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RESEARCH ON THE KINEMATICS OF A MECHANISM WITH QUICK RETURN OF THE OSCILLATING ARM

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ABSTRACT

The paper presents the analysis of a mechanism with quick return of its oscillating arm. For this purpose it has been realized a computer program that permits simulating of the studied mechanism. The results of the simulations are finally presented.

Keywords: mechanism, oscillating arm, quick return, cinematic analysis

INTRODUCTION

The study of the kinematics of the various mechanisms used in industrial applications represents a very important stage in their design. In these studies it is necessary to develop simulators for the functioning of the analyzed mechanisms that allow, among other things, the analysis of the influence of various constructive parameters on the distribution of speeds and accelerations [1-19]. In this paper is analyzed the kinematics of a widely used mechanism in industrial applications which permits a quick return of its oscillating arm marked with *3* in Figure 1. For this purpose a computer program that simulates the functioning of the analyzed mechanism has been developed and a series of results of the simulations performed are finally presented.

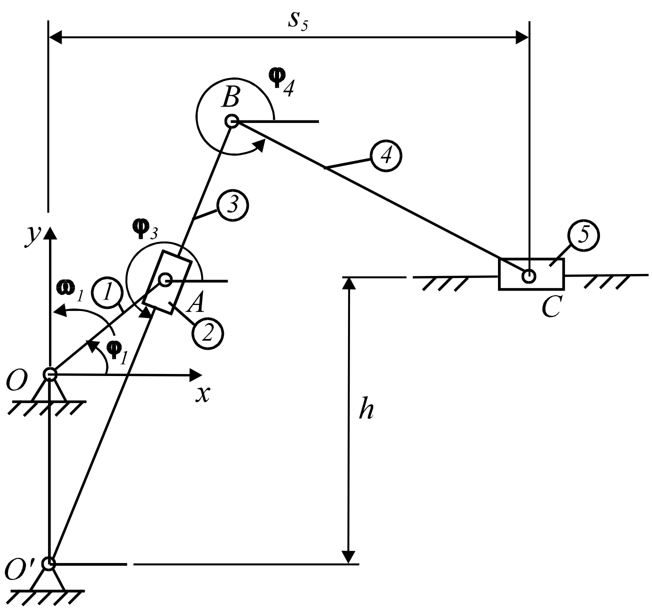

Figure 1. Mechanism with quick return of its oscillating arm 3

THEORETICAL CONSIDERATIONS AND SIMULATION RESULTS

The mechanism in Figure 1 has two independent loops [20]: *O-A-O'-O* and *O'-B-C-O'*. By projecting the vector equations: $\overline{OA}+\overline{AO'}+\overline{O'O}=0$ and $\overline{O'B}+\overline{BC}+\overline{CO'}=0$ corresponding to the two component loops on (*Oxy*) system of coordinates it results:

$$\begin{cases} l_1\cdot\cos\varphi_1+s_3\cdot\cos\varphi_3=0 \\ l_1\cdot\sin\varphi_1+s_3\cdot\sin\varphi_3+e=0 \end{cases} \tag{1}$$

$$\begin{cases} l_3\cdot\cos(\varphi_3-\pi)+l_4\cdot\cos\varphi_4-s_5=0 \\ l_3\cdot\sin(\varphi_3-\pi)+l_4\cdot\sin\varphi_4-h=0 \end{cases} \tag{2}$$

where: $l_1=OA$, $s_3=AO'$, $e=O'O$, $l_3=O'B$, $l_4=BC$.

By solving the equations above it results:

$$s_3=\sqrt{l_1^2+2\cdot l_1\cdot e\cdot\sin\varphi_1+e^2} \tag{3}$$

$$\varphi_3=\mathrm{ATAN2}\left(-\frac{l_1\cdot\sin\varphi_1+e}{s_3},-\frac{l_1\cdot\cos\varphi_1}{s_3}\right) \tag{4}$$

$$\sin\varphi_4=\frac{1}{l_4}(l_3\cdot\sin\varphi_3+h) \tag{5}$$

$$s_5=-l_3\cdot\cos\varphi_3+l_4\cdot\cos\varphi_4 \tag{6}$$

where: $\mathrm{ATAN2}(y,x)$ calculates arctan(*y/x*) by taking into account the signs of *x* and *y*.

