Technologies of supporting decision in understanding conditions for projecting technological processes

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Abstract. Modern agriculture involves the implementation of a particular technological operation, according to the appropriate map-task, which is developed pre-based on diverse information. Knowledge of a certain structure of soil cover variability, obtained using information and technical systems of local operational monitoring of the agrobiological state of agricultural lands, allows us to adopt effective operational decisions for efficient managemen tagrobiological potential of agricultural lands.

Obviously, under such conditions, there is a need for fundamentally new approaches to agricultural production, which is to ensure the proper quality of technological operations. The quality of the implementation of technological operations is an integral indicator of the efficiency of production of agricultural products within the agrobiological field. The necessary quality of implementation of the basic technological processes in plant growing is provided by the integrated information and technical systems of operational monitoring of the agrobiological state of agricultural lands.

This opens new prospects for organic farming using such "smart" agricultural machines.

In connection with this, the task is to obtain reliable data on the agrobiological state of the soil environment by reducing the error in determining the magnitude of the electrical conductive properties of the soil, providing individual stabilization of the working electrodes and the mechanism of lifting / lowering the working electrodes, copying inequalities of the soil environment, reducing the intensity of the destruction of the soil structure , self-cleaning of the working contact of the electrode and ensuring the stability of the electrical contact of the electrode with the soil, by instrument design perfection. The task is achieved by using the information and technical system of operational monitoring of the soil environment of the structure to determine the conductive characteristics of the soil environment.

The purpose of this research is to determine the critical loading at the loss of stability by thin-walled working electrodes made in the form of working electrodes of various shapes (thin-walled solid, three-spit and four-spindle discs with different thickness of the rim). Information and technical system of local-operational monitoring of agrobiological state of soil environment of different configurations with one-side compression. .

Keywords: information and technical system, local operational monitoring, soil, samples, variability, size, research.

SETTING THE PROBLEM

Existing methods for controlling the agrobiological state of the soil environment and sampling of soil samples according to available techniques do not take into account the variability of their parameters over the area of agricultural land [1-38]. In order to implement the technology of differentiated introduction of technological material, a simplified method of uniformly dividing the surface of the field at the level of the squares (preferably 5-15 ha) is used for further diagnostics and control of the field using such differentiation. On the one hand, such a division is due to the convenience and simplicity of this method, on the other hand, the lack of reliable field data and, accordingly, the instrument for splitting the field according to other criteria based on the original data. According to this method, in a conditionally equal square, fields with fundamentally different parameters may fall into the field, the average value of which will not reflect the real parameters of the plot. The method of uniform division at the level of the square of the surface of the field does not take into account the specifics of the field and the heterogeneity zones, as a consequence of the low

reliability of the data obtained using this method, and, accordingly, the possibility of using such data for the qualitative management of technological processes using the technology of differentiated introduction of technological material [16].

In some cases, the values of the soil environment parameters will be understated, and some will be overestimated within one square [20]. Differentiated control of the norm of introducing technological material, within the limits of this square, should be carried out precisely on the basis of the average value of this parameter. Therefore, such a way to implement a differentiated introduction of technological material will be ineffective.

Under these conditions, there is a need to find the most effective way for operational monitoring of the agrobiological state of agricultural lands [32].

The most effective way of operational monitoring of the agrobiological state of agricultural land is to measure the electrical conductivity characteristics of the soil environment. The conductive properties of the soil environment is a complex indicator of its agrobiological state, which takes into account the hardness of moisture, the content of nutrients in the soil, the saturation of the bases, the capacity of the cation exchange, etc. [22, 33].

The task is to obtain reliable reliable data on the agrobiological state of the soil environment by reducing the error in determining the value of the conductive properties of the soil. To provide the indicated tasks, the information and technical system of local operational monitoring of the agrobiological state of agricultural lands is used by measuring the electrical conductivity of soils [34].

The information and technical system of local operational monitoring of the agrobiological state of agricultural lands is used: before the implementation of the technological operation, simultaneously with the implementation of the technological operation (sowing, introduction of mineral fertilizers, etc.); during the growing season and after harvesting [30, 31, 33, 39].

