or biquaternions in the kinematics of the body was pointed out by J. Novák. The general methods of analytical solution were dealt with by S. G. Kislicin and J. F. Moroshkin. In the kinematics of spatial mechanisms, the Czech mechanic V. Brát also introduced the use of matrix calculus [2], V. Stejskal and M. Valášek [4], K. Juliš, R. Brepta [5].

In our work, after the introductory theoretical part we show models of the mechanism compiled in MSC Adams-View.

Article objective. The presented paper shows the solution of the kinematic analysis of a mechanical system by the currently available computer program MSC Adams. The model of the pressing mechanism is solved, which represents a mechanical system with one degree of freedom. After building the model in the MSC Adams View program, the results of the kinematic analysis of the mechanism are obtained after starting the simulation.

The paper shows the mechanism shown in Fig.1. In terms of kinematics, the mechanism consists of four members, one of which is the basis. The mechanism has one degree of freedom. Performs a translational motion [4-5].

Pressure mechanism on the Fig. 1 consists of the crank 2, connecting rod 3, piston 4 and spring. The mechanism is used to convert angular motion of the crank into linear motion of the piston. A mechanism is used to produce mechanical transformations in a machine.

The solved mechanism transforms the rotational movement of member 2 into the translational movement of member 4. Our task is to investigate the movement of its individual members and significant points.

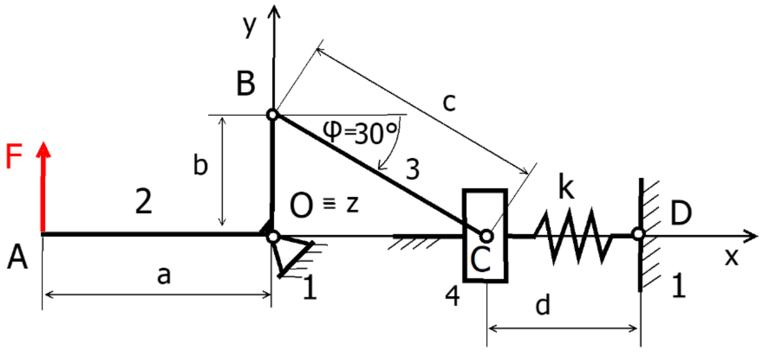
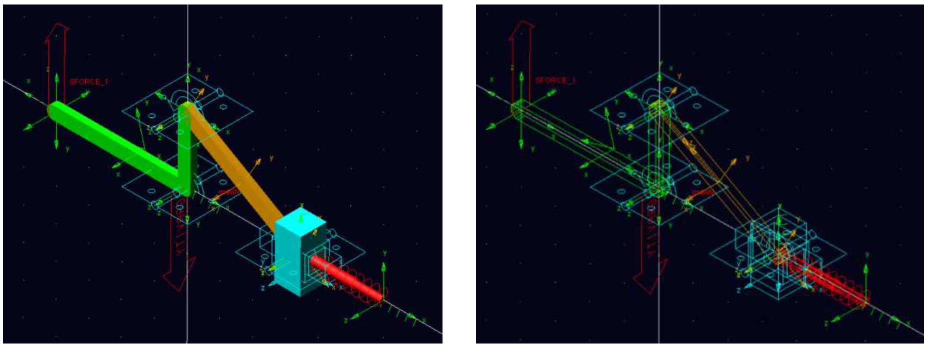


Fig. 1. Model of the Mechanism with one degree of freedom



a *b*

Fig. 2. a)-b) Model of the Mechanism in MSC Adams/View

The aim is to describe the movement of the piston 4. We solve the crank slider mechanism of the pressure mechanism.

The kinematic scheme from the point of view of the kinematic solution contains the dimensions of the members and the connecting kinematic pairs. Individual members are marked with numbers. The base is marked with the number 1, the crank drive member with the number 2, the connecting member with the number 3, the sliding member with the number 4. The spring has a stiffness k = 5N / mm. Individual dimensions of the mechanism:

OB = 100mm, OA = 200mm, BC = 200mm, the spring is mounted in the center of gravity of member 4 and on the base in place (0, -300.0). Width of individual members Width = 20mm, Depth = 10mm. The force F acts on the driven member 2. Next we solved the problem for variants P1 to P4 at different parameters of the loading force F.

General overview of the system.

We solve the problem for variants P1 to P4 with different parameters of the loading force in the following parts.

