KINEMATICS AND OPERATION PROCESS OF THE COMPLEX AGGREGATE USED TO PREPARE THE GERMINATIVE BED IN VEGETABLE FARMING

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Abstract

Preparing the germination bed represents an essential work for growing and developing plants in vegetable farming. The machinery used can have a positive or negative influence on improving or degrading the soil's physio-mechanic characteristics and on the quality of the work, therefore choosing them requires a lot of attention. These aspects are a results of studying the kinematics and work process of the complex aggregate that is used during this stage.

Key words: soil, germinative bed preparation, complex aggregate, kinematics, work process.

INTRODUCTION

Modeling the soil consists of a set of activities performed with the purpose of improve the soil's physical, chemical and biological properties. During these activities the soil is overturned, aerated, mixed, crumbled, leveled, pressed and modeled. Soil activities can be basic activities and germinative bed preparation activities.

During the germinative bed preparation, the soil is aerated up to the seeding or planting depth, in order for the soil to provide the required pedoclimatic conditions for the plants to develop, during the seeding and sprouting stages.

The complex aggregates are machines that are used for preparing the germinative bed.

The working organs that are shaped like blades with variable size are mounted on parallel bars called blade-bearing bars. These bars are given an oscillating motion from the tractor's power outlet. They move on a plane perpendicular to the machinery's movement direction. The mechanism powering the bars transforms the rotation movement into translational-oscillator movement.

MATERIALS AND METHODS

This piece of work will determine and study the trajectory of the $F(x_F, y_F, z_F)$ point, the top of the

lateral blade on the studied complex aggregate's blade-bearing bar.

The mechanism powering the blade-bearing bar is presented in figure 1.*a*. This case presents a crank-rod mechanism featuring a crankshaft. The running element is the AB crank, while the led element is represented by the BC bar. The blade-bearing bar executes the translational-oscillator movement (Caproiu St., 1982, Naghiu L., 2003, Pásztor J and Bratucu Gh., 2008, Sztachó-Pekáry I. et al., 2007). The chosen frame of reference, xGz, is a mobile system which moves at a constant speed reported to a stationary system, according to figure 1.*b*.
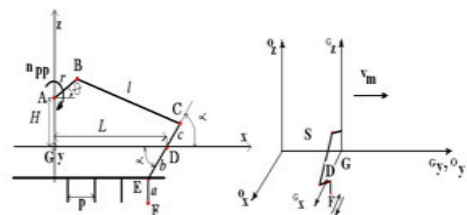

Figure 1. 1. a - Kinematics of a point from the complex aggregate blade-bearing bar, the running mechanism; b - mobile and stationary reference

The $F(x_F, y_F, z_F)$ point's coordinates are determined using the coordinates of points A,

B, C, D and E (Pásztor J and Bratucu Gh., 2008).
$A(x_A, y_A, z_A)$ point's coordinates:

$$A(x_A, y_A, z_A) \begin{cases} x_A = 0 \\ y_A = 0 \\ z_A = H \end{cases} \qquad (1)$$

$B(x_B, y_B, z_B)$ point's coordinates:

$$B(x_B, y_B, z_B) \begin{cases} x_B = x_A + r \cdot \cos\theta \\ y_B = 0 \\ z_B = z_A + r \cdot \sin\theta \end{cases}, \qquad (2)$$

where: r is the length of the AB element, in m; ϑ − the rotation angle of the AB element, in rad (fig,1.a.)

The ϑ angle is the variable parameter:

$$\theta = \varpi \cdot t = 2\pi \cdot n \cdot t \ [rad]. \qquad (3)$$

where: ω is the power outlet's angular speed, in rad/s; n − the power outlet's speed, in rot/s.