It has been developed a computer program using Maple programming language that simulates the analyzed mechanism functioning. The dimensions of the component links are: $l_1=0.2\,\mathrm{m}$; $l_3=0.9\,\mathrm{m}$; $l_4=0.7\,\mathrm{m}$, $e=0.4\,\mathrm{m}$, $h=0.5\,\mathrm{m}$. Also, it has been considered that the angular speed of the crank *1* has a constant value equal to 5 rad/s.

Using the computer program mentioned above it has been analyzed the variation of the parameters ω_3 and ε_3 corresponding to the oscillating arm *3* and the variation of the speed v_5 and of the acceleration a_5 of the work element *5* when *e* varies between 0.3 m and 0.45 m and when l_1 varies between 0.15 m and 0.3 m.

The angular speed ω_3 and the angular acceleration ε_3 have been calculated with the relations:

$$\omega_3=\dot{\varphi}_3=\frac{\mathrm{d}\varphi_3}{\mathrm{d}\varphi_1}\cdot\frac{\mathrm{d}\varphi_1}{\mathrm{d}t}=\omega_1\cdot\frac{\mathrm{d}\varphi_3}{\mathrm{d}\varphi_1} \tag{7}$$

$$\varepsilon_3=\dot{\omega}_3=\frac{\mathrm{d}\omega_3}{\mathrm{d}\varphi_1}\cdot\frac{\mathrm{d}\varphi_1}{\mathrm{d}t}=\omega_1\cdot\frac{\mathrm{d}\omega_3}{\mathrm{d}\varphi_1} \tag{8}$$

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The speed v_5 and the acceleration a_5 of the work element 5 have been calculated in a similar way with the following relations:

$$v_5 = \dot{s}_5 = \frac{ds_5}{d\varphi_1} \cdot \frac{d\varphi_1}{dt} = \omega_1 \cdot \frac{ds_5}{d\varphi_1} \tag{9}$$

$$a_5 = \dot{v}_5 = \frac{dv_5}{d\varphi_1} \cdot \frac{d\varphi_1}{dt} = \omega_1 \cdot \frac{dv_5}{d\varphi_1} \tag{10}$$

In Figures 2 and 3 are presented the variation curves during a cinematic cycle of the angular speed ω_3 and of the angular acceleration ε_3 when e varies between 0.3 m and 0.45 m.

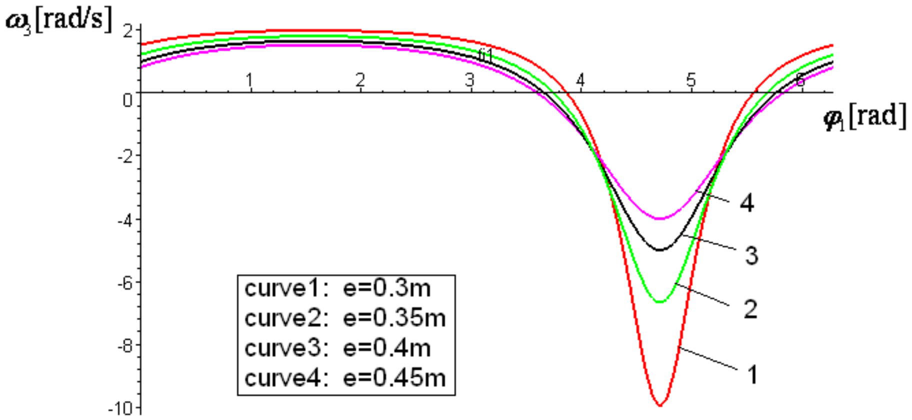

Figure 2. The variation of the angular speed ω_3 when e varies between 0.3m and 0.45m