A local coordinate system is associated with each member. The motion of a point located on a member with a local coordinate system is then described with respect to the global coordinate system (Fig. 3). We are interested in the position of the selected point of the member of mechanism with respect to the global coordinate system in which the mechanism is located.

The following table (Table 1) shows the parameters of the model of the mechanism on (Fig. 1):

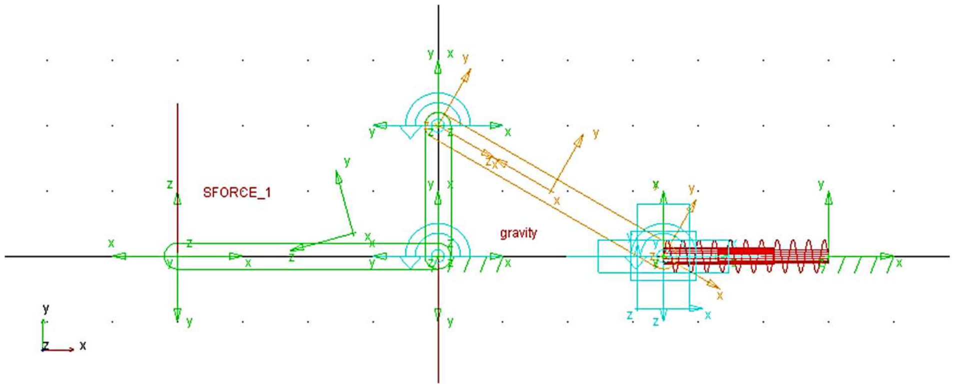
Table

Variant of the Mechanism with Force and Time of the Solution

Variant	F [N]	Time [sec]
P1	140	0.0800
P2	160	0.0632
P3	180	0.0531
P4	200	0.0474

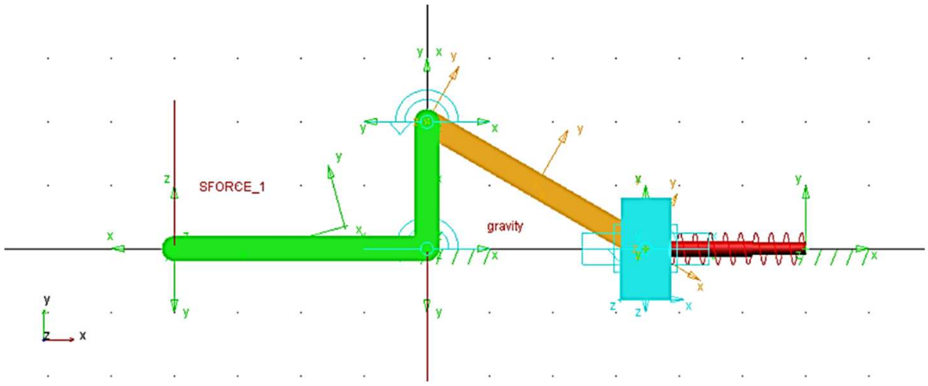
Kinematic analysis of the model in MSC Adams software.

The next figure (Fig. 3) shows a manipulator model created in the MSC Adams/View.



a

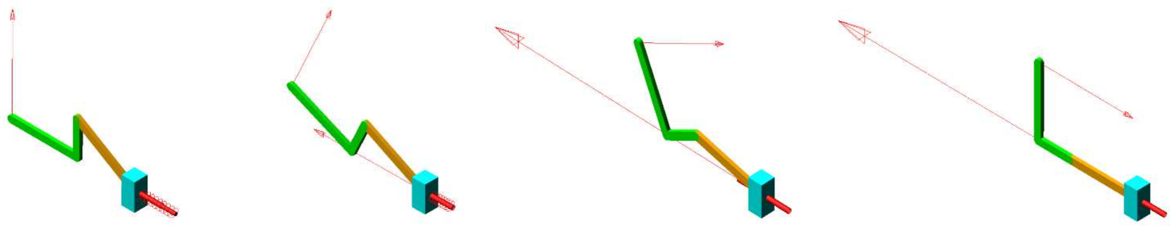
Fig. 3. Model of the mechanism in MSC Adams/View



