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# KINETICS STUDY ON LABORATORY MODEL OF THE MECHANISMS OF PARALLEL GANG SHEARS' TYPE ASSIGNED FOR CUTTING METALLURGICAL PRODUCTS

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**ABSTRACT**
In this study is presented the kinetics study on laboratory model of the shear type mechanisms for cutting metallurgical products at the mill train of the semi-finished steel products Rolling Mill No. 2. In the approach of experimental and application studies has been used an *experimental installation* reduced to the 1:5 dividing rule by comparison with the shear existent in exploitation, conceived and projected at the Faculty of Engineering in Hunedoara, respecting totally the conditions of geometrical and technological similarity with the industrial equipment, The kinetics study aims to determine positions, velocities and acceleration of a mechanism elements depending on angle of sight of the driving element which is in rotational movement or depending on linear movement if the driving element executes a translational movement.
**KEYWORDS:**
mechanism, positions, velocities, accelerations

## 1. INTRODUCTION

In order to perform the kinetics study of plane mechanisms is necessary to divide the mechanism in ASSUR kinetics groups and driving element, because most methods of kinetics study, aiming to generalize them easily, have been elaborated for such kinetics groups (dyads, triads, tetrads, etc.).

In the theory of mechanisms are known methods of graphical – analytical kinetics study that have the property to be used rapidly and simply, but as a consequence of high volume of graphical representations the accuracy of results is low. Analytical methods, for example the method of contours involves a high volume of mathematical calculus such as solving of some sets of equations for as many as positions of driving element, calculus that can be easily solved by an electronic computer. Kinetics study of the researched mechanism using the Mathcad programming environment follows to be presented.

## 2. MECHANISM OPERATION

Operation of this type of mechanism is performed in phases: in the first phase is lowered the superior cutter on the surface of steel semi-finished product and after this they stop and the inferior cutter which performs the cutting operation starts to lift.

After cutting has done the inferior cutter comes back to the initial position then starts to lift the superior cutter too. These movements are coordinated by the crankshaft and are accomplished at a stroke of $360^0$ of this crankshaft. In a kinetics cycle are taken into account four working stages during whose take place the operation of one cutting (1). These are marked by the crank angle measured in the counterclockwise direction in the following periods: $270^0$-$180^0$; $180^0$-$90^0$; $90^0$-$0^0$; $360^0$-$270^0$.

## 3. STRUCTURAL ANALYSIS OF THE MECHANISM

The mechanism will be approached depending on movement phases, because the bearers will be modified. From 270 up to $180^0$, is lowered the superior cutter together with a pad up to a certain height, the inferior cutter remaining in the initial position (figure 1).

The mechanism consists of handhold 1, small driving rod 2, higher arm 3, lower arm 5, big driving rod 4 and superior slider.

From structural point of view the mechanism can be decomposed in simple triad of order 3, 3rd class, composed from small driving rod 2, upper arm 3, big driving rod 4 and superior slider 4, kinematics couplings of class V: A, B, C, D, E and translation coupling and engine element (hand-hold 1).

The mechanism is plane and consists of five kinematics elements (1, 2, 3, 4, 6) and seven kinematics couplings of class V, six revolving couplings (O,A,B,C,D,E) and a translation coupling.

## 4. DETERMINATION OF POSITIONS FOR COMPONENT ELEMENTS

To determine the positions will be used the figure 1:

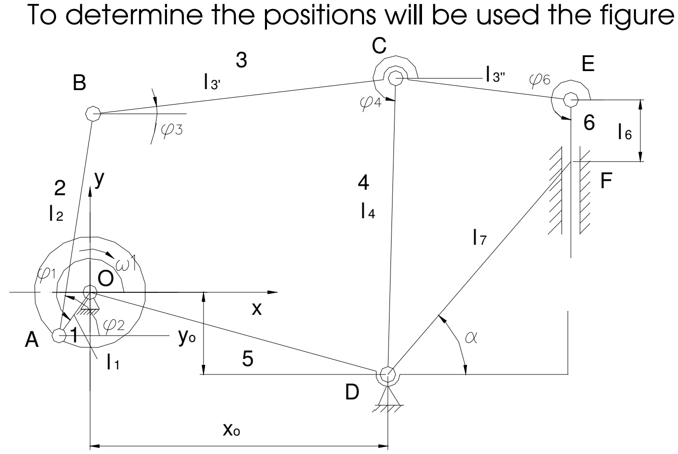


Figure 1. Kinetics Scheme of ABCDE triad

Determination of positions for ABCDE triad sown in figure 2 will be accomplished choosing the origin of the coordinate system of axes xy in the point O. By notations in the figure will be written the projections of contour equations for ABCDE triad:

