KINEMATICS, WORKING PARAMETERS AND MODES OF VARYING THE DIGGING SHARE OF THE ELEVATOR-TYPE POTATO COMBINE

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INTRODUCTION

The development of the means of mechanization in agriculture has resulted in the creation of tractor units realizing new technological and constructive concepts, the overlapping of technological operations provided with multipurpose technological hook-on machines of modular construction with a changeable structure of configuration, for a set of certain regular assignments' applications of new active working bodies (AWB).

This tendency is realized by the development of a universal elevator-type potato combine different from the so far used by the varying of the digging share. Application of such AWB has allowed to raise functionality and reliability of a combine at work.

As tests have shown, the efficiency of a combine in many respects depends on a correct choice of constructive and regime parameters of the digging share. In connection with this, the analysis of various aspects of their working process is of interest, with the purpose of revealing its laws and the development of engineering recommendations at the choice of rational parameters of such AWB

At work, the features of kinematics varying the digging share have been considered, which has allowed to formulate some recommendations at the choice of the design's constructive and regime parameters' shares and to find out the variable opportunities of their practical change and a combination for the optimum operational adjustment of a drive.

KINEMATICS SHAKING SHARE WITH ELLIPS CUTTING EDGE

Let's define the current coordinates of the points of an edge share during the movement of a combine on the worker way.

In the system of coordinates $X_1O_1Y_1$ (see Fig. 1) the equation of an ellipse:

$$\frac{X_1^2}{a^2} + \frac{Y_1^2}{b^2} = 1; \tag{1}$$

In the system of coordinates $X_1O_1Y_1$ (parallel axes) we have:

$$\begin{cases} X_2^* = X_1 - C_x; \qquad C_x = 0; \\ Y_2^* = Y_1 + C_y; \end{cases} \tag{2}$$

hence

$$\begin{cases} X_1 = X_2^* - C_x; \\ Y_1 = Y_2^* - C_y; \end{cases} \tag{3}$$

substituting (3) in (1)

$$\frac{(X_2^* - C_x)^2}{a^2} + \frac{(Y_2^* - C_y)^2}{b^2} = 1 \tag{4}$$

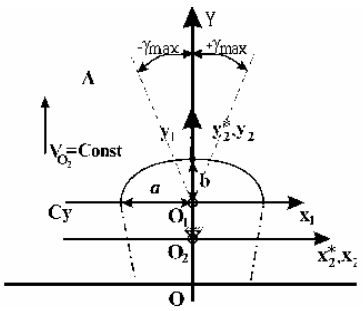

Fig. 1. The circuit of movement share

At turn share with system $X^*_2O_2Y^*_2$ concerning point O_2 (turn of axes) in the system $X_2O_2Y_2$ on a corner γ it is received:

$$\left.\begin{aligned} X_2 &= X_2^* \cos\gamma_t - Y_2^* \sin\gamma_t; \\ Y_2 &= X_2^* \sin\gamma_t - Y_2^* \cos\gamma_t; \end{aligned}\right\} \quad \left.\begin{aligned} X_2^* &= X_2 \cos\gamma_t + Y_2 \sin\gamma_t; \\ Y_2^* &= X_2 \sin\gamma_t + Y_2 \cos\gamma_t; \end{aligned}\right\} \tag{5}$$

Let's substitute expressions (5) in (4) and we shall receive

$$\frac{(X_2\cos\gamma_t+Y_2\sin\gamma_t-C_x)^2}{a^2}+\frac{(-X_2\sin\gamma_t+Y_2\cos\gamma_t-C_y)^2}{b^2}=1 \tag{6}$$