b

Fig. 4. Front view of the rendered model of the mechanism in MSC Adams/View

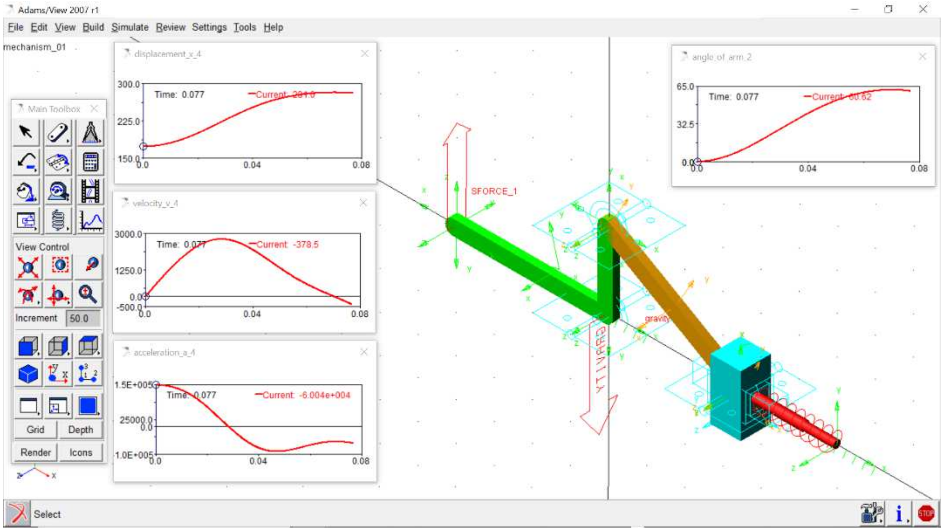
A 3D computer model of the manipulator is created in MSC Adams [12]. Modelling elements and procedures for the creation of bodies and their kinematic bonds were used. After proposing the model, the functionality is verified and the simulation is started (Fig. 5) [6-11].



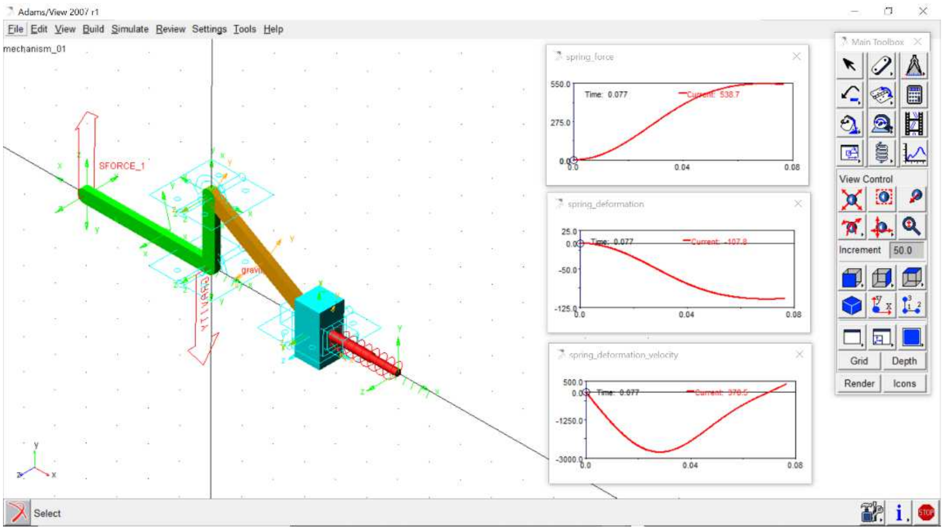
a *b* *c* *d*

Fig. 5. a) – d) Mechanism in the motion with force F=200N

The resulting graphs of trajectory of point obtained by the simulation are displayed in a graphical form with the postprocessor are in the following figures (Fig. 6 a-b).