- For the OABCD closed loops:

$$\begin{cases} l_1 \cdot \cos\varphi_1 + l_2 \cdot \cos\varphi_2 + l_3' \cdot \cos\varphi_3 + l_4 \cdot \cos\varphi_4 = x_0 \\ l_1 \cdot \sin\varphi_1 + l_2 \cdot \sin\varphi_2 + l_3' \cdot \sin\varphi_3 + l_4 \cdot \sin\varphi_4 = y_0 \end{cases} \quad (2)$$

- For the CDEF closed loops CDEF

$$\begin{cases} -l_4 \cdot \cos\varphi_4 + l_{7x} = l_3'' \cdot \cos\varphi_3 + l_6 \cdot \cos\varphi_6 \\ l_4 \cdot \sin\varphi_4 + l_{7y} = l_3'' \cdot \sin\varphi_3 + l_6 \cdot \sin\varphi_6 \end{cases} \quad (3)$$

Calculation phases presented above are solved by the mean of Triad Program, written in Mathcad environment, and graphical representations for variation of the position angles $\varphi_2$ , $\varphi_3$, $\varphi_4$, d6 depending on position $\varphi_1$ of the hand-hold are shown in figures 2, 3, 4. 5.

## 5. DETERMINATION OF ANGULAR VELOCITIES FOR ELEMENTS 2, 3, 4 AND LINEAR VELOCITY FOR ELEMENT 6 (FOR THE POSITION OF HAND-HOLD OF 270-180⁰)

In order to determine the angular velocities of the elements 2, 3, 4 and linear velocity of element 6 will be used the figure 2 and will be differentiated the sets of equations (2) and (3):

$$\begin{cases} -l_1 \cdot \omega_1 \cdot \sin\varphi_1 - l_2 \cdot \omega_2 \cdot \sin\varphi_2 - l_3' \cdot \omega_3 \cdot \sin\varphi_3 - l_4 \cdot \omega_4 \cdot \sin\varphi_4 = 0 \\ l_1 \cdot \omega_1 \cdot \cos\varphi_1 + l_2 \cdot \omega_2 \cdot \cos\varphi_2 + l_3' \cdot \omega_3 \cdot \cos\varphi_3 + l_4 \cdot \omega_4 \cdot \cos\varphi_4 = 0 \end{cases} \quad (4)$$

$$\begin{cases} l_4 \cdot \omega_4 \cdot \sin\varphi_4 = -l_3'' \cdot \omega_3 \cdot \sin\varphi_3 \\ l_4 \cdot \omega_4 \cdot \cos\varphi_4 = l_3'' \cdot \omega_3 \cdot \cos\varphi_3 + v_6 \end{cases} \quad (5)$$

Graphical representations of angular velocities for elements 2,3,4 and linear velocity variations for the element 6 depending on position $\varphi_1$ of the hand-hold is shown in figures 2, 3, 4, 5.

## 6. DETERMINATION OF ANGULAR ACCELERATIONS FOR ELEMENTS 2, 3, 4 AND LINEAR ACCELERATION FOR THE ELEMENT 6 (FOR THE POSITION OF HAND-HOLD OF 270-180⁰)

In order to determine the angular accelerations for elements 2, 3, 4 and linear acceleration for element 6, will be differentiated the equations of velocities, keeping notations shown in figure 2.