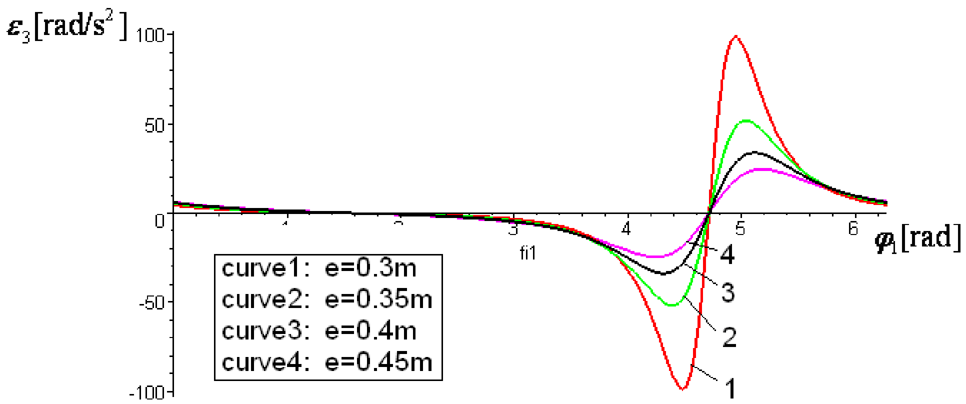

Figure 3. The variation of the angular acceleration ε_3 when e varies between 0.3m and 0.45m

From the two graphs it is observed that with the decrease of the *e* values there is a significant increase both of ω_3 values and of ε_3 values.

Figures 4 and 5 present the variation curves of v_5 and of a_5 when *e* varies between 0.3m and 0.45 m.

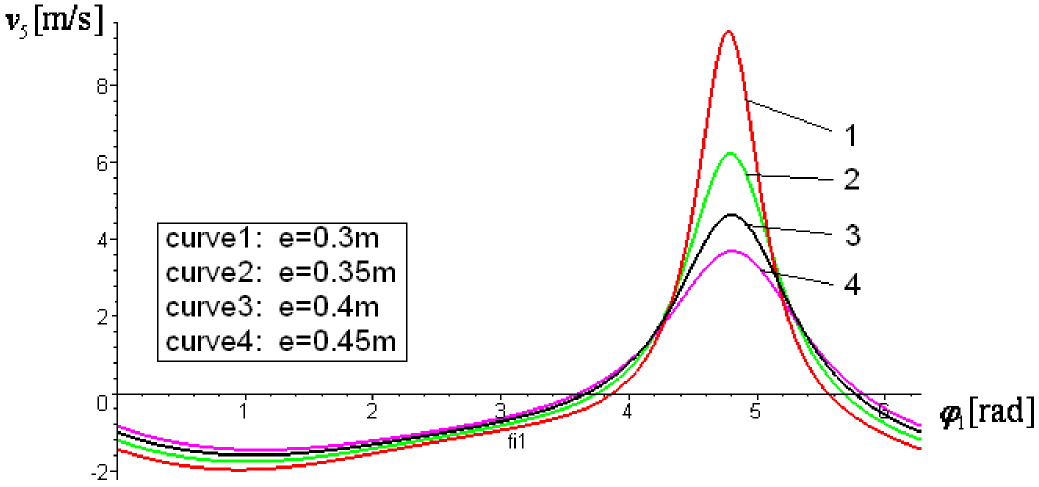

Figure 4. The variation of the speed v_5 when e varies between 0.3 m and 0.45 m

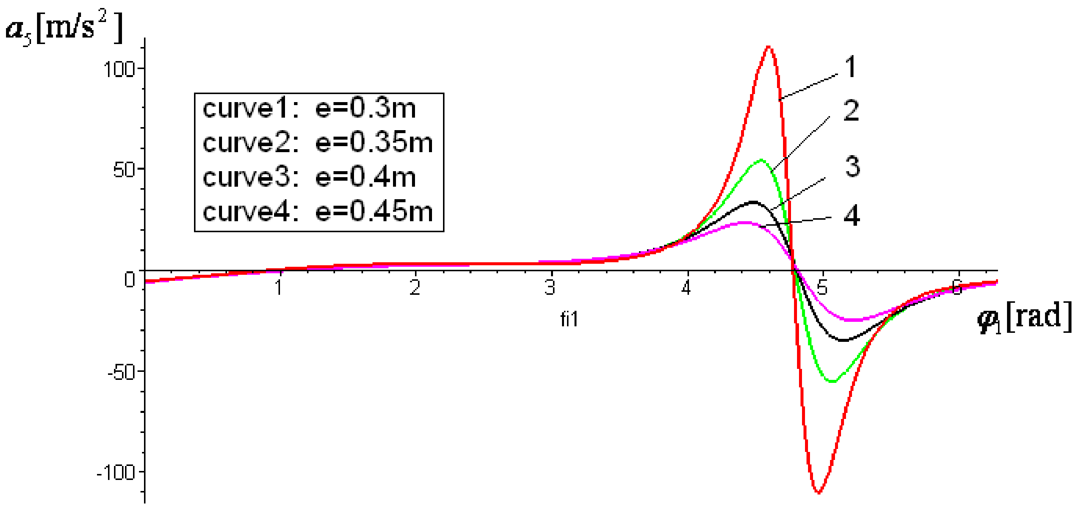

Figure 5. The variation of the acceleration a_5
when e varies between 0.3 m and 0.45 m