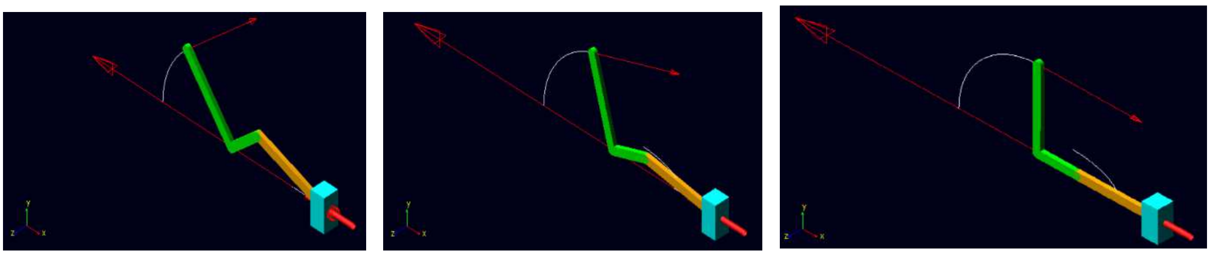
a



b

Fig. 6. a) – b) Measure of the kinematics quantities

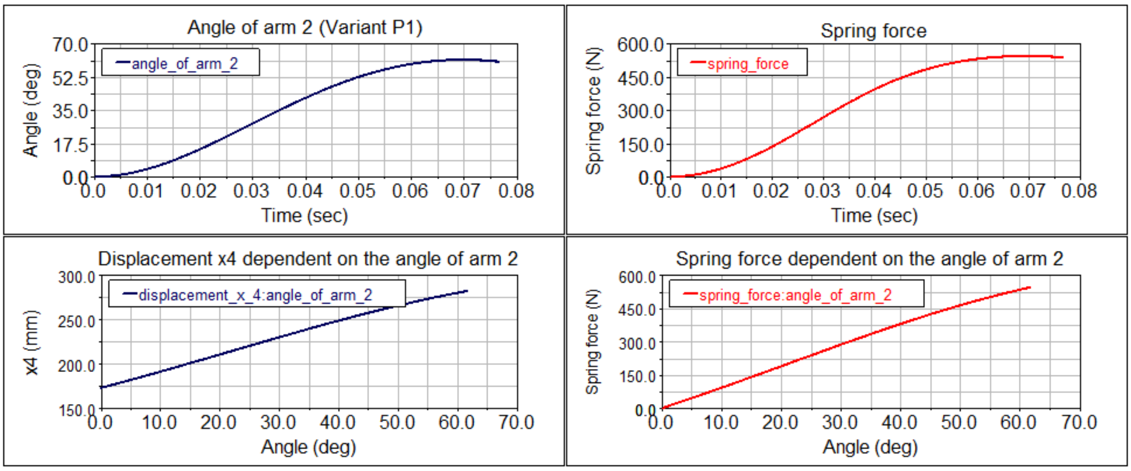
The representation of the trajectory of the points in various views (Fig. 7 a-c) is shown below.



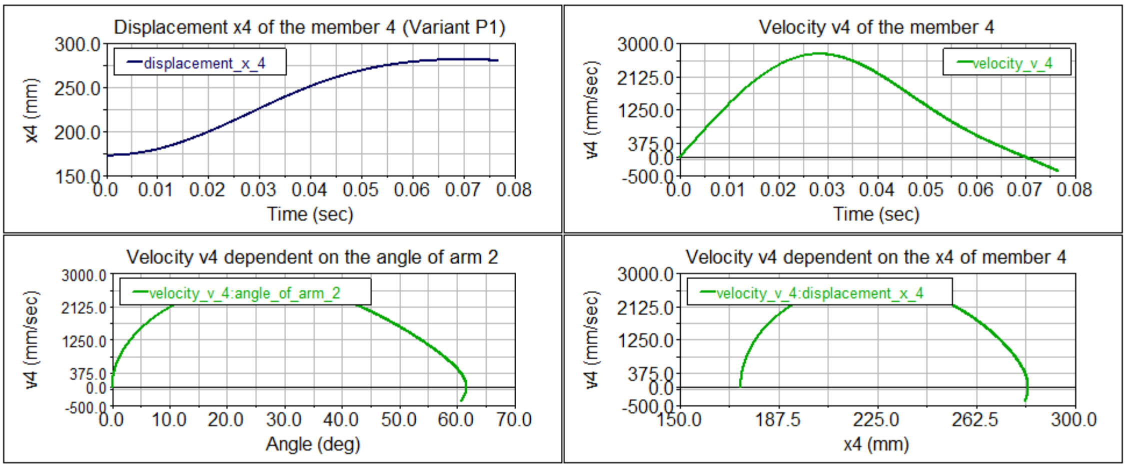
a *b* *c*

Fig. 7. a)-c) Model with MOTION in Joint and Trajectory of the Point of the Member