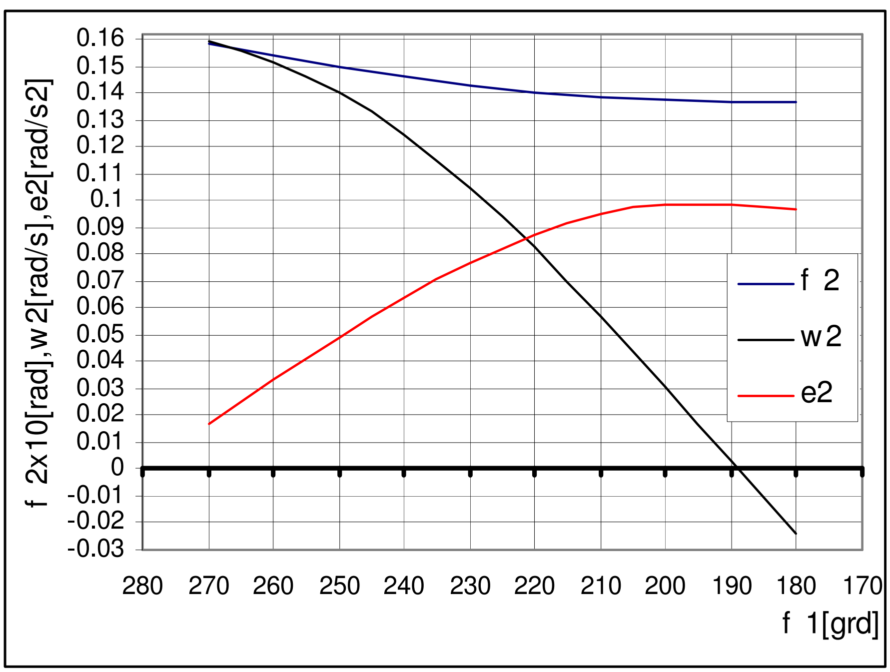


Figure 2. Variation of to position angle, angular velocity and angular acceleration for small driving rod 2 depending on angle f1

$$\begin{cases} -l_2\varepsilon_2\sin\varphi_2 - l_3^{'}\varepsilon_3\sin\varphi_3 - l_4\varepsilon_4\sin\varphi_4 = l_1\omega_1^{2}\cos\varphi_1 + l_2\omega_2^{2}\cos\varphi_2 + l_3^{'}\omega^{2}\cos\varphi_3 + l_4\omega_4^{2}\cos\varphi_4 \\ l_2\varepsilon_2\cos\varphi_2 + l_3^{'}\varepsilon_3\cos\varphi_3 + l_4\varepsilon_4\cos\varphi_4 = l_1\omega_1^{2}\sin\varphi_1 + l_2\omega_2^{2}\sin\varphi_2 + l_3^{'}\omega_3^{2}\sin\varphi_3 + l_4\omega_4^{2}\sin\varphi_4 \end{cases} \quad (6)$$

$$\begin{cases} l_4\varepsilon_4\sin\varphi_4 + l_3^{''}\varepsilon_3\sin\varphi_3 = -l_4\omega_4^{2}\cos\varphi_4 - l_3^{''}\omega_3^{2}\cos\varphi_3 \\ l_4\varepsilon_4\cos\varphi_4 - l_3^{''}\varepsilon_3\cos\varphi_3 - a_6 = l_4\omega_4^{2}\sin\varphi_4 - l_3^{''}\omega_3^{2}\sin\varphi_3 \end{cases} \quad (7)$$

Graphical representation for variations of angular accelerations for elements 2, 3, 4 and linear acceleration with respect to element 6 depending on position $\varphi_1$ of hand-hold are shown in figures 2, 3, 4, 5:

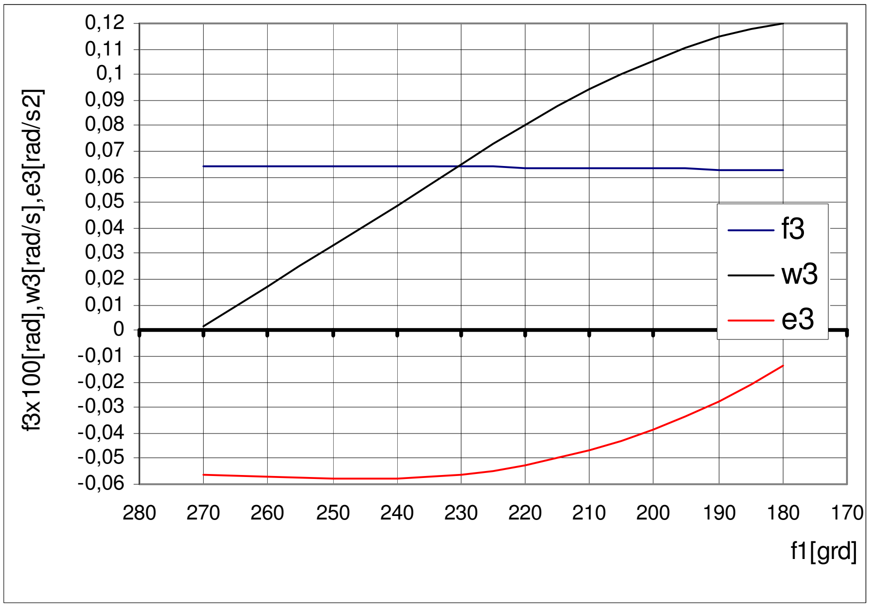


Figure 3. Variation of to position angle, angular velocity and angular acceleration for higher arm 3 depending on angle f1