Physical simulation of soil electrical conductivity in the functioning of such systems was performed to verify the effectiveness of the operation of information and technical systems of local operational monitoring of the agrobiological condition of agricultural lands and the reliability of the data.

This opens new prospects for organic farming using such "smart" agricultural machines [32].

In this sense, the development and use of a fundamentally new class of agricultural machinery - information and technical systems for the operational monitoring of the condition of agricultural lands becomes relevant.

Therefore, an important task is to develop and substantiate the functional structure of the modern information and technical system of operational monitoring of the state of agricultural lands.

The analysis of recent research and publications

The structure of the soil varies greatly in many agricultural fields. Physical properties of the soil, such as the soil structure, have a direct effect on water capacity, capacity of cation exchange, yield, etc. Nutrients contained in soils are used by the plant, and their content in the soil decreases. The generally accepted characterization of nutrient content in soils is the content of nitrogen, the presence of which in soil largely determines the yield. Cartography of soil electrical conductivity is widely used as an effective means of mapping the soil structure and other soil properties [17].

A quick description of the variability of agricultural land is an important component for zonal management methods [16-19].

The Veris trailer unit moves in the field, one pair of isolated electrodes enters the electric current into the ground, and the other pair measures the voltage drop that will be different (for example, the depth conducts a current better than mull or sand). Measurements of electrical conductivity are combined with GPS data and are clearly displayed as a map. Veris 3100 uses two beams of electrical conductivity for mapping two depths of soils (0-30.5 cm and 0-91.5 cm) at the same time [20].

Device Veris 3100 forms two sets of cards - a map of the surface layer (30.5 cm) and a map covering the root zone (91.5 cm). The top layer map is often used to select sampling points, and a deeper map to determine the fertilizer application rate (especially nitrogen) [20].

These devices are too costly and give a significant measurement error, which creates the conditions for further study of these systems.

The device for determining the conductive properties of the soil environment is used: before the execution of the technological operation, simultaneously with the implementation of the technological operation (seed, application of mineral fertilizers, etc.); During the growing season and after harvesting. This opens new prospects for organic farming using such "smart" agricultural machines.

In Fig. 1 there is a general view of the information and technical system of local operational monitoring of the state of the soil environment (top view), Fig. 2 - a general view of the information and technical system of local operational monitoring of the state of the soil environment (side view) is depicted.