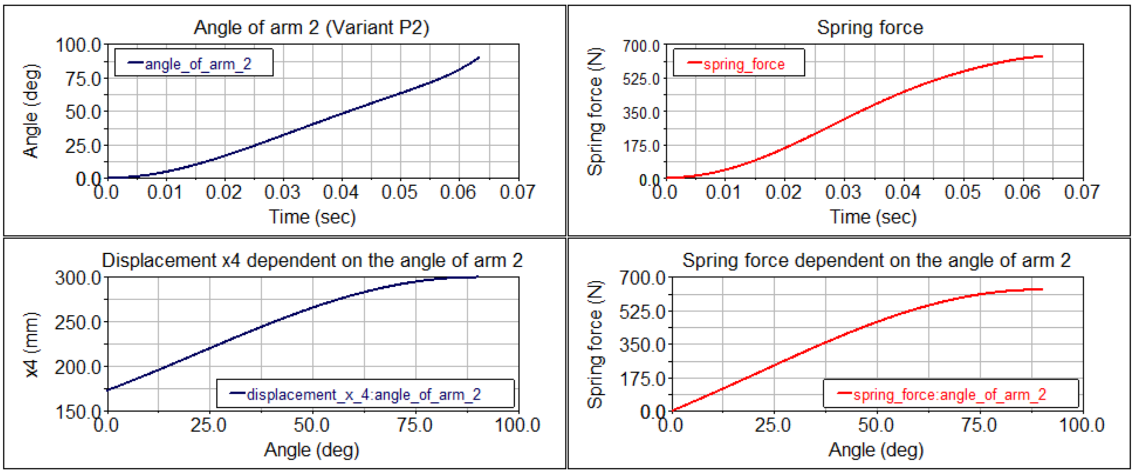
The kinematics parameters of the selected point of the members is shown in Fig. 8 a) to h).


Angle of arm 2 (Variant P1)
angle_of_arm_2
Angle (deg)
70.0 52.5 35.0 17.5 0.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
Time (sec)
Spring force
spring_force
Spring force (N)
600.0 450.0 300.0 150.0 0.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
Time (sec)
Displacement x4 dependent on the angle of arm 2
displacement_x_4:angle_of_arm_2
x4 (mm)
300.0 250.0 200.0 150.0
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0
Angle (deg)
Spring force dependent on the angle of arm 2
spring_force:angle_of_arm_2
Spring force (N)
600.0 450.0 300.0 150.0 0.0
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0
Angle (deg)

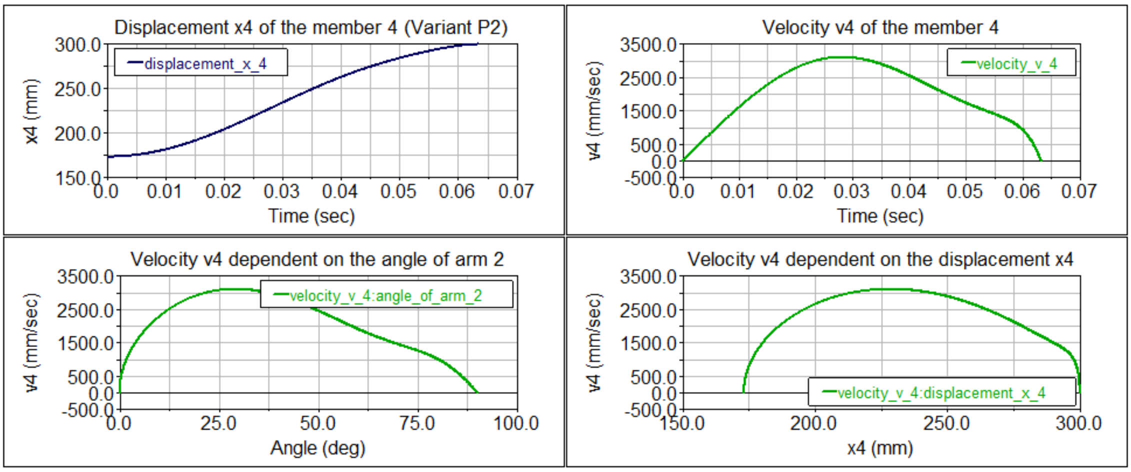
a


Displacement x4 of the member 4 (Variant P1)
displacement_x_4
x4 (mm)
300.0 250.0 200.0 150.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
Time (sec)
Velocity v4 of the member 4
velocity_v_4
v4 (mm/sec)
3000.0 2125.0 1250.0 375.0 0.0 -500.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08
Time (sec)
Velocity v4 dependent on the angle of arm 2
velocity_v_4:angle_of_arm_2
v4 (mm/sec)
3000.0 2125.0 1250.0 375.0 0.0 -500.0
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0
Angle (deg)
Velocity v4 dependent on the x4 of member 4
velocity_v_4:displacement_x_4
v4 (mm/sec)
3000.0 2125.0 1250.0 375.0 0.0 -500.0
150.0 187.5 225.0 262.5 300.0
x4 (mm)