Point $C(x_C, y_C, z_C)$ is located at the intersection of two circles, one with the origin in point B, having the BC radius, and the other with the origin in point D, with the radius DC. By resolving the system formed by the circles' equation, the C point's coordinates reported to the mobile reference are obtained.

$$\begin{cases} (x_B - x)^2 + (z_B - z)^2 - l^2 = 0 \\ (x_D - x)^2 + (z_D - z)^2 - c^2 = 0 \end{cases} \qquad (4)$$

$D(x_D, y_D, z_D)$ point's coordinates are considered to be known are the following:

$$D(x_D, y_D, z_D) \begin{cases} x_D = L \\ y_D = 0 \\ z_D = 0 \end{cases}. \qquad (5)$$

Using the relations (5), the equation system (4) is modified as follows:

$$\begin{cases} z = \pm\sqrt{c^2 - (L-x)^2} \\ a_1 \cdot x^2 + b_1 \cdot x + c_1 = 0 \end{cases}, \qquad (6)$$

Where a_1, b_1, c_1 are the computable coefficients from the actual construction data:

$$a_1 = z_B^2 + (L - x_B)^2,$$
$$b_1 = m \cdot (L - x_B) - 2z_B^2 \cdot L,$$
$$c_1 = \frac{m^2}{4} + z_B^2 \cdot L^2 - z_B^2 \cdot c^2,$$
$$m = x_B^2 + z_B^2 + c^2 - L^2 - l^2 \qquad (7)$$

where: H is the height difference between the blade-bearing bar and the power outlet, in m; l − length of the BC element, in m, according to figure 1.a. From the solutions obtained using the system (6) the versions corresponding to geometric restrictions are chosen.

The $tg\alpha$ expression is determined using the $C(x_C, y_C, z_C)$ point's coordinates, which is necessary for describing the trajectory of points $E(x_E, y_E, z_E)$ şi $F(x_F, y_F, z_F)$:

$$tg\alpha = \frac{z_C}{x_C - L}$$

$$E(x_E, y_E, z_E) \begin{cases} x_E = L - b \cdot \cos\alpha \\ y_E = 0 \\ z_E = -b \cdot \sin\alpha \end{cases},$$

$$F(x_F, y_F, z_F) \begin{cases} x_F = x_E \\ y_F = 0 \\ z_F = z_E - a \end{cases} \qquad (8)$$

where: b is the length of the DE element, in m; a - the blade's length, in m, *figure 1.a.*

RESULTS AND DISCUSSIONS

The xGz reference is considered mobile and has a translational movement at a constant speed, v_m, reported to the xOz reference (fig, 1. b).

The parametric equations reported to the xOy reference are obtained by resolving the following operations:

$$^{O}[P_F] = [T]\,^{G}[P_F],$$

$$(9)$$

where: P_F represent the coordinates of point F; T − transformation matrix (Naghiu, L., 2003). The transformed equations will be:

$$\begin{bmatrix} ^{O}x_F \\ ^{O}y_F \\ ^{O}z_F \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & S \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} ^{G}x_F \\ ^{G}y_F \\ ^{G}z_F \\ 1 \end{bmatrix},$$

$$(10)$$

Where S is the distance covered by the complex aggregate following the movement's direction. The distance covered by the complex aggregate is time dependent and is calculated using the relation:

$$S = v_m \cdot t.$$

$$(11)$$

Parametric equations of the absolute movement of point $F(x_F, y_F, z_F)$ are obtained by making the corresponding replacements:

$$\begin{cases} ^{O}x_F = x_F \\ ^{O}y_C = 0 + v_m \cdot t. \\ ^{O}z_C = z_F \end{cases}$$

$$(12)$$

The trajectory of the blade's top (Vlad C. and all., 2012) is determined by using the $F(x_F, y_F, z_F)$ point's parametric equations. By drawing the trajectory followed by the complex aggregate's working organ several aspects can be determined: studying soil modelling at different speeds of the complex aggregate, the theoretical study of the aggregate's behavior and also the theoretical study of the blades' working process.
The equations for joined blades and blades mounted on the other bars can be determined by using the parametric equations of the absolute movement (12). During calculations, the following will be taken into consideration: step between the blades, p; phase shift between time crankpin, φ_n; the distance between the blade-bearing bars, d.