Also, from the two graphs in Figures 4 and 5 it can be noticed that with the decrease of the *e* values there is a significant increase both of v_5 values and of a_5 values.

Figures 6 and 7 present the variation curves of ω_3 and of ε_3 when l_1 varies between 0.15 m and 0.3 m.

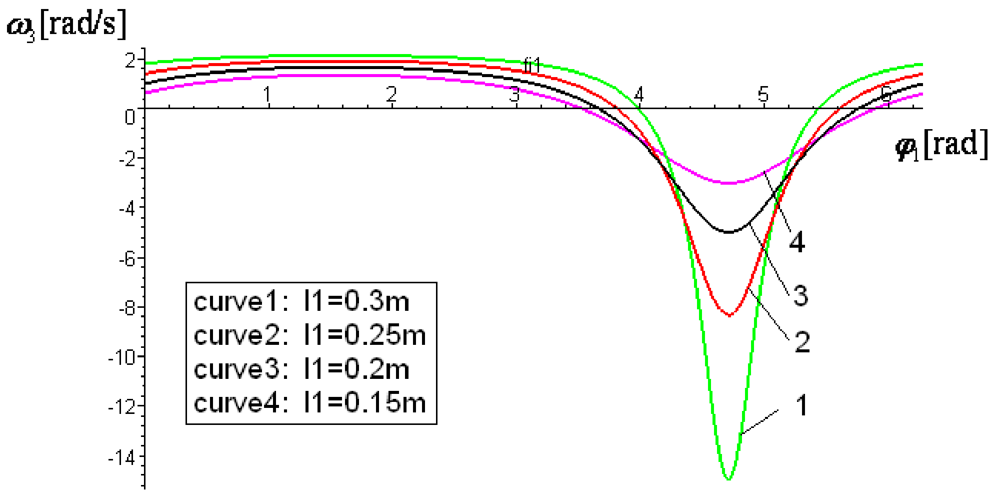

Figure 6. The variation of the angular speed ω_3 when l_1 varies between 0.15 m and 0.3 m

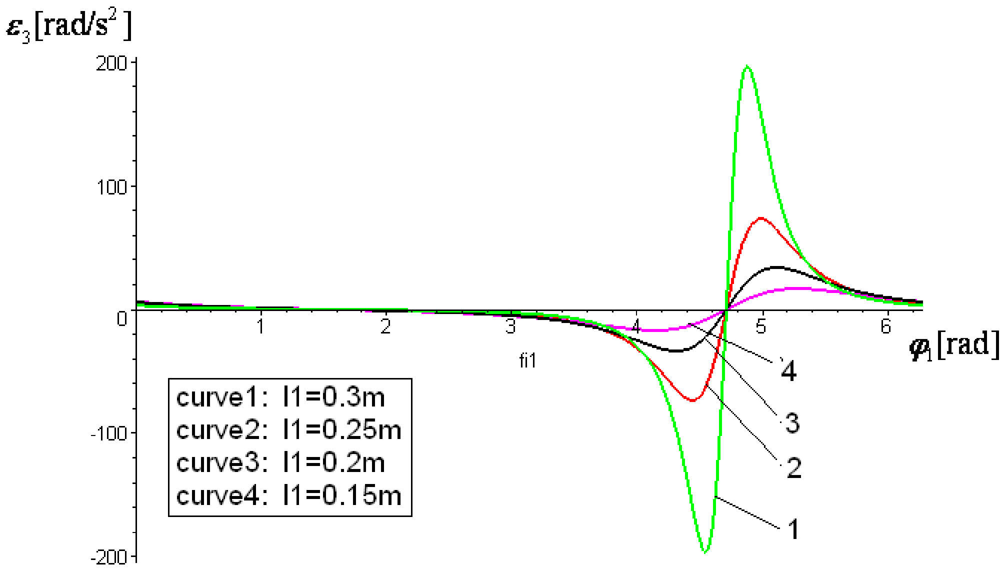

Figure 7. The variation of the angular acceleration ε_3 when l_1 varies between 0.15 m and 0.3 m

From the two graphs in Figures 6 and 7 it is observed that with the increase of the l_1 values, the angular velocity ω_3 values and the angular acceleration ε_3 values have a significant increase in the second part of the cinematic cycle.