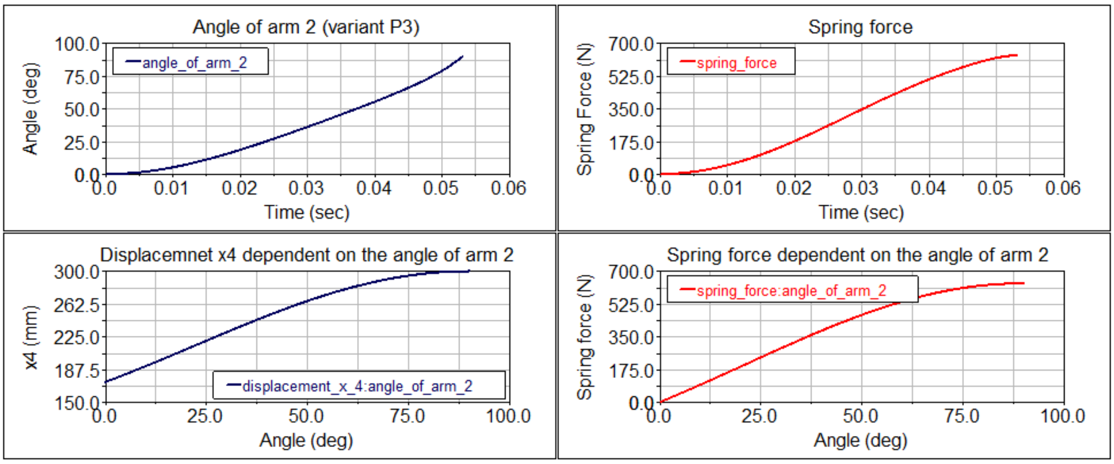
b


Angle of arm 2 (Variant P2)
angle_of_arm_2
Angle (deg)
100.0 75.0 50.0 25.0 0.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07
Time (sec)
Spring force
spring_force
Spring force (N)
700.0 525.0 350.0 175.0 0.0
0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07
Time (sec)
Displacement x4 dependent on the angle of arm 2
displacement_x_4:angle_of_arm_2
x4 (mm)
300.0 250.0 200.0 150.0
0.0 25.0 50.0 75.0 100.0
Angle (deg)
Spring force dependent on the angle of arm 2
spring_force:angle_of_arm_2
Spring force (N)
700.0 525.0 350.0 175.0 0.0
0.0 25.0 50.0 75.0 100.0
Angle (deg)

