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ANALYSIS OF biphasic Shovel FOR TECHNOLOGY Precision Agriculture

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The analysis of the functioning of the automated system stabilization progress opener for the two-phase method earnings at sowing seeds of cultivated crops for precision farming technology.

Seeds, drill two-phase model of functioning, quality of earnings.

Formulation of the problem. Currently acquire two-phase application coulter systems with a mechanism of correction of the position of pushing the drive [1, 2], which allow the incorporation of high-quality seeds at a given depth. The use of a two-phase system due to the fact that the existing structures do not allow shovels fully comply earnings quality seeds.

Analysis of recent research. This method earnings seed crops in the ground (Fig. 1) is implemented in 2 phases. In the first phase 1 conical schilynoutvoryuvach radial leash 3 of restrictive flange 2 is in the soil and forms a gap on depth a_1 with geometric parameters conducive to jamming in it seeds and less than specified a depth. For schilynoutvoryuvacha of continuous movement by irregularities and stabilizing its course serve spring c_1 and damper d_1. Further, the gap is supplied seeds that fixed wedge it between the walls of the grooves without rolling along the line.

In the second phase pushing disc 6, which is connected via radial suspension frame 5 and 4, moves along the axis of the slit and along the walls with cut grooves moist soil, "she urges the" seeds on the set depth a.

Feature two-phase method earnings seeds is that schilynoutvoryuvach and drive are pushing each other on the technological distance$b$. In this regard, for laying the seeds on the set depth corresponding to the surface equidistantly field line correction is necessary to respect the provisions of pushing the drive flange schilynoutvoryuvacha with restrictive conditions for traffic on surface microrelief field.

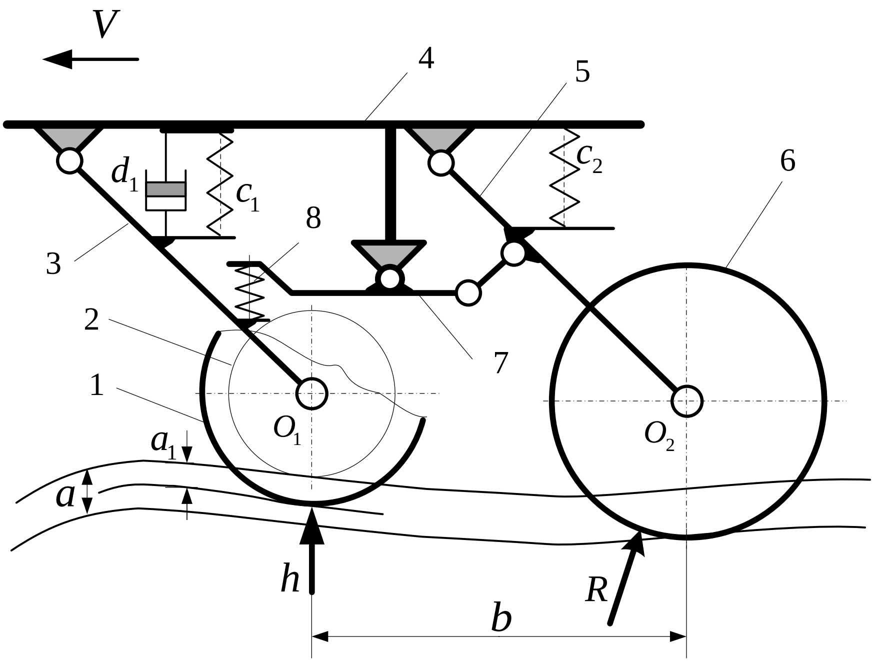

Fig. 1. Scheme of Soshnikova two-phase method for sowing crops.