Such a technological solution will provide an opportunity to ensure optimal control of the seed rate, seed, fertilizer, etc., taking into account the agrobiological state of the soil environment.
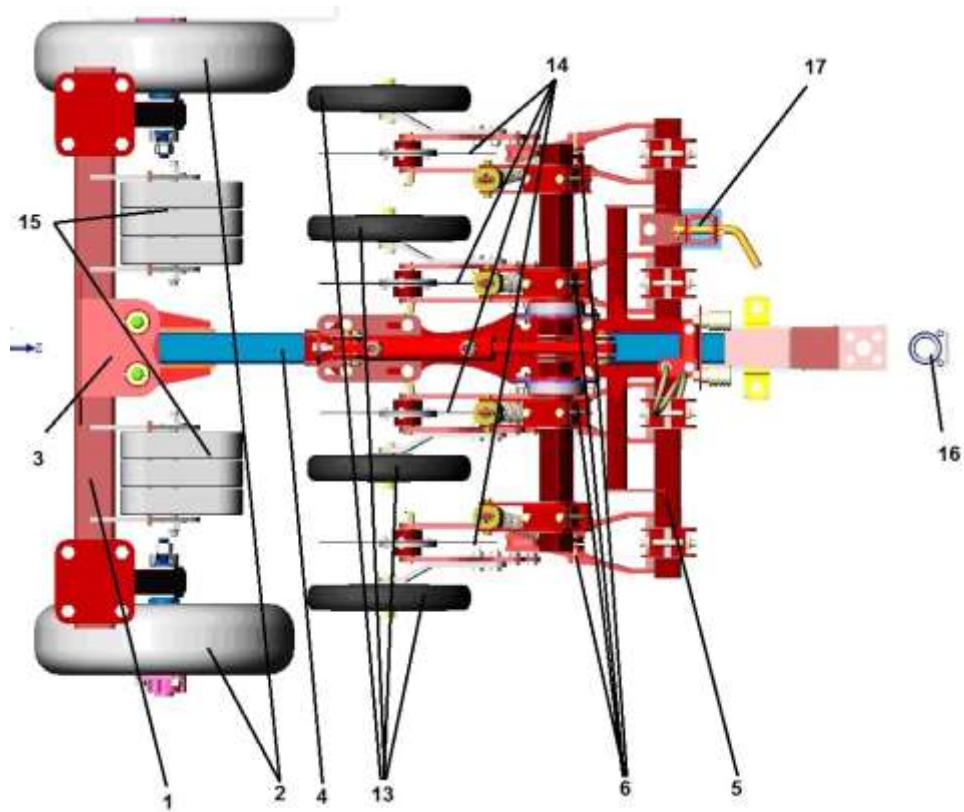
Fig. 1. The general view of the information and technical system of local operational monitoring the state of the soil environment
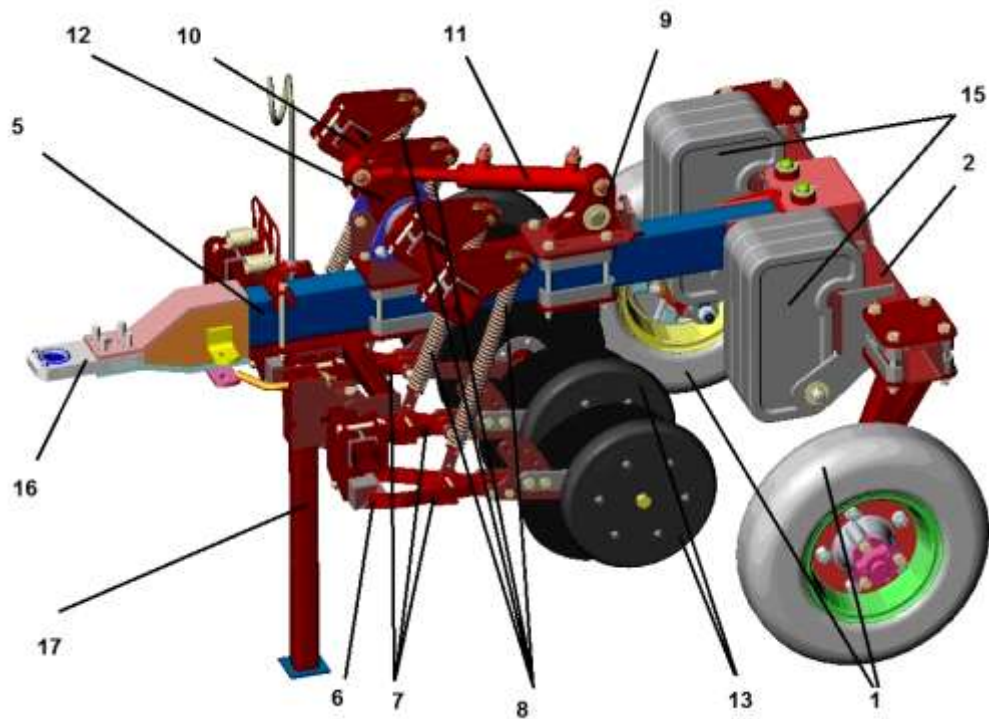

Fig. 2. General view of information and technical system of local operational monitoring the agrobiological state of the soil environment

The information and technical system of local operational monitoring of the soil environment is formed (Fig. 2) from the support wheels 1, the P-shaped frame 2, the mounting 3, the longitudinal frame 4, the transverse frame 5, the joints 6, the levers 7, the spring supports 8, the bracket 9, a rotary shaft 10, a hydraulic cylinder 11, a mount bracket 12, copying wheels 13, working electrodes 14, a ballast 15, a tow 16 and a stand 17.