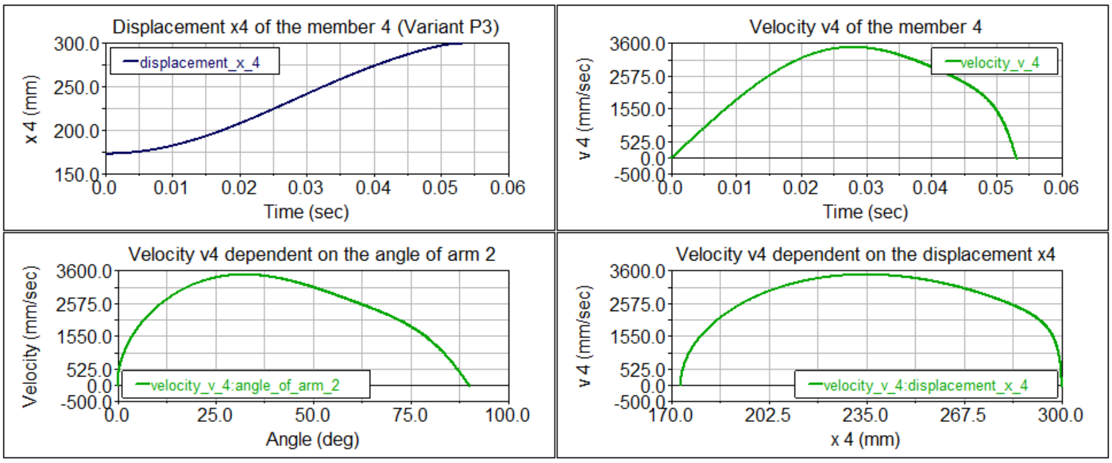
c


Displacement x4 of the member 4 (Variant P2)
displacement_x_4
x4 (mm)
Time (sec)
Velocity v4 of the member 4
velocity_v_4
v4 (mm/sec)
Time (sec)
Velocity v4 dependent on the angle of arm 2
velocity_v_4:angle_of_arm_2
v4 (mm/sec)
Angle (deg)
Velocity v4 dependent on the displacement x4
velocity_v_4:displacement_x_4
v4 (mm/sec)
x4 (mm)

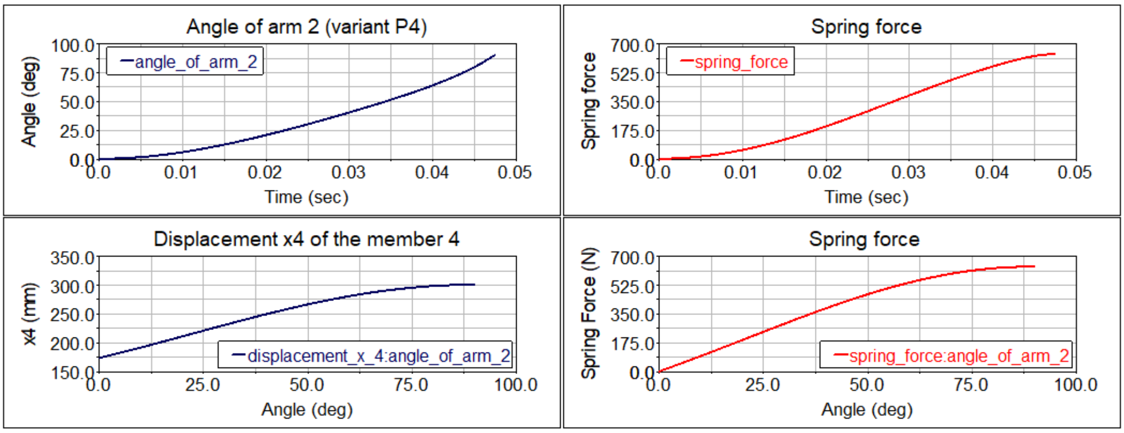
d


Angle of arm 2 (variant P3)
angle_of_arm_2
Angle (deg)
Time (sec)
Spring force
spring_force
Spring Force (N)
Time (sec)
Displacemnet x4 dependent on the angle of arm 2
displacement_x_4:angle_of_arm_2
x4 (mm)
Angle (deg)
Spring force dependent on the angle of arm 2
spring_force:angle_of_arm_2
Spring force (N)
Angle (deg)

