

## DEVELOPMENT OF CURVED HOLE MACHINING METHOD

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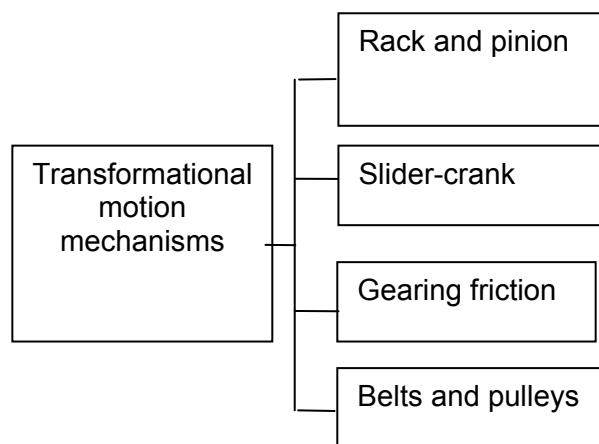
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**Abstract:** The paper presents the construction of a special device that permits the machining of curved holes by electrical discharge machining (EDM). An example is described of the production of a curved hole in a workpiece and from the experimental results it is found that the mechanism can perform a stable electrical discharge machining.

**Keywords:** Curved hole, Electrical discharge machining, device

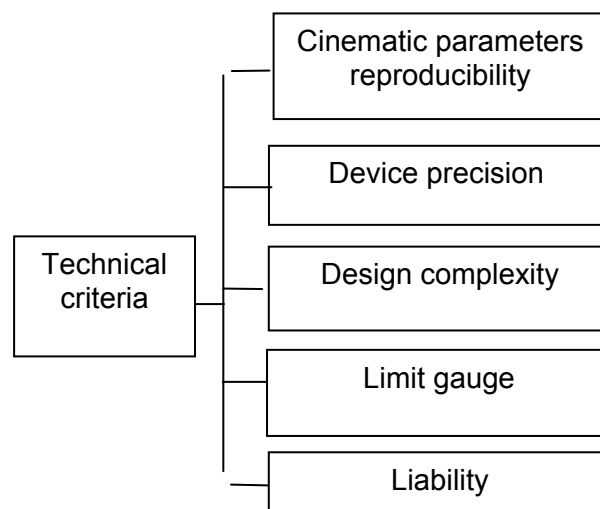
### 1. INTRODUCTION

Machining curved holes by means of electrical discharge machining implies the development of a device installed on an EDM which converts the translational motion into a rotational motion. Researches were performed on transformational motion mechanisms to be used in designing of the device. The most suitable mechanisms are presented in the figure 1.



**Fig. 1 Transformational mechanisms.**

A technical analysis on the above mechanisms is performed considering the technical criteria to be fulfilled by the experimental device as it is shown in the figure 2. The cinematic parameters reproducibility is the most important criterion for a stable gap in electrical discharge machining. The second important criterion is the device precision. Less important criteria for the experimental device designing are the liability, the design complexity and the limit gauge. Table 1 shows the score of each mechanism according to the bibliography.



**Fig. 2 Technical criteria**

**Table 1. Mechanism scores**

Mechanism \ Technical criterion	Rack and pinion	Slider-crank	Gearing friction	Belts and pulleys
Cinematic parameters reproducibility (0,22)	2,20	2,20	2,20	2,20
Device precision (0,19)	1,90	1,90	1,52	1,90
Sensitivity (0,14)	1,12	1,40	1,12	1,40
Liability (0,17)	1,70	1,70	1,36	1,53
Handling (0,11)	1,10	1,10	1,10	1,10
Design complexity (0,06)	0,43	0,54	0,48	0,60
<b>Total score</b>	<b>8,45</b>	<b>8,84</b>	<b>7,78</b>	<b>8,73</b>

After scoring the slider-crank and the belts and pulleys mechanisms are preferred. The best score results for the slider-crank mechanism on which the device design is based.