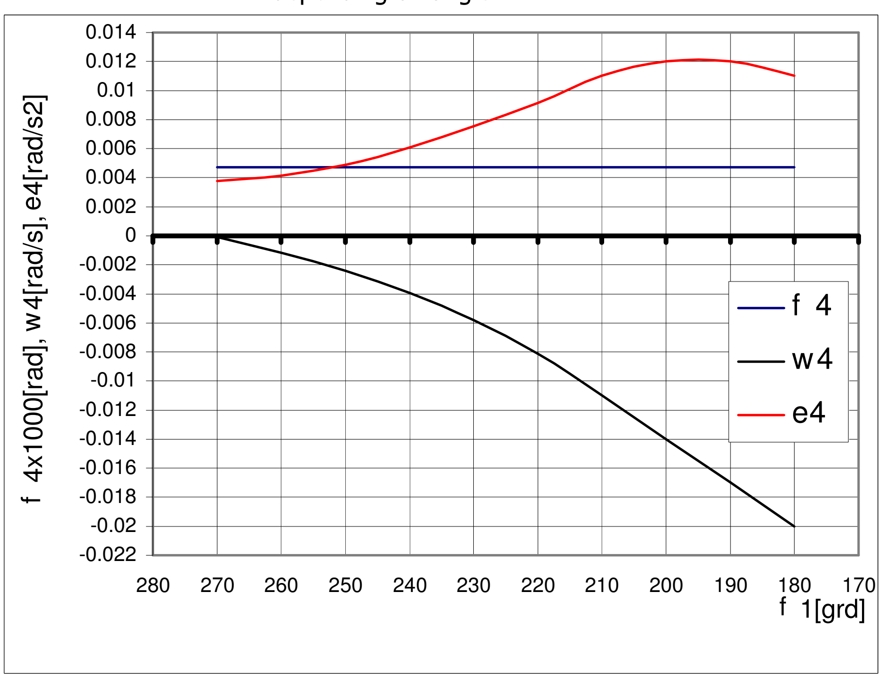


Figure 4. Variation of to position angle, angular velocity and angular acceleration for big driving rod 4 depending on angle f1

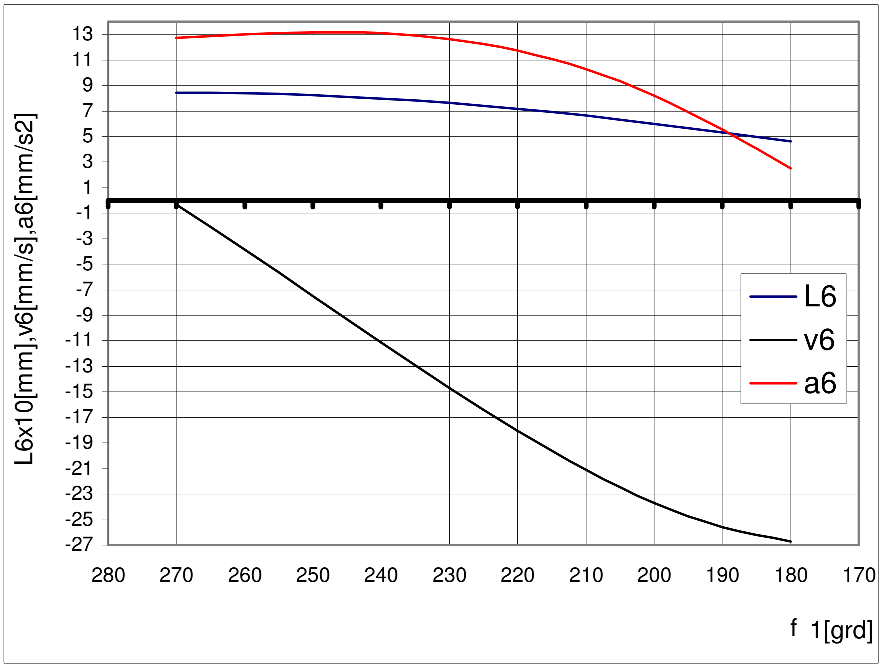


Figure 5. Variation of movement, linear velocity and linear acceleration for superior slider 6 depending on f1

## 7. CONCLUSIONS

The conclusion of calculus performed is that both velocities and accelerations have low values because the angular velocity of the driving element has a low value too. Variations of accelerations give us information with respect to variations of inertia forces that act on kinetics elements, which are necessary in the kinetics – static design. Kinetics study is also necessary to determine the relative positions of elements at mechanism assemblage.

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