At $V \neq 0$ at the moment of time t coordinates $X_{2i} = X_i$, and coordinates $Y_i = Y_{2i} + V \cdot t$ then in motionless system XOY we have:

$$Y_2 = (Y - V \cdot t)$$

$$\frac{\left[X\cos\gamma_t+(Y-V\cdot t)\cdot\sin\gamma_t-C_x\right]^2}{a^2}+\frac{\left[-X\sin\gamma_t+(Y-V\cdot t)\sin\gamma_t-C_y\right]^2}{b^2}=1 \tag{7}$$

$$X_{\max}(t)=a\cdot\cos\gamma_t;$$

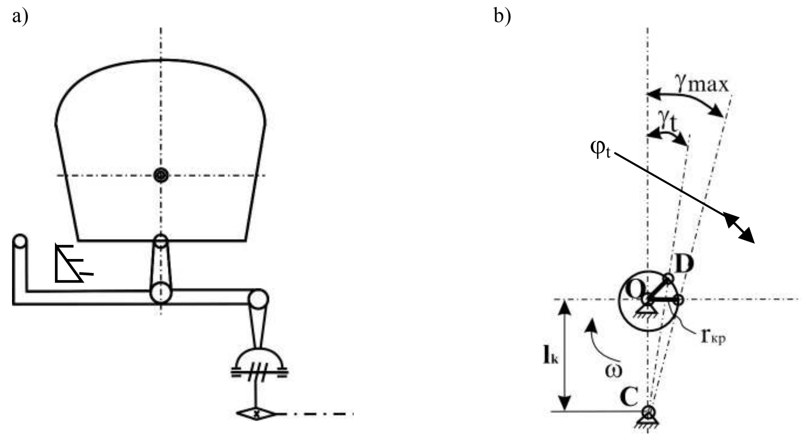

Fig. 2. Variant of the circuit of a drive share.

The corner γ_t at the moment of time t is defined by the parameters of a drive shaking share and frequency of fluctuations ω of the share (see Fig. 2 b)).

In this case the coulisses mechanism with

$$K_{np}=\frac{r_{kp}}{l_k};\; l_k=\frac{r_{kp}}{K_{np}};\quad \varphi_t=\omega\cdot t;$$

From ΔOBD: OB = $r_{кр.}\cos\varphi_i$; BD = $r_{кр.}\sin\varphi_i$; From ΔCBD:

$$\operatorname{tg}\gamma_t=\gamma_{\max}=arc\sin K_{кр.}=arc\sin\frac{r_{кр.}}{l_{к.}};$$

$$\operatorname{tg}\gamma_t=\frac{BD}{BC}=\frac{BD}{BO+OC}=\frac{r_{kp}\sin\varphi_t}{r_{kp}\cos\varphi_t+k}=\frac{r_{kp}\sin\varpi\cdot t}{r_{kp}\cos\varpi\cdot t+l_k}; \tag{8}$$

$$\gamma_t = arc\,\mathrm{ctg}\left(\frac{r_{kp}\sin\varpi\cdot t}{r_{kp}\cos\varphi_t + l_k}\right) \tag{9}$$

$$\gamma_{\max} = arc\sin K_{\kappa p.} = arc\sin\frac{r_{kp}}{l_k} \tag{10}$$

Let's consider a trajectory of a point of M of a contour of the cutting edge. At $t = 0$ and $\gamma_t = 0$ we determine coordinates of a point of M: X_M and Y_M, satisfying the equation (8). We have a point of M which participates in two movements: 1) relative around of centre O_1 of mobile system X_1OY_1 with frequency ω and amplitude $\gamma_{\max}$; 2) portable with centre O_1 in system XOY with speed V = const along axis OY.

a) b)

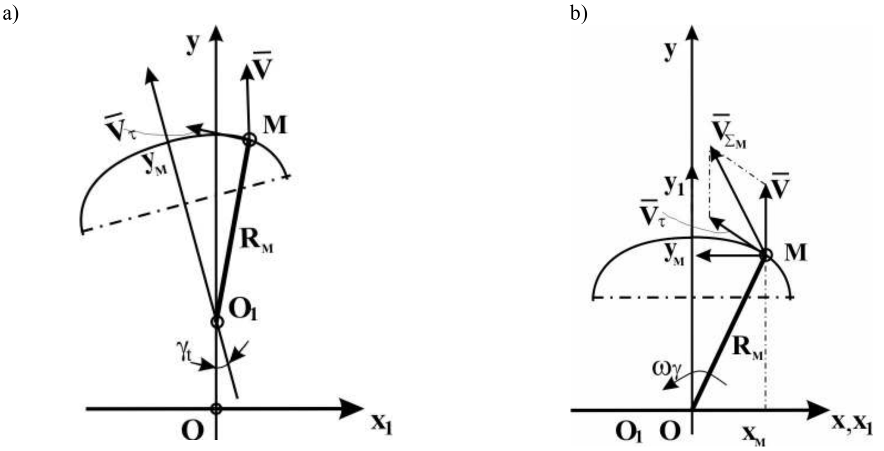

Fig. 3. Circuits of movement share

From Fig. 3 a) we have:

$$R_M = \sqrt{X_M^2 + Y_M^2}; \quad \omega_\gamma = \frac{d\gamma_t}{dt} = \frac{d}{dt}\left(arc\,\mathrm{ctg}\frac{r_{kp}\sin\omega t}{r_{kp}\cos\omega t + l_k}\right); \tag{11}$$

In Fig. 3 b) it is visible that $V_\tau = \omega_\gamma \cdot R_M$.

At any moment of time t, $\gamma = \gamma_t$, then

$$\left.\begin{aligned} &X = X_M\cos\gamma_t - Y_M\sin\gamma_t;\\ &Y = (X_M\sin\gamma_t + Y_M\cos\gamma_t) + Vt;\\ &\gamma_t = aar\,\mathrm{ctg}\left(\frac{r_{kp}\sin\omega t}{r_{kp}\cos\omega t + l_k}\right); \end{aligned}\right\} \tag{12}$$

Expression (12) - also is the required equation of movement of a point of M at work shaking share. Changing t, it is possible to construct diagrams of change of coordinates $X(t)$, $Y(t)$, $\gamma_t(t)$ any point of cutting edge share.

RESULTS OF CALCULATIONS OF KINEMATICS VARYING SHARE

In a starting position before the beginning of the movement of the harvest unit the coordinate i-points of an edge share correspond to Table 1.

Table 1. Coordinates of points of an initial structure of an edge share

№ i-point	1	2	3	4	5	6	7	8	9	10	11
X,м	0,3	0,29	0,294	0,286	0,275	0,260	0,240	0,214	0,168	0,110	0,0
Y,м	0	0,02	0,04	0,06	0,08	0,10	0,12	0,14	0,16	0,18	0,20

Changes of coordinates of some points of an edge share during the movement of the harvest unit obtained with the use of the program supplement MathCAD are submitted in Figs. 4 - 6. At the initial data:

Coordinates of the point (0,26; 0,1) change as follows (see Fig. 4)

v:= 1.8; r_k:=0.05; l_k:=0.12; w:= 15.0 x_m:= 0.26; y_m:= 0.1

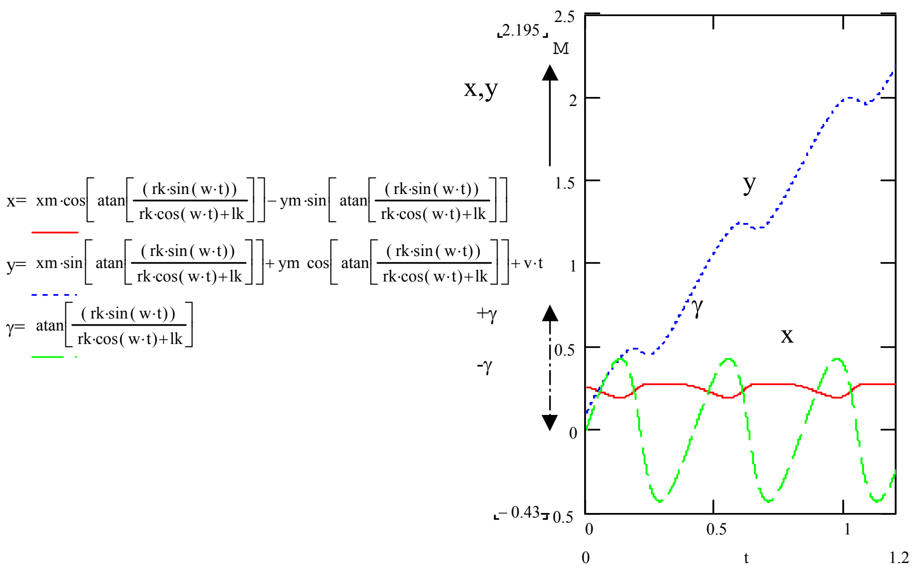

Fig. 4. Change of coordinates of some points of an edge share during movement of the harvest unit