## 2. THE ANALYSIS OF THE DEVICE

The authors comparatively analyze the cinematic parameters of both the crank and the EDM unit. The equations (1) and (2) which involve the velocity and acceleration of point B on the crank and point C on the EDM unit are shown below:

$$\frac{v_c}{v_b} = -\left(\sin \varphi_1 + \frac{1}{2} \lambda \cdot \sin 2\varphi_1\right) \quad (1)$$

$$\frac{a_c}{a_b} = -(\cos \varphi_1 + \lambda \cdot \cos 2\varphi_1) \quad (2)$$

Where the notations are as in the figure 3 and  $\lambda$  is the ratio between the length of the crank  $l_1$  and the length of the slider  $l_2$ . The associated graphics of the two equations for different values of  $\lambda$  ratio (0.2; 0.3; 0.5 si 0.7) and angles from  $30^\circ$  to  $175^\circ$  are shown in the figures 4 and 5.

To be noticed that the smallest variations between either velocity and acceleration ratios are for the value of  $\lambda=0.2$ . Again, the acceptable velocity and acceleration ratios are for the angles from  $45^\circ$  to  $135^\circ$  which limits the device designing.

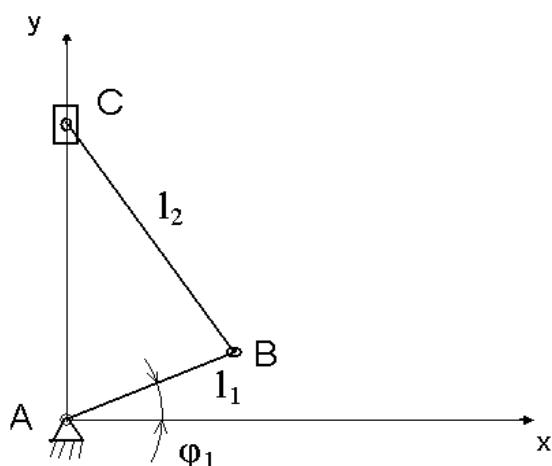


Fig. 3 Slider-crank mechanism

This results in the fabrication of a device based on the slider-crank mechanism with which an experimental procedure is performed.

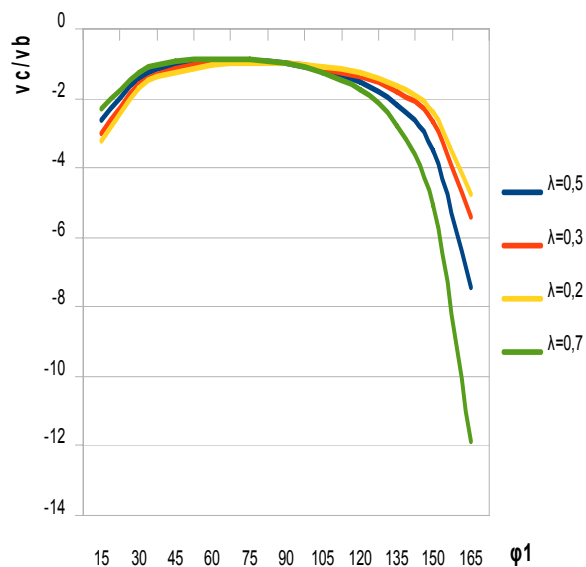


Fig. 4 The velocity

The device can produce curvatures from 50 to 70 mm using electrodes of 1.5 to 12 mm in diameter. Because of the difficulty of fluid circulation and sludge removal from the gap, right tubular cylinder electrodes are used through which the dielectric is introduced by injection.

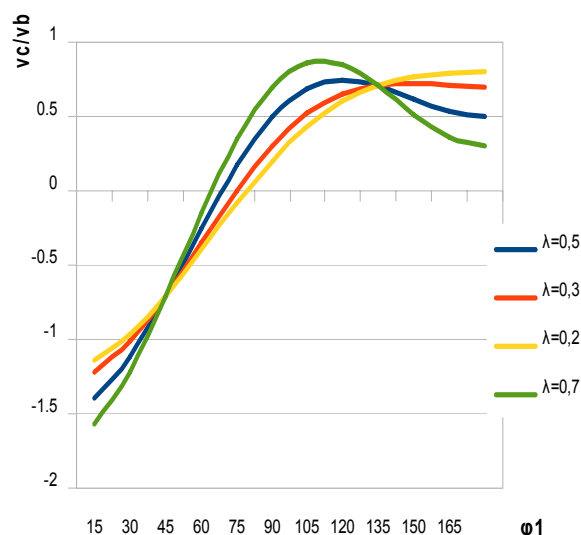


Fig. 5 The acceleration

The experimental procedure foresees two working conditions, a rough and a smooth, according to the table 2. The right tubular cylinder electrodes are made of electrolytic copper with the purity of 99.7% having the