Correction position pushing the disc may be done by means of correcting lever 7 with a spring 8. However, the effectiveness of this correcting mechanical lever is provided for a narrower range of technological parameters of Soshnikova systems such as speed V traffic, frequency and amplitude surface irregularities field h, The resistance of the soil R when immersed disc and so on. In particular the resistance R an influential factor in the course of pushing depth disk 6, depending on the type of soil, its physical and mechanical properties, humidity and more. Moreover, the value of these properties greatly varies in size depending on the field coordinates of the seed unit in the field. This means that crop sowing machines mistsevyznachenoyi must simultaneously with traditional agricultural requirements for planting crops, including the depth of earnings and solve even more problems with regard to variable factors existing in the "machine-to-right." As is known account of dependent variables coordinate global operating factors underlying technologies of precision agriculture (TV) [3].

In the case of a two-phase system Soshnikova technologies in the vehicle should be considered mistsevyznacheni characteristics of the soil, including its mistsevyznachenu density. Therefore, further analysis Soshnikova mistsevyznachena system takes into account information about the density of the soil with the possibility of automatic correction position pushing disk (Fig. 2).

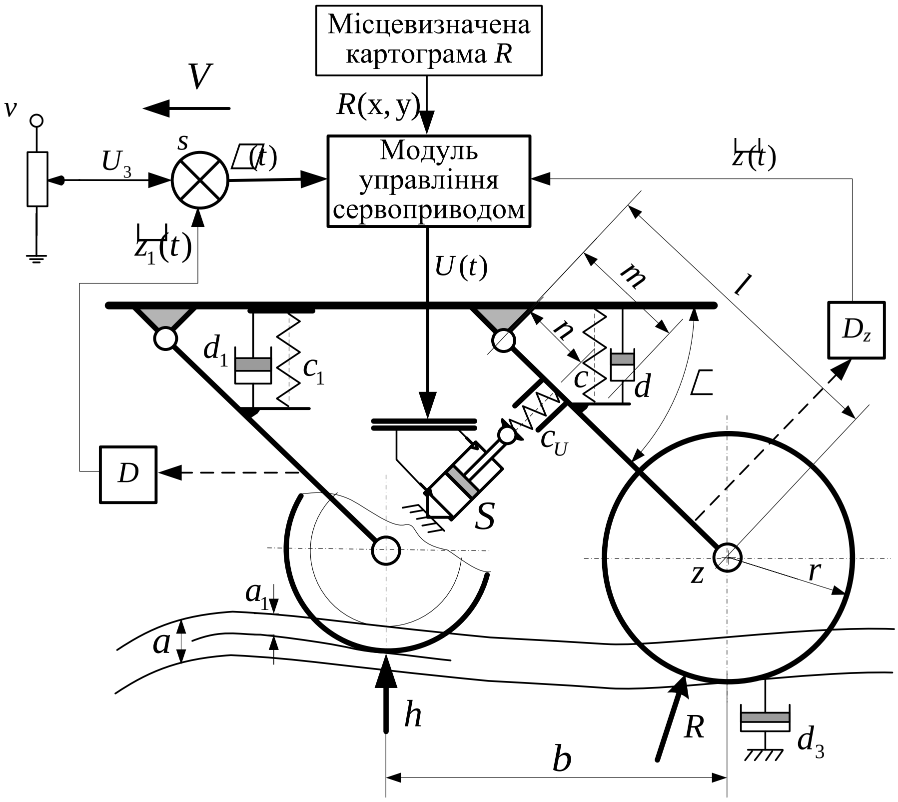

Fig. 2. Soshnikova system with automatic correction of the position of pushing the drive.

The purpose of research. This automated system should enable the vehicle to work on technologies and improve the efficiency of the device and correcting Soshnikova the whole system for a wide range of process operating conditions.

Results. Regulation schilynoutvoryuvacha controlled by position sensors$D$, The signal of which is fed to the adder s. By adder served as a signal of manual settingsU_3And the output signal have $l\ (t)$ Which is fed to the servo control module. By this module is supplied as feedback signal$\widehat{Z}(t)$ by pushing the disc position sensor, and signal $R(\mathrm{x}, \mathrm{y})$ mistsevyznachenoyi calculation of unit density soil. Last operates on the basis of information about the current coordinates MTA field and cartograms mistsevyznachenoyi density of soil.