While using such a device, there is a significant error in determining which due to the fact that during the work process the stability of the contact of the disk electrode with the ground is disturbed due to the transverse deviations of the working disk electrodes relative to the straight line of motion due to the construction of the device, the lack of copying the surface roughness fields of disk electrodes. This changes the contact area of the disk electrode with the soil, because in the case of transverse oscillations, flat disks electrodes with one side may not contact the soil at all.

The analysis of the state of research on the interaction of working bodies with the soil should be noted that over the past decade, significant changes in the formation of soil has not occurred. Therefore, in the form of representation of the model of soil construction, all works relating to the interaction with it working bodies, can be divided into five groups: 1) solid; 2) solid elastic medium; 3) a continuous bulking environment that is not deformed; 4) solid elastic-visco-plastic environment; 5) formalization by methods of the theory of similarity and dimensions [1, 2, 3, 4, 5, 6, 7]. Proceeding from this, most often used models that are more reminiscent of interaction with a completely solid body or models that are used in the classical theory of soil mechanics, which are based on the mechanics of friable discrete media [9, 10]. In addition, when constructing a model of interaction most often used either one-dimensional models, or at best, flat solutions that do not always reflect the actual process of changing the properties of the soil under the influence of the working body.

In addition, when solving the problems of interaction of the working body with the soil, either purely experimental studies or numerical methods using programs that construct solutions in which are based on Finite Element Method (FEM) or finite volume (DEM) methods [12, 13, 14, 15 , 16, 17]. In these solutions, embedded models of stress-strain relations are used, which do not always reflect the actual processes of deformation. In addition, the listed methods significantly reduce the generality of the results. This leads to a significant limitation of obtaining new knowledge about the ongoing processes.

The purpose of this research is to develop an effective technology for decision-making support in conditions of uncertainty when designing technological processes.

Presentation of the main content of the research. An important parameter in measuring the conductive characteristics of the soil environment is to provide a stable contact area of the working electrodes with the soil. The existing designs do not fully fulfill the specified conditions, which negatively affects the reliability of the information received. In connection with this, there was a need to develop a design that would ensure the stability of the working electrodes with the soil during the measurement of the conductive properties of the soil environment.

To illustrate the drawbacks of the existing design and the advantages of the design, their diagrams are shown in fig. 3, fig. 4.1, fig. 4.2.

It is worth to say that the design of the systems has a number of common elements, including common elements, available and developed (Fig. 3, Fig. 4.1, Fig. 4.2). There are: 1 support wheel, 2 frame, 3 working electrode. Further, the existing system consists of 4 risers, which are rigidly connected to the frame, so when moving with agricultural land, such a system can form fissures of width h, due to the appearance of angles of the roll, delent and rusting due to non-linear movement of the aggregates due to their deviation or rotation. In turn, this contributes to the measurement error of the conductive parameters of the soil environment, since one side of the disk does not contact the soil at all (Fig. 4.2, a).
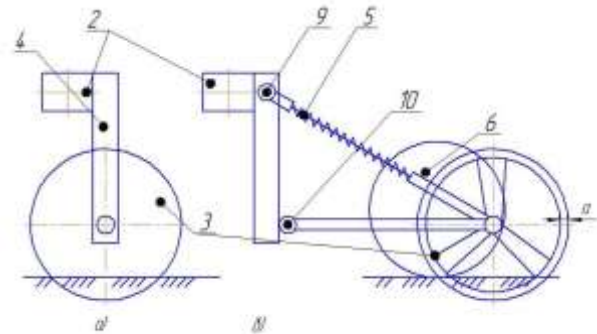

Fig. 3. Comparative scheme of the device for determining the conductivity characteristics of the soil environment (side view): a) available construction; b) the design is developed; 2 - frame; 3 - working electrode; 4 - stand; 6 - support wheel; 5 - vertical suspension of suspension; 9 - upper hinge; 10 - lower hinge

In the developing design, this problem is eliminated due to the compensation of such angles partly due to the suspension, and in part - the upper and lower suspension hinges of the designed design, which allow compensating the transverse deflection α within 15-20 degrees, while maintaining a stable contact of the electrodes with the soil. With the use of copying wheels 6 (pitch 4.1, 4.2), the existing design clearly provides the depth H of the motion of the working electrodes in the soil. In an existing construction (see 4.1, p. 4.2), it changes due to the corners of the deferent, due to oscillations and lateral

displacement of the structure of the system during the movement of the surface irregularities of the field.