In Figures 8 and 9 are presented the variation curves of v_5 and of a_5 when l_1 varies between 0.15 m and 0.3 m.

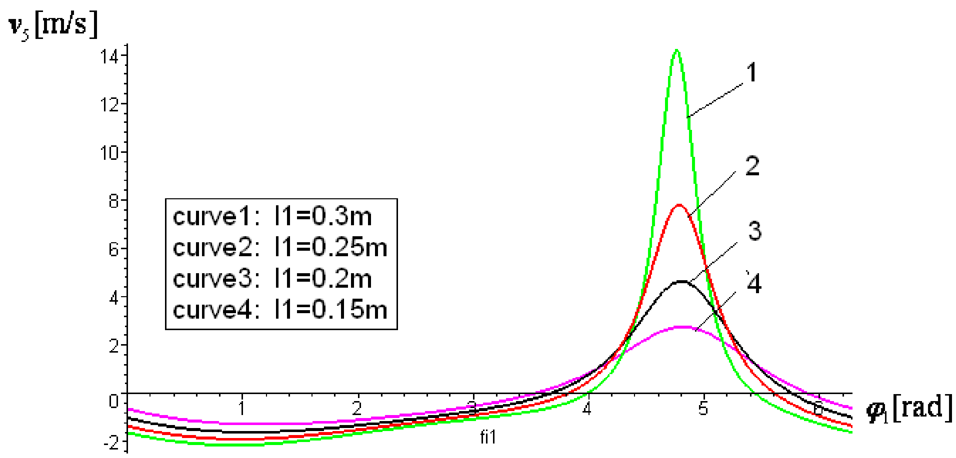

Figure 8. The variation of the velocity v_5 when l_1 varies between 0.15 m and 0.3 m

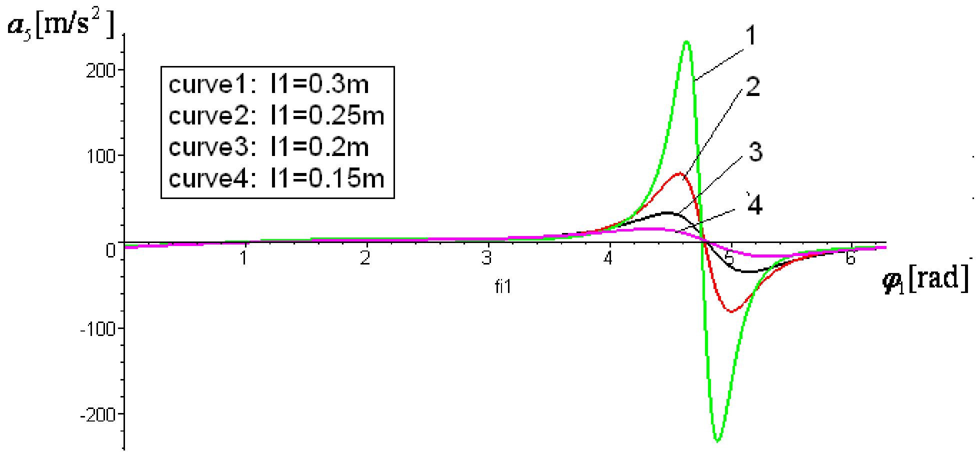

Figure 9. The variation of the acceleration a_5 when l_1 varies between 0.15 m and 0.3 m

From the two graphs in Figures 8 and 9 it can be noticed that with the increase of the l_1 values, v_5 values and a_5 values have a significant increase.

CONCLUSIONS

In this paper it has been analyzed the kinematics of a widely used mechanism in industrial applications which permits a quick return of its oscillating arm. In this scope a computer program that simulates the functioning of the analyzed mechanism has been developed. It has been presented a series of results obtained with the computer program concerning the variation of some cinematic parameters when it was considered some intervals of variation for the dimensions of the components of the mechanism.

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