Block diagram of the automated systems of correction of the position of pushing the drive shown in Fig. 3.

The block signal mistsevyznachenoyi calculate the density of the soil block reading (PC card) cartograms soil condition signal $R(\mathrm{x}, \mathrm{y})$. The same block signal $\gamma(x, y)$ of the world coordinates of MTA in the field of sensor Global Positioning System (GSP). The output signal of this block is normalized in amplitude and synchronized with global coordinates signal $R(\mathrm{x}, \mathrm{y}, t)$.

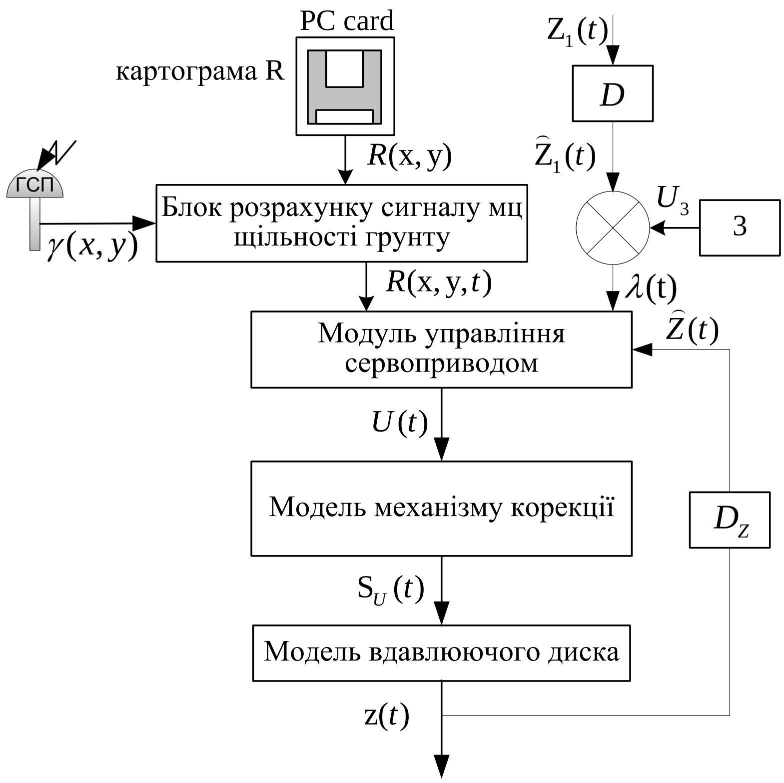

Fig. 3. Block diagram of the automated systems of correction of the position of pushing the drive.

As a signal for track (whole operation) is the output signal $\lambda(\mathrm{t})$. This signal is formed as a result of feeding signals to the adder $\hat{Z}_1(t)$ sensor D schilynoutvoryuvacha position control signal and manual adjustment of the pushing drive with relatively schilynoutvoryuvacha output signal U_3.

The purpose of the operation is achieved, on the one hand, by the movement of schilynoutvoryuvacha at depth a_1 And by the servo action on leash radial suspension pushing disk (controlled sensor D_Z of the output signal feedback $\hat{z}(t)$. As a result, the output of the system have a final depth of earnings seeds $z(t)$.

The main task is to calculate the optimal control action values $U(t)$ Which is fed to the position adjustment mechanism pushing the disc. servo rod S (Fig. 2) adjusts the relative position of pushing the drive schilynoutvoryuvacha depending on the set of regulations, the state of the surface roughness of the field, and the value of ground resistance according to the MTA coordinate location and size of the field pushing dipping drive. As a result, the output of the system have specific provision pushing drive $Z(t)$ That is the function of the control signal action $U(t)$ Coming from the servo control module.

Quality functioning Soshnikova group will evaluate the deviation error estimates $\hat{z}(t)$ real depth course of pushing the disc from the set $\delta_3(t)$ on crediting period T operation share:

$$I = \int_0^T \Delta^2 dt, \qquad (1)$$

where: $\Delta = \delta_3(t) - \hat{z}(t)$ - Accuracy of the assignment.