At the change of frequency staggers of the share we shall receive the following picture of change of the coordinates of the same point share:

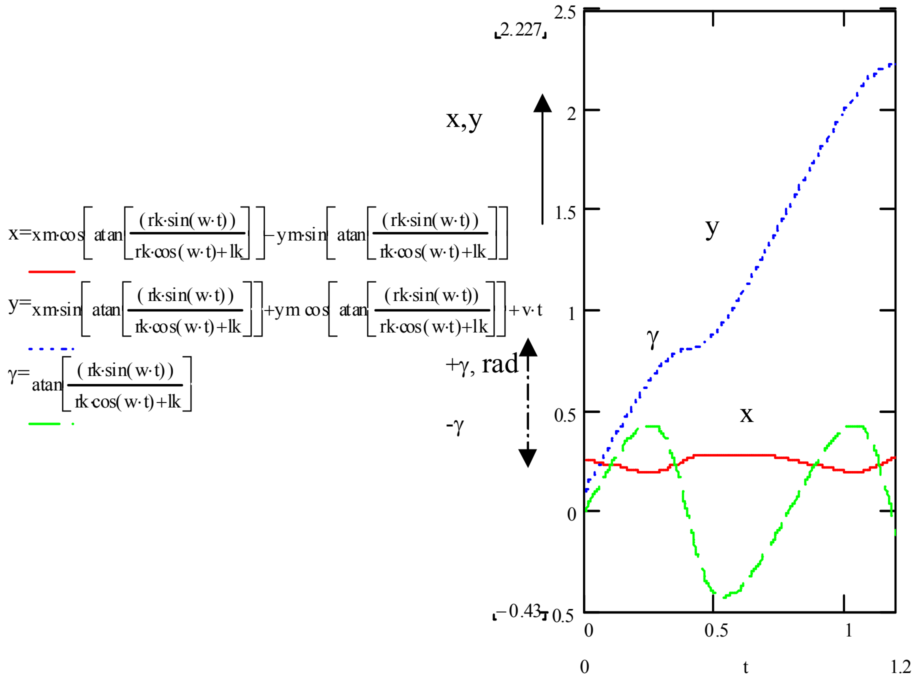

Fig. 5. Change of the coordinates of the points of an edge share during the movement of the harvest unit

A qualitative character of the change of kinematic characteristics of the movement of points of an edge shaking share at the change of parities of the regime parameters of work share (speed of the unit, frequency staggers, the maximum corner of a deviation) is well seen from the diagrams shown in Fig. 6.

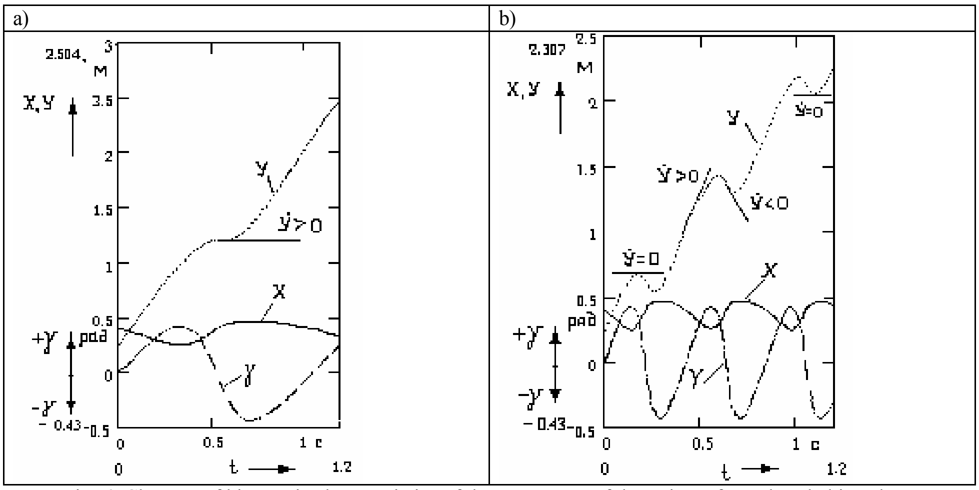

Fig. 6. Changes of kinematic characteristics of the movement of the points of an edge shaking share

From the diagrams it follows, that the longitudinal absolute speed of the chosen point of an edge shaking share has the periods of movement with negative speed.

