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KINEMATIC ANALYSIS OF A THREE-MEMBER END CAM MECHANISM

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Abstract:
The aim of this work is to determine the positions, velocities and accelerations of points, typical of a given mechanism. The determination was carried out analytically - by using methods of analytic geometry and mechanics and by creating a 3D model of an end cam mechanism and computer simulation. The results received from the two methods were compared.
Keywords:
analytic geometry, mechanics of mechanisms, CAD/CAE system, displacement, velocity, acceleration.

1. INTRODUCTION

Determination of the positions, velocities and accelerations of points typical of a given mechanism is an often met engineer's problem. The studied mechanism is part of an assembly giving possibilities of oscillating movement when welding plate iron automatically. The mechanical diagram was chosen between several possible versions and the law of motion of the leading member is known.

The displacements, velocities, accelerations and laws of their changes of definite mechanism's points have to correspond to the requirements of a given manufacturing process. The velocities and accelerations of the single elements must not exceed the admissible values established from the practice. The displacements, velocities, accelerations and laws of their changes of the end cam mechanisms can be determined by using methods of analytic geometry [1].

The possibilities of solving a number of engineer's problems without using the classical methodic were given by bringing into use the CAE systems.

The aim of this work is determining the displacements, velocities, accelerations and laws of their changes of definite points for one 3D approximation of an end cam mechanism in the medium of CAD/CAE systems and after that the results to be compared with these received when using methods of analytic geometry .

2. FORMULATING THE PROBLEM

The studied three-member mechanism is classified in [1], under №2883 and is from the group of the three-member mechanisms with general purpose. It is shown in fig.1.

The end cam 1 rotates round an immovable axis y-y with constant angular speed. The surface a is flat and the normal k is shown. The angle between the normal k and the axis y-y is β. At angle of rotation φ of the cam 1, the follower 2 moves along the axis z. The axis z is parallel to axis y and is at distance R from it. The follower moves reciprocally. The power circuit is not shown in the diagram. From an engineer's point of view the problem is routine – determining the kinematical parameters of a three-member end cam mechanism.

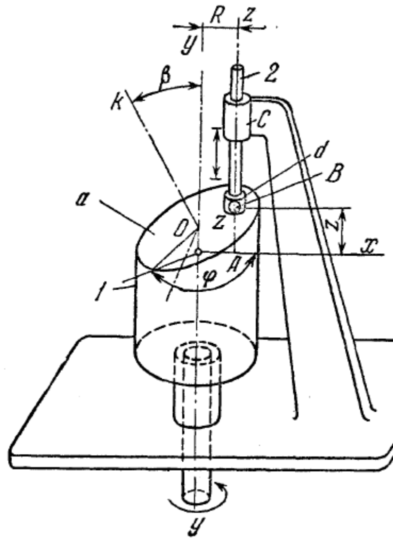

Figure 1. Diagram Of The Mechanism

The following parameters of the approximated end cam mechanism will be determined:

- The displacements, velocities, accelerations and laws of their changes of determined points - analytically
- The displacements, velocities, accelerations and laws of their changes for given points in the medium of the system COSMOSMotion™, integrated with the CAD system SolidWorks.

3. SOLVING THE PROBLEM

3.1. Analytical determination of the displacements, velocities, accelerations and laws of their changes of determined points.

Methods of analytic geometry will be used in order to solve the above mentioned problem. The tangent between the follower and surface a from fig.1 is an ellipse. The points of this ellipse belong to a cylinder with radius R and axis coinciding with axis x – fig. 2. At the same time the points of the ellipse belong to the plane a.

The equation of a plane passing through an axis is: $A.x + Cz = 0$. The boundary condition of $x = c \quad z = R$ is used in order to determinate A and C.