In mathematical description of Soshnikova convenient system to break links for each link record your equation. For this we use representation of differential equations describing the system, the transfer function of each part.

Transfer function model by pushing the disc assembly find the differential equations of motion of pushing the drive. For the equations of motion dynamics Soshnikova groups on the surface roughness of the field will make use of the Lagrange equations of the dynamics of the 2nd kind [4, 5]

$$\frac{d}{dt}\frac{\partial T}{\partial \dot{q}_i} - \frac{\partial T}{\partial q_i} = -\frac{\partial \Pi}{\partial q_i} - \frac{\partial \Phi}{\partial \dot{q}_i} + Q_{q_i} \qquad (2)$$

where: T and Π - Kinetic and potential energy;

Φ - Dissipative function;

q_i - Generalized coordinates;

Q_{q_i} - Generalized force.

If accepted assumptions are pushing drive system, which is determined by the provisions of generalized coordinates z. The kinetic energy of the system consists of a power forward of the center of mass pushing the disc and variations of angular velocity of rotation ω:

$$T = \frac{1}{2}(M(z'^2 + (\tan(\beta)z')^2) + I\omega^2) \qquad (3)$$

where: M - Weight pushing disk;

I - Moment of inertia pushing the disk axis of rotation;

ω - Variations in rotation speed of pushing the drive that caused the work radial suspension.

Variations speed ω defined by the expression:

$$\omega = \frac{\tan(\beta)z'}{r}. \qquad (4)$$

After substituting (4) (3) we have:

$$P = \frac{1}{2}\left(\frac{I tan(b)^2 z\grave{}(t)^2}{r^2}\right) + M\left(z\grave{}(t)^2 + tan(b)^2 z\grave{}(t)^2\right) \qquad (5)$$

The potential energy of the system is:

$$P = Mgz(t) + \frac{1}{2}\left(c\frac{m}{l}z(t)^2 + c_U D_U^2\right) \quad (6)$$

where: c_U - Stiffness of the spring mechanism pushing the drive position correction;

D_U - Deformation of the spring mechanism pushing position correction drive.

Deformation D_U determined by the formula:

$$\Delta_U = \left(z(t)\frac{m}{l} - S_U \right). \quad (4)$$

In view of (7) we have:

$$P = Mgz(t) + \frac{1}{2}\left(\frac{cmz(t)^2}{l}\right) + \frac{1}{2}c_U\left(z\frac{m}{l} + S_U\right) \quad (5)$$

Dissipative function of the system in this case is:

$$F = \frac{1}{2}d\frac{m}{l}z'^2 \quad (6)$$

Partial derivative of velocity coordinates z provides:

$$F = \frac{dmz^{ý}[t]^2}{2l} \quad (7)$$

Generalized power system:

$$Q = R_Z + R_X \tan[b]. \quad (8)$$

Ingredient $\frac{¶T}{¶q_i}$ in this case is:

$$\frac{¶T}{¶(z)} = 0 \quad (9)$$

After substituting (5) - (12) in the dynamic equations (2) and the necessary transformations we obtain the differential equations of motion of pushing the drive:

$$z''\left(\frac{I\tan(\beta)^2}{R^2} + M\left(1+\tan(\beta)^2\right)\right) + z'\frac{\left(dm + ld_3\right)}{l} + z\left(\frac{cm}{l} + \frac{n^2\sin(\beta)^2 c_U}{l^2}\right) - Q_u = S_U\left(\frac{n\sin(\beta)c_U}{l}\right) \quad (10)$$

where: $Q_u = R_Z + R_X \tan(\beta) - Mg$.

Transfer function model Soshnikova pushing the drive system is:

$$W_{vd} = \frac{A_4}{A_1 s^2 + A_2 s + A_3}. \quad (11)$$

where: $A_1 = \frac{I\tan(\beta)^2}{R^2} + M\left(1+\tan(\beta)^2\right)$; $A_2 = \frac{\left(dm + ld_3\right)}{l}$;

$A_3 = \frac{cm}{l} + \frac{n^2\sin(\beta)^2 c_U}{l^2}$;

$$A_4 = \frac{n\sin(\beta)c_U}{l};$$

s - A symbol of differentiation over time.

