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SOFTWARE FOR THE OPTIMISATION OF THE CUTTING APPARATUS KINEMATICAL PARAMETERS FOR AGRICULTURAL HARVESTING MACHINES

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Abstract:

In this paper it is presented a specialized software written in AutoLISP language, for the optimisation of the cutting apparatus kinematical parameters which, on the basis of some improved mathematical models, allows the analytical plotting of these trajectories in a very short time and with maximum precision, making possible the easy optimisation of some kinematical parameters of the working process, as: the machine rate of travel (travel speed), the bladed-rotor rotation speed or the operating crank rotation speed.

Keywords:
software, optimisation, cutting apparatus, kinematical parameter, agricultural harvesting machines, AutoLISP

1. INTRODUCTION

For the optimisation of the cutting apparatus kinematical parameters first it is necessary the parameterised generating on the basis of same constructive and functional parameters, the blades trajectories focussing the areas no covered by knives or the overlapping areas.

The trajectories of the cutting blades represent, for the straight reciprocating motion apparatus, the result of composing two translation motions (on due to the agricultural machine displacement and another one due to the straight reciprocating motion of the blades driven by a "reciprocating rod-crank" - type mechanism). For rotary apparatus the trajectories are of cycloid-shaped, resulting from the composing of two motions a translation one (due to the agricultural machine displacement) and a rotational one (due to the rotary motion of the cutting blade on the horizontal plane).

For the optimisation of some kinematical parameters of the cutting apparatus, as: the machine rate of travel (travel speed), the bladed-rotor rotary speed or the operating crank rotary speed, in this paper is presented an AutoLISP software, which allows the analytical plotting of the blade trajectories with maximum precision.

2. THE CUTTING DIAGRAM GENERATION FOR THE STRAIGHT RECIPROCATING MOTION CUTTING APPARATUS FOR HARVESTER MACHINE

The straight reciprocating motion cutting apparatus can be with knife and counter-knife or with double-knife. The most utilised cutting apparatus for all cultures of the cereals are the one with knife and counter-knife, with normal cutting (Fig. 1).

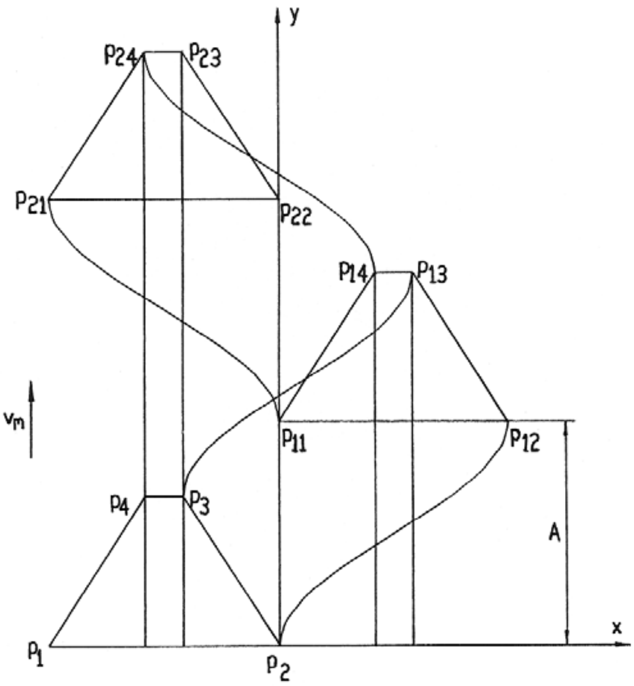


Fig. 1. *The cutting diagram of a conventional sickle bar mower with countershear*

The space passed through by the knife of the cutting apparatus in lateral directions, dependent on connecting rod-crank mechanism used for drive, is calculated with following equation [1,4,6]:

$$x = r \cdot (1 - cos\,\omega t) \qquad (1)$$

where: r –is the radius of the drive mechanism crank, [m];
ω –the crank angular speed, [rad/s].