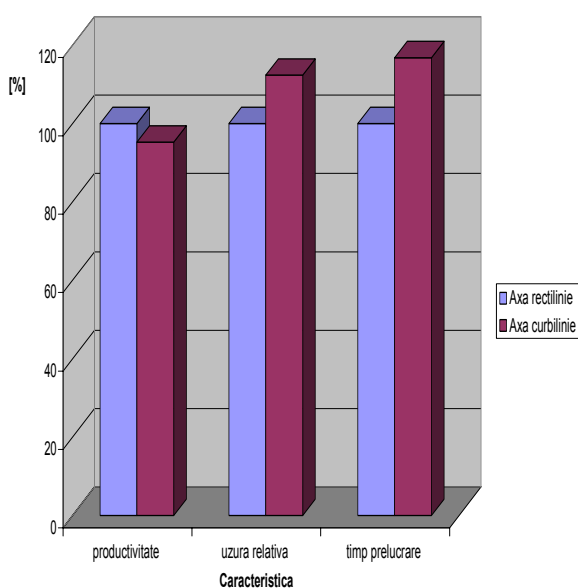
external diameter of 10 mm and the internal diameter of 7 mm and the curvature of 60 mm. The length of the path produced by the relative motion of EDM unit and measured by means of a dial comparator having the resolution of 0.01 mm is of 5 mm.

In each case the workpiece and the tube are weighted before and after the experiment by means of an analytical balance UWE NJV-1500 having the resolution of 0.01g and the scale from 0 to 300g.

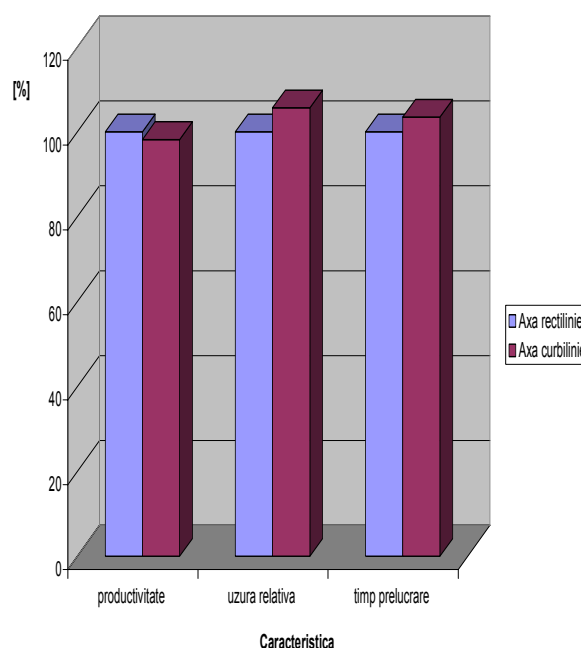
**Table 2. Experimental working conditions**

No of experiment	Intensity I [A]	Time of impulse [μs]	Time of break [μs]
1, 2, 3	25	900	48
4, 5, 6	12,5	48	6

Of the experimental results graphics are drawn comparatively showing the percentage of average productivities, relative average wears, and relative processing times as in the figure 6 and 7 for the rough and smooth working conditions.



**Fig.6. Values of the rough working conditions for the rectilinear and curvilinear electrodes**



**Fig.7. Values of the smooth working conditions for the rectilinear and curvilinear electrodes**

### 3. CONCLUSIONS

From the experimental results, it is found that the values of the production of curved holes are slightly inferior to those of rectilinear holes but the difference is not significant.

The difference becomes even less significant for the smooth working conditions. It comes out that the influence of working conditions on the process parameters is similar for either machining curvilinear or rectilinear holes.

The experimental procedure confirms the device efficiency and the further research will be focused on the process optimization.

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