Taking into consideration the boundary condition we receive:

$$-\frac{R}{c}.x + z = 0 \qquad (1)$$

The equation of a cylinder with radius R and axis coinciding with x is:

$$y^2 + z^2 = R^2 \qquad (2)$$

The equation of the ellipse is given in parametrical form as a function of the parameter $\varphi = \varphi(t) = \omega.t$. Taking into consideration (1), (2) and fig.2 the following quantities are determined:

$$\begin{aligned} \varphi &= \varpi.t, \\ x &= c.\cos\varphi, \\ y &= -R\sin\varphi, \\ z &= R\cos\varphi. \end{aligned} \tag{3}$$

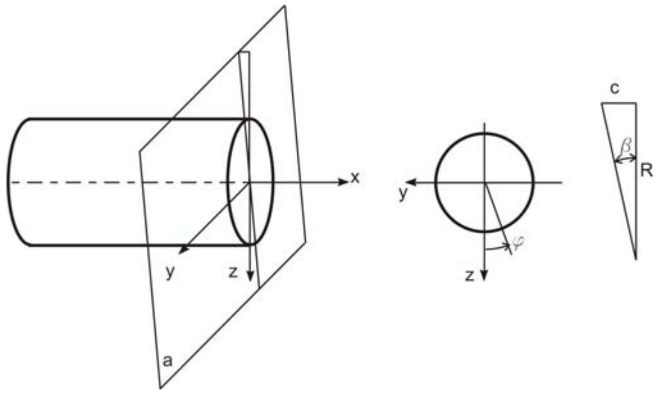

Figure 2. Geometric Analysis

The value of the coordinate x gives the displacement of the follower. The law of motion of the follower is:

$$x = c.\cos(\varpi t) \tag{4}$$

After successive differentiation, the laws' of velocity and acceleration change take the form:

$$V = \frac{dx}{dt} = \frac{d}{dt}(c.\cos(\varpi t)) = -c.\sin(\varpi t).\varpi \quad , \tag{5}$$

$$a = \frac{dV}{dt} = \frac{d}{dt}(-c.\sin(\varpi t).\varpi) = -c.\cos(\varpi t).\varpi^2 \tag{6}$$

Calculations are made for R=35mm, c=1,5mm и $\omega=2\pi$ rad.s^{-1}– fig.3.

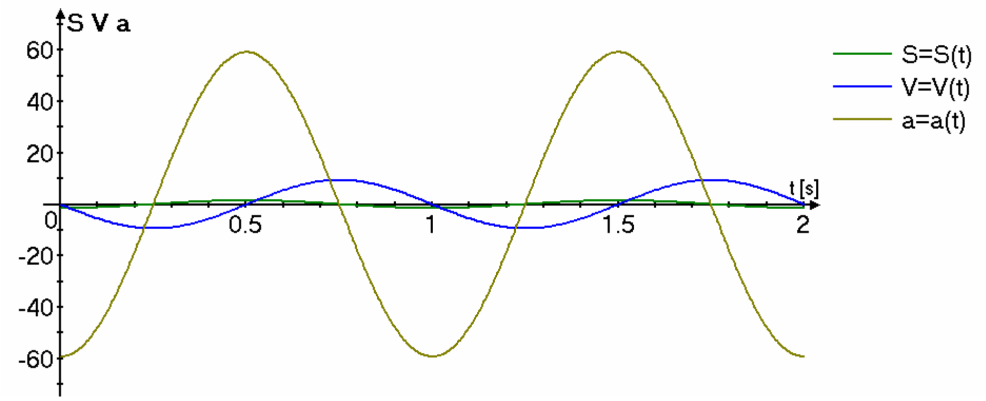

Figure 3. Analytically Determined Displacements, Velocities And Accelerations

3.2 Determination of the displacements, velocities, accelerations and laws of their changes of given mechanism's points in the medium of the system COSMOSMotion™, integrated with the CAD system SolidWorks.

This problem can be solved in the following steps:

- Generating a 3D model in the CAD system SolidWorks – fig.4;
- Defining the movable and immovable elements– fig.5;
- Defining the constraints– fig.6;
- Defining the searched results– fig.7;
- Defining the plots– fig.8;
- Starting the analysis;
- Examination of the received results– fig.9.