These trajectories are shown in figure 2, based on the parametric equations of point $F(x_F, y_F, z_F)$ (Vlad C. and all., 2012).
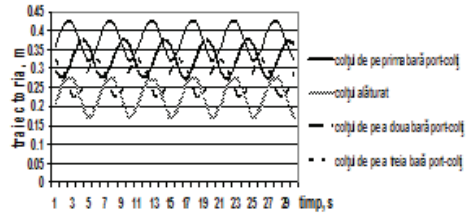

Figure 2. Blades' tips oscillation on a horizontal plane

By analyzing the aggregate's operation, the blade-bearing bar's oscillation on a plane perpendicular to the movement direct can be observed. This can be verified by using the parametric equations of point $F(x_F, y_F, z_F)$. The fact that the blade-bearing bars follow an oscillatory movement on plane xOz can be observed in figure 3.
Parametric equations $xF=f(r, n, H, l, c, L, b, \varphi_n)$ and $zF =f(r, n, H, l, c, L, b, \varphi_n)$ can also be used to represent the trajectories on the xOz vertical plane, according to figure 3.
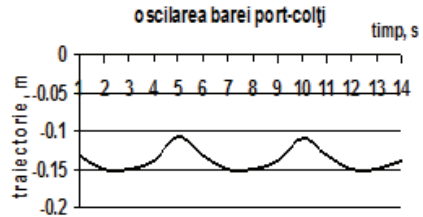

Figure 3. The blade bar's oscillatory movement.

During operation, the blades follow the bar's movement, receiving the alternation translational movement perpendicular to the forward movement in the xOz plane, according to figure 4.
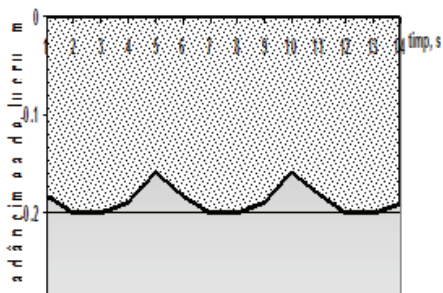
Figure 4. The operation process executed by the blade in vertical plane

By analyzing the blades′ operation mode, it is observed that there are unprocessed sections in the soil caused by the vertical oscillation. A second and a third blade bar are required to be mounted on the complex aggregate in order to eliminate this inconvenience.

The parametric equations are useful for studying the joint operation process of the blades on a vertical plane, perpendicular to the forward movement, like pictured in figure 5.
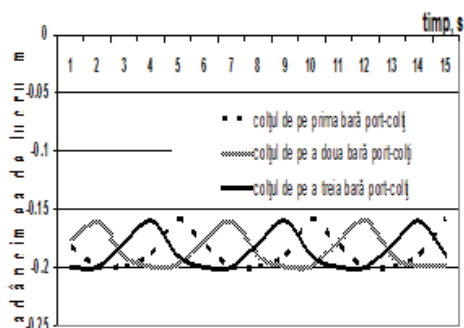

Figure 5. The blades′ operation process on vertical

By analyzing the the trajectory of the complex aggregate′s blades′ tips, it is observed that the soil is being processed energetic and uniform up to the set working depth if three operating organs mounted on paralel blade bars and working in phase shift are being used.

CONCLUSIONS

Parametric equations $xF=f(r, n, H, l, c, L, b, \varphi_n)$ and $zF =f(r, n, H, l, c, L, b, \varphi_n)$ describe sinusoid trajectories of the complex aggregate′s blades on vertical and horizontal plane.

By analyzing the work process of the operating organs on the complex aggregate, it can be observed that the agricultural machinery provides the soil crumbling and a good mixture of soil layers up to the set working depth, if fitted with two or three blade bars.

Parametric equations $xF=f(r, n, H, l, c, L, b, \varphi_n)$ and $zF =f(r, n, H, l, c, L, b, \varphi_n)$ offer the possibility to study the complex aggregate′s optimization.

The parametric equations represent mathematical models for studying the complex aggregate′s dynamics and energetics.

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