The space passed through by the harvester machine (A [m]) (Fig. 1) in concordance with machine speed (v_m [m/s]) and with rod-crank mechanism rotation speed for the cutting apparatus drive (n [rev/min]), respectively:

$$A = \frac{30 \cdot v_m}{n} \qquad (2)$$

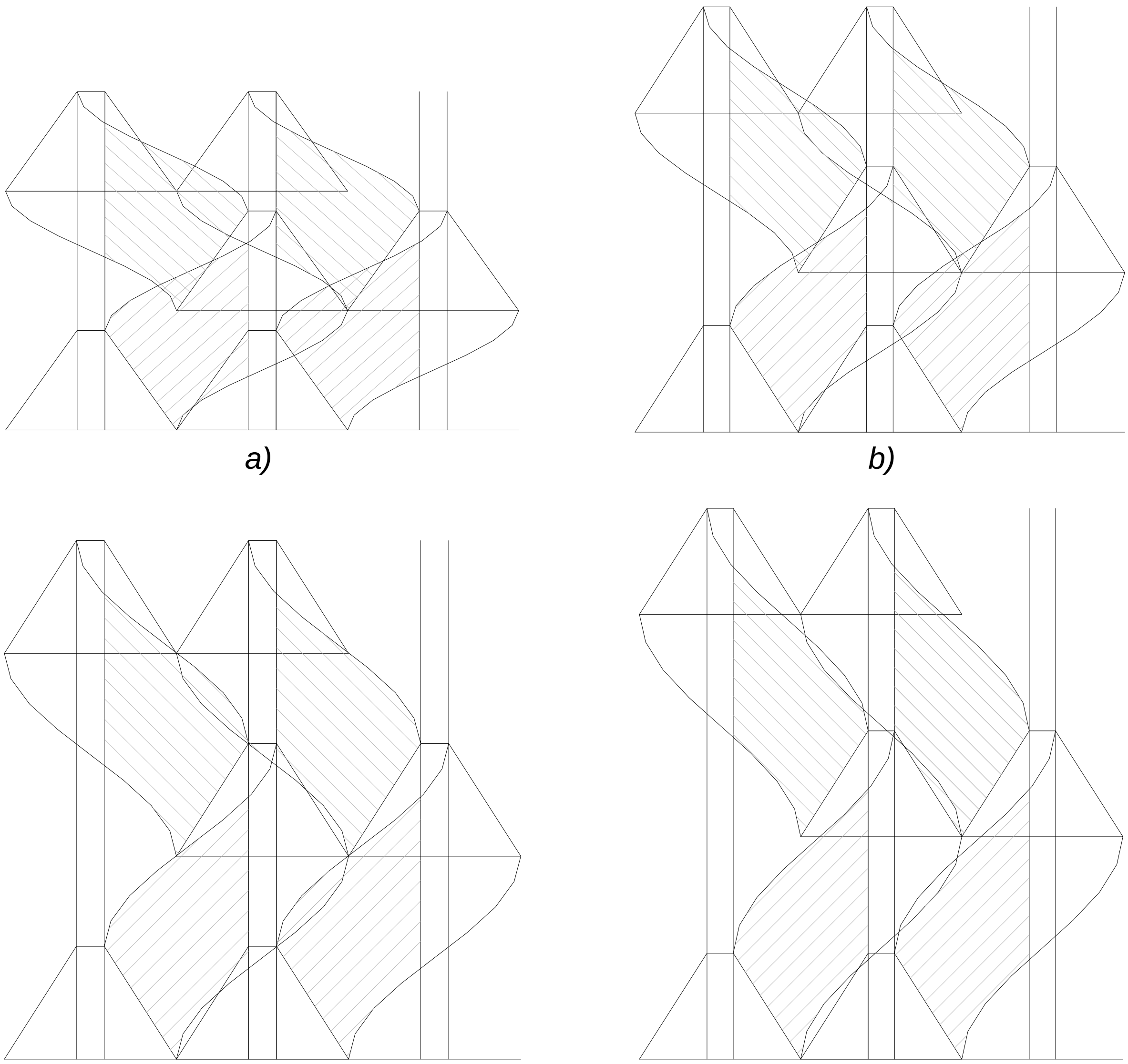
The motion equations of the straight reciprocating motion cutting apparatus dependent on space passed through by the machine (A) and the drive mechanism crank length (r), are:

$$\begin{cases} x = r \cdot (1 - cos\dfrac{\pi \cdot x}{A}) \\ y = \dfrac{A}{\pi} \cdot arccos(1 - \dfrac{x}{r}) \end{cases} \quad (3)$$

In order to draw the cutting diagram on the computer, according to the mathematical pattern described before, an AutoLISP software was developed and used. The table 1 contain the values which can be considered as working dates, and the figure 2 show as the cutting diagrams for each of these working dates.