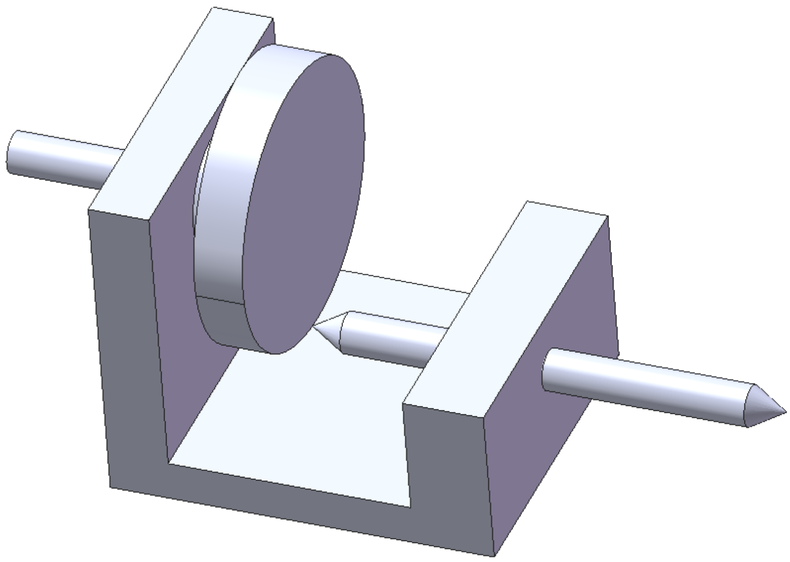

Figure 4. 3D Model

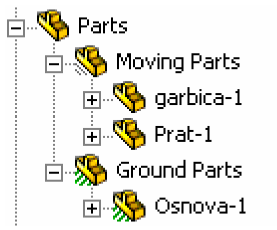

Figure 5. Types Of Parts

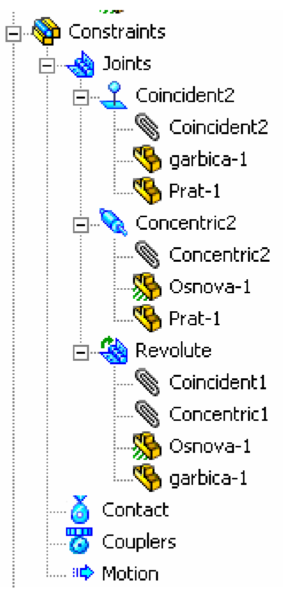

Figure 6. Defining The Constraints

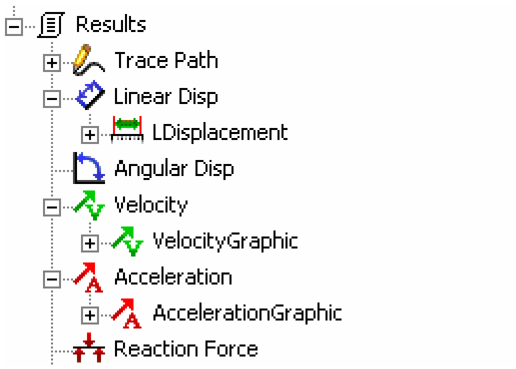

Figure 7. Defining The Results

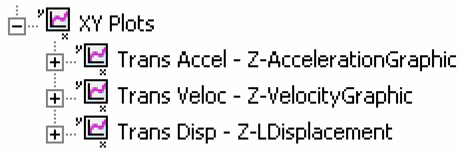

Figure 8. Defining The Plots

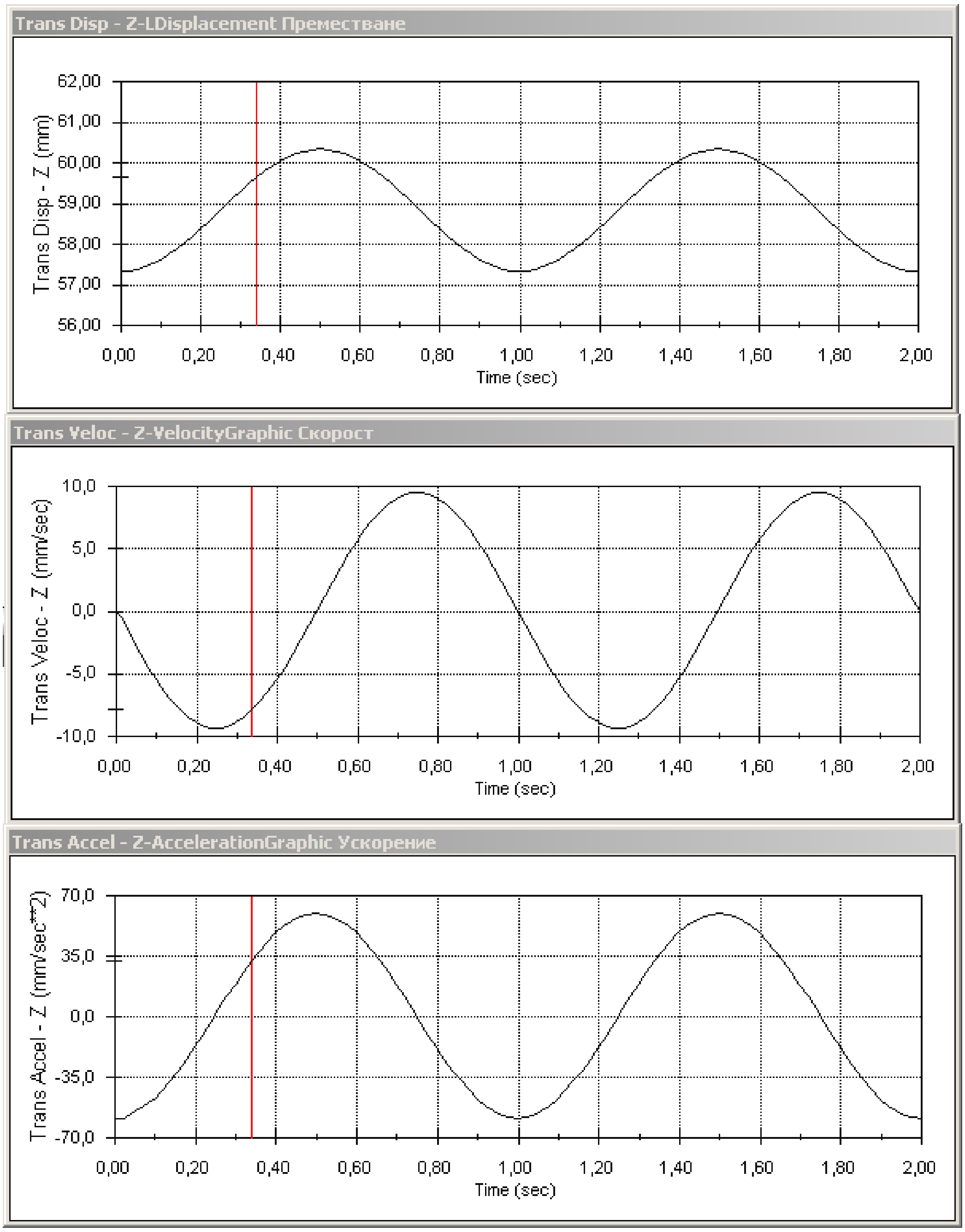

Figure 9. Results From The Analysis

4. ANALYZING THE RECEIVED RESULTS

The determined displacements, velocities and accelerations values of given points in the medium of the system COSMOSMotion™ are exported in csv format. The results received form the studied 3D model in the medium of the system COSMOSMotion™ coincide with the results received analytically with very few deviations. The results received by analysis of a 3D model in the medium of a CAE system can be used with sufficient accuracy when caring out theoretic kinematical analysis is not possible.

The working principle used in the study and the received results can be applied in the other analogous cases and as a basis when choosing a suitable method.

The possibilities of the different CAE systems become visible with increasing the complexity of the mechanisms that are studied. COSMOSMotion can be used when solving a number of practical problems such as dimensioning motors and driving members, determining the required power, arranging joints, synthesis of cams, studying drives, dimensioning springs and shock absorbers and when predicting the behavior of contact parts. The result is reducing the number and the price of the physical prototypes and their producing time. More versions of the design at its early stage can be considered which gives possibility of choosing the optimum.

Bibliography

[1.] Artobolevski I, "Mechanisms in Modern Engineering" volume V – "Cam and Frictional Mechanisms with Flexible Members" – Moscow, "Nauka" 1981

[2.] COSMOSMotion™ 2007 Online User's Guide, Structural Research & Analysis Corp., 2007