At an increase of the speed of movement of the unit and preservation of constant frequency staggers share, or at the constant speed of movement of the harvest unit by the reduction of frequency staggers (see Fig. 6 a) it is possible to change the intensity of the undermining influences share to a layer and roots of weeds.

Differentiating sizes X, Y, γ_t in time, we shall receive the projections to coordinate axes of speeds and acceleration points of M and its angular acceleration in function of time, which is necessary for the dynamic share modeling process.

Trajectories of points of the ends of diameters ellipse contour of an edge share have a harmonious character. At $t = 0$: for a median point of an edge share, the designated letter of M: $X_M = 0$; $Y_M = b$; for the extreme point T located on the end of the greater diameter ellipse of an edge of an edge share: $X_T = a$; $Y_T = 0$.

From the expression (12) the changes of coordinates X of the points are defined by the expressions:

– point M: $x = -b \cdot \sin \gamma_t \pm X_{M\max} = \pm\, b \cdot r_{кр}/l_k$;

– point T: $x = a \cdot \cos\gamma_t$; $\pm X_{t\max} = \pm\, a \cdot \cos(\arcsin(r_{кр}/l_k))$;

The character of the movement of the points on the contour line in the 1st plane, parallel to the vector of speed V of moving the unit whose equation X_i = const = d, shall be defined from the expressions (8) and (9), having substituted for X the value $X_i = d$.

Size X_i varies from $-a$ up to $+a$.

$$\left.\begin{aligned} &\frac{\left[d\cos\gamma_t + (y - Vt)\sin\gamma_t - C_x\right]^2}{a^2} + \frac{\left[(y - Vt)\cos\gamma_t - d\sin\gamma_t - C_y\right]^2}{b^2} = 1 \\ &\gamma_t = ar\,\mathrm{ctg}(r_{кр} \cdot \sin wt / (r_{кр} \cdot \cos wt + l_к)) \end{aligned}\right\} \quad (13)$$

The periodic and nonlinear dependence follows from the expressions (13) and causes a sign-variable acceleration of points share in the direction of the movement of the machine. Thus amplitudes of this acceleration grow with an increase of deviations from the axis OY. The similar statement is fair and typical to a contour of the share accelerations. It means, that the intensity shock undermining a layer, roots and stalks of weeds under the influence of an edge share grows with the removal of the contour points from an axis staggers and from the plane of its symmetry, and also at the growth of the frequency and amplitude of $\gamma_{\max}$ fluctuations.

Rational combinations constructive (a, b, c_x, c_y) and regime parameters (V, w, $\gamma_{\max}$) undermining the share are determined from the conditions: 1 – preservations of width and straightforwardness of an undermined earth strip; 2 – maintenance of a mode of sliding cutting in all the points share; 3 – maintenance of the necessary amplitude and the mark accelerations in anyone on the width of the capture share longitudinal planes for an achievement of cleanliness of cutting and absence of drawing the cutting parts of plants.

THE CONCLUSION

The developed approach to a definition of the kinematic characteristics shaking share is suitable for any configuration of an edge share and the coordinates of the poles of its angular stagger.

On the basis of the received results the drives of the developed shares which have allowed to provide operative adjustments or continuous regulation of regime parameters in function of the speed of movement and parameters of conditions of cleaning which characterize a condition of ground, productivity and contamination with weeds were developed and tested in natural conditions.

SUMMARY

The article presents a set of materials of the analysis of kinematics, working parameters and modes of operation varying share with ellipse cutting edge and reveals opportunities for rational constructive - regime adjustment of the working body in the conditions of operation. Expressions are received and the analysis of kinematics, working and regime parameters varying share with an ellipse cutting edge is given.

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