Table 1. *The working dates for cutting diagram from figure 2*

Parameters	*Figure 2*			
	a)	*b)*	*c)*	*d)*
The machine speed, v_m [m/s]	2	2.5	3	3.5
The crank rotation speed, *n* [rev/min]	1000	1000	1000	1000
The crank length, *r* [cm]	3.8	3.8	3.8	3.8



c) d)

Fig. 2. *The cutting diagrams for the working dates shows in table 1*

3. THE CUTTING DIAGRAM GENERATION FOR ROTARY APPARATUS FOR MOWING MACHINES

The rotary motion cutting apparatus can be: with horizontal plane motion or with vertical plane motion. There is, all over the world, a tendency in using the rotary cutting apparatus with horizontal plane motion, used especially for cutting grass and brush, which cutting diagram is represented in Fig. 3.

The space passed through by the machine (*S*) in the time of knife action (*t*), dependent on its speed (v_m), must be in concordance with cutting apparatus length (*h*), which the expression is [1]:

$$S = v_m \cdot t = h \quad (4)$$

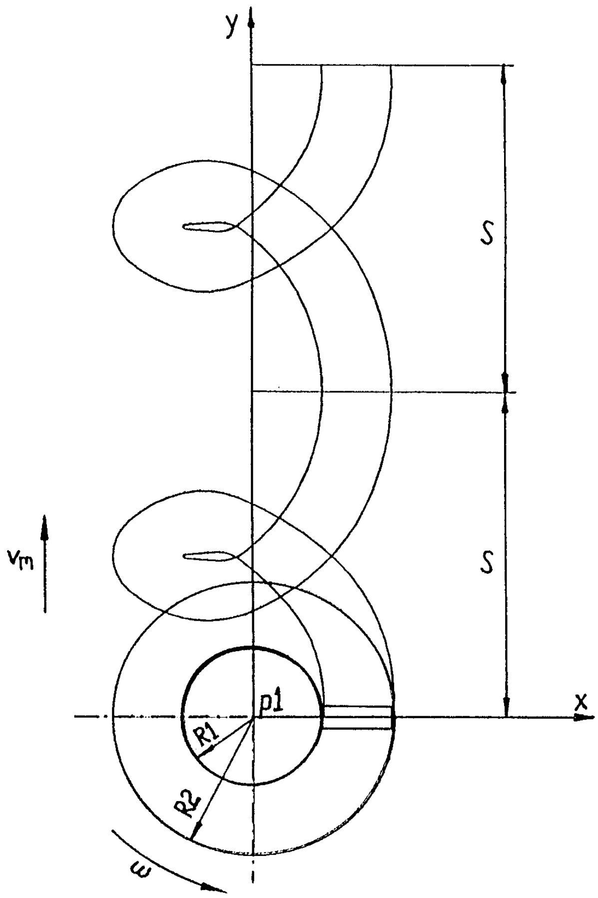


Fig. 3. *The cutting diagram for the rotary cutting apparatus with horizontal plane motion*

The time which a knife drive in a complete revolution is calculated with expression:

$$t = \frac{60}{z \cdot n} \quad (5)$$

where: z –is the number of the rotor blades;
n –the disk rotation speed, [rev/min].