Position correction mechanism pushing disk drives positional meets design [6], the dynamics model which may be represented as follows:

$$\begin{cases} S_U^{'}(t) = V_{S_U}(t); \\ V_{S_U}^{'}(t) = -\frac{2\xi_k}{T_k}V_{S_U}(t) - \frac{1}{T_k^2}S_U(t) + \frac{K_k U(t)}{T_k^2}, \end{cases} \quad (12)$$

where: K_k, ξ_k and T_k - In accordance with the gain, damping and time constant adjustment mechanism position; $U(t)$ - Managing performance.

The system of equations (15) represented in the equation:

$$s^2 S_U(t) + \frac{2\xi_k}{T_k} sS_U(t) + \frac{1}{T_k^2} S_U(t) = \frac{K_k U(t)}{T_k^2}. \quad (13)$$

Given (16) transfer function model servomehanizmu correction position pushing the disc is:

$$W_{np} = \frac{K_k}{T_k^2 s^2 + 2T_k \xi_k s + 1}. \quad (14)$$

Model pushing position sensor disk present equations:

$$\begin{cases} \hat{z}(t) = \tilde{\mu}(t) A_d; \\ \tilde{\mu}'(t) = -\frac{1}{T_d}[\tilde{\mu}(t) - z(t)], \end{cases} \quad (15)$$

where: $\hat{z}(t)$ - The output signal of the sensor;

$A_d = 1 + \Delta_d(t) + \xi_d(t);$

$\Delta_d(t)$ and $\xi_d(t)$ - Systematic and random error components relative functioning sensor;

$T_П$ - Time constant of the sensor;

$\tilde{\mu}(t)$ - An intermediate variable.

The system (18) present in the form:

$$\hat{z}(t)\left[\frac{s}{A_d} + \frac{1}{T_d A_d}\right] = \frac{z(t)}{T_d}. \quad (19)$$

Then the transfer function model position sensor pushing drive will look like:

$$W_d = \frac{A_d}{T_d s + 1} \quad (20)$$

Equation (14) (17) (20) are two-phase model of Soshnikova systems for precision farming technology. The analysis of this model makes it possible to choose the structure and values of the control action $U(t)$ (Act regulations) that achieve sustainability of the functioning and operation at acceptable values of error tracking task.

To ensure normal operation of Soshnikova applied servo control module, which, together with other elements to form Soshnikova system of automatic control scheme. It is important to provide high dynamic characteristics such as stability of operation, time, speed, accuracy and more regulation. To do this, on the one hand, the known structure of the system to find the optimal values of dynamic parameters, and determine the structure and parameters of the control law, on the other. The structure and parameters of the control action $U(t)$ choose based on the conditions providing the necessary values of sustainability and quality of transients being evaluated indicator (1).

Odds control law will seek the help of transfer function which represented as:

$$W_U = \frac{K_1}{K_2 s^2 + K_3 s + 1} \tag{16}$$

where: K_1, K_2, K_3 - Carbon control law.

Soshnikova analyze the work group when management provisions is pushing drive servo mechanism as a "motor-reducer" with parameters T_k = 0,08 c, ξ_k = 0.3, K_k = 0.8. Dynamic parameters of the sensor output intensity with seed flow values: T_d = 0.1 s, A_d = 1.2. Odds control law K_1, K_2, K_3 the magnitude 0.6; 0.1 and 0.1 respectively. Solving mathematical model of the management of deep drive pushing the pace was conducted among the Simulink software MatLab. The result of a two-phase solution Soshnikova the functioning of the system according to the circuit in Fig. 2 shown in Fig. 4. From the depth chart the course of pushing the disc shows that there is a significant impact on the quality of the job systematic and random components of sensor errors D_Z Which controls the position of pushing the drive.