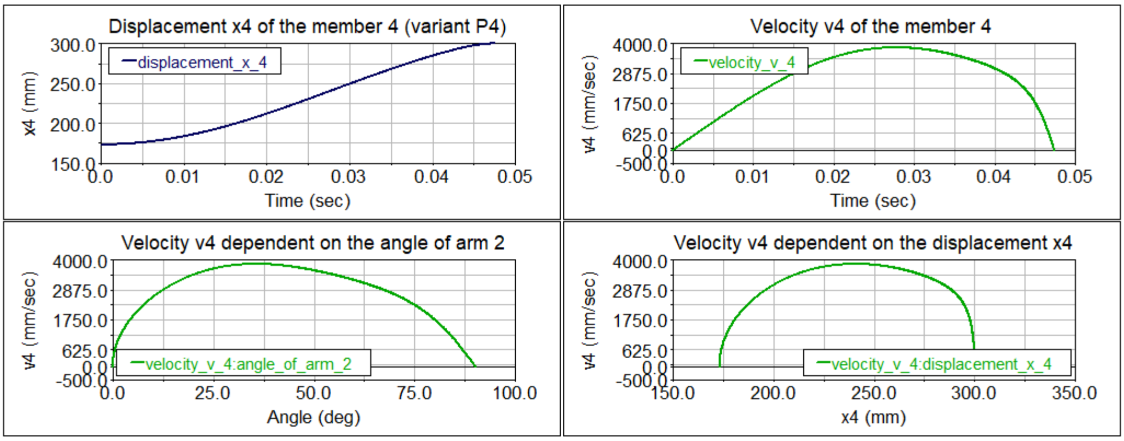
e


Displacement x4 of the member 4 (Variant P3)
displacement_x_4
x 4 (mm)
Time (sec)
Velocity v4 of the member 4
velocity_v_4
v 4 (mm/sec)
Time (sec)
Velocity v4 dependent on the angle of arm 2
velocity_v_4:angle_of_arm_2
Velocity (mm/sec)
Angle (deg)
Velocity v4 dependent on the displacement x4
velocity_v_4:displacement_x_4
v 4 (mm/sec)
x 4 (mm)

f



g



h

Fig. 8. The kinematics parameters of the selected point of the members of the mechanism a)-b) variant P1, c)-d) variant P2, e)-f) variant P3 and g)-h) variant P4

Conclusions. Computer programs allow us to interactively simulate and visualize the model. They allow us to conveniently edit the model and quickly visualize the results. Outputs in the form of graphs allow the display of current values of measured quantities in real time during the ongoing simulation and also bring visualization of the animation of the mechanism movement. It is also possible to create a video output of the simulation in AVI format.

The MSC Adams/View postprocessor is part of the computer prototype modeling process and is a convenient tool for creating, processing, editing and presenting simulation results in the form of graphs. It is also possible to display the model in the current state and print the results prepared in this way. We also calculated the position of the center of gravity of the pressure member 4.

MSC Adams works with a 3D model. The advantage is the ability to simulate the movement of the prototype model and its control in the program environment and verification of functionality in the form of 3D visualization. Based on the results obtained from the simulation, it is possible to modify the proposed model and test its behavior at different magnitudes of the loading force. The software used allows us to quickly assess the behavior of mechanisms under load and thus saves time that would be needed to create real prototypes of mechanisms.

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МОДЕЛЮВАННЯ В MSC ADAMS/VIEW ЯК ЧАСТИНА СУЧАСНОГО ПІДХОДУ ДО ПРОЕКТУВАННЯ МЕХАНІЧНИХ СИСТЕМ РОБОТІВ

У сучасному світі технологій ми стикаємося із широким застосуванням просторових механізмів та пов'язаних механічних систем. Ми досліджуємо дані руху на основі характеристик, які нам потрібно з'ясувати. Є кілька способів їх вирішити. Найстаріші з можливих рішень – це аналітичні та графічні рішення.

Нині для кінематичного аналізу доступний ряд комп'ютерних продуктів. Одна з них – програма MSC Adams. Дозволяє графічну та числову обробку обчислених значень, яка дасть вам загальне уявлення про поведінку механізму. Методи опису механізмів – це робота Денавіта та Хартенберга та робота Каліцина, Кисліцина, Лебедєвої, Литвина. Загальні методи динамічного аналізу плоских механізмів приписуються авторам: Брат, Козлов, Макаричів, Тимофєєв, Юревич, Бейчі, Коплік, Леу, Хауг, Стейскал, Валашек та інші.

Перевагою комп'ютерного моделювання є швидкість та гнучкість вирішення завдань у процесі проектування, розробки та впровадження інновацій. У наведеній статті показано рішення кінематичного аналізу механічної системи в MSC Adams.

Вирішено модель притискного механізму, що представляє механічну систему з одним ступенем свободи. Мета полягає в тому, щоб вирішити кінематику за допомогою MSC Adams View. Результати рішення графічно обробляються у програмі, що використовується. Використані елементи моделювання та процедури формування тіл та їх кінематичних зв'язків. Перевагою є можливість моделювати рух моделі-прототипу та керувати ним у програмному середовищі, а також керувати продуктивністю у вигляді 3D-візуалізації. За результатами моделювання можна побудувати реальну модель та спроектувати блоки.

Програмне забезпечення для моделювання – це зручний інструмент проектування, який заощаджує час та ресурси. Він також підходить для детального дослідження та практичного вивчення механічних систем.

Ключові слова: *моделювання; кінематичний та динамічний аналіз; траєкторія.*

Рис.: 8. Табл.: 1. Бібл.: 12.

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