The space passed through by the machine (S) in a full rotation of the cutting apparatus rotor, dependent on machine travel speed (v_m [m/s]) and on the disk rotation speed (n [rev/min]), has the expression:

$$S = \frac{v_m \cdot 60}{n} \qquad (6)$$

The x,y-coordinates of the blade path can be calculated using the following equations:

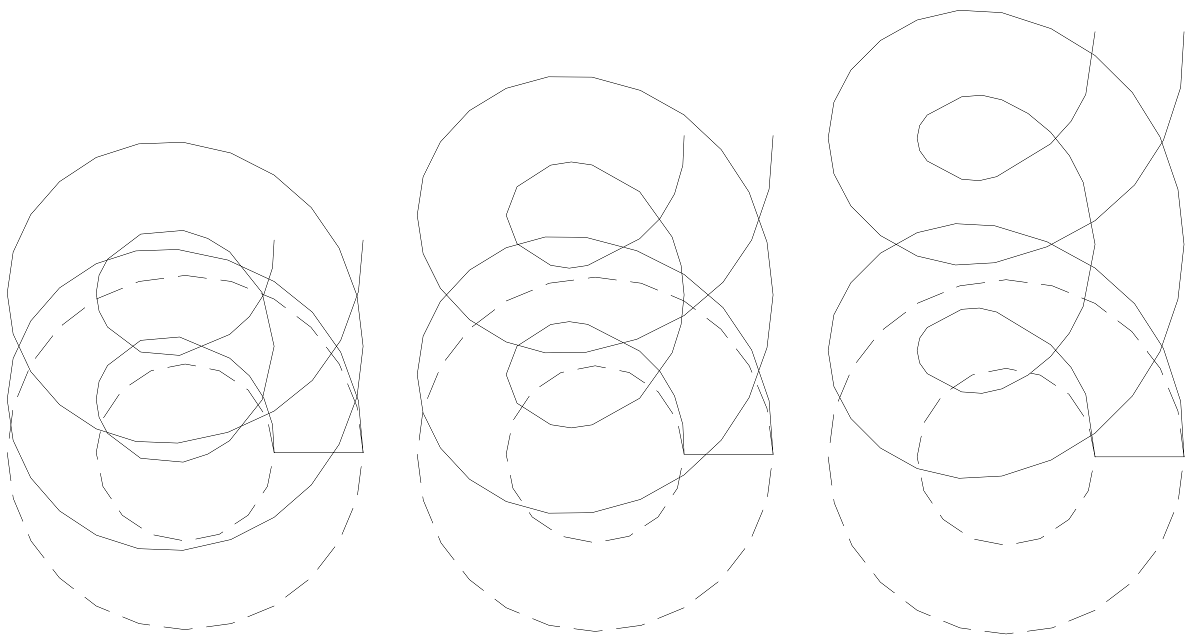
$$\begin{cases} x = R \cdot cos(\omega \cdot t) \\ y = v_m \cdot t + R \cdot sin(\omega \cdot t) \end{cases} \qquad (7)$$

where: R is the disposal radius of whichever point on the blade.

In order to plot the cutting diagram on the computer, according to the mathematical model described before, an AutoLISP software was developed, and the results of the running of this software is presented in figure 4. The table 2 contain the values which can be considered as working dates.

Table 2. *The working dates for cutting diagram from figure 4*

Parameters	Figure 4		
	a)	*b)*	*c)*
The machine travel speed, v_m [m/s]	2	3	4
The disk rotation speed, n [rev/min]	500	500	500
The disk radius, R_1 [m]	0.2	0.2	0.2
The blade length, h [m]	0.1	0.1	0.1



a) b) c)

Fig. 4. *The cutting diagrams for the rotary cutting apparatus with horizontal plane motion, results from running of AutoLISP software*

4. CONCLUSIONS

The software written in AutoLISP language allows the parametrical computer aided generation of the cutting diagram in a very short time and with maximum precision, on the basis of some kinematical and functional parameters given by the keyboard.

With a minimum effort, this software can be developed to determine the optimum travel speed, on the basis of optimum paths of the knives.

Because of necessary knowledge from several domain such as: harvesting machines, analytical geometry, computer programming, computer aided design, etc., this paper has a pronounced interdisciplinary character.

This paper presents a new concept concerning the optimisation of the cutting apparatus kinematical parameters for agricultural harvesting machines, based on the mathematical description of the knifes motion and their parameterized computer aided generating, using AutoLISP and AutoCAD.

5. REFERENCES

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