The general principal differences of the information and technical system of local operational monitoring of the agrobiological state of the soil environment - a device for determining the conductive properties of the soil environment are:

1. Presence of a copier wheel, which determines the depth of the working electrode in the soil H.

2. Suspension of the bearing wheel and working electrodes.

3. Three-spoke thin-walled metal disk with a rim to provide a stable area of contact of electrodes with soil.

4. Articulation of the lever suspension of working electrodes with soil to compensate for the angles of the roll, trimert and rotation due to the movement of the machine-tractor unit by the information and technical system of operational monitoring of the agrobiological state of the soil environment and ensuring the stable contact of the working electrodes with the soil.
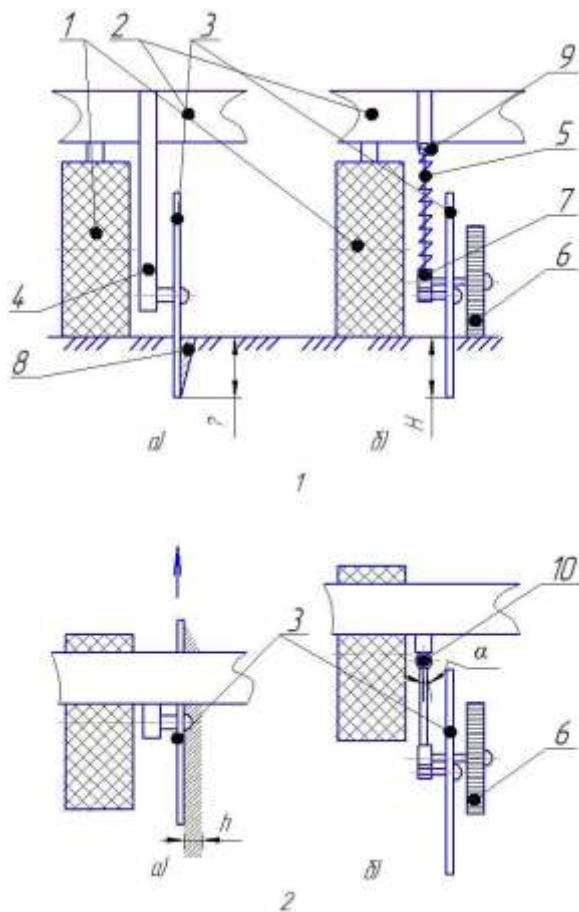

Fig. 4. Comparative diagram of the device for determining the conductivity characteristics of the soil environment (front view, top view): a) available construction; b) the design is developed; 1 - support wheel; 2 - frame; 3 - working electrode; 4 - stand; 5 - vertical suspension of suspension; 6 - copier wheel; 7 - adjustment mechanism of the depth of the wheel; 8 - furrow formed by a working electrode; 9 - upper hinge; 10 - lower hinge

The technical result, which is achieved using the information and technical system of local operational monitoring of the agrobiological state of the soil environment, is:

1. Ensure a stable contact of the electrodes with the soil: due to the compensation of the angles of the roll, delent and the risk caused by the movement of the technical system.

2. Determination of the depth of entry of the working electrode into the ground using a copier wheel.

3. Decrease in area growth per unit depth / entry into the soil of the working electrode due to the construction of a three-spoke thin-walled metal disk with a rim in the design.

4. The absence of the formation of a groove by working electrodes due to compensation of the angle of rotation of the upper and lower hinges of the suspension of the angle α.

The functional scheme of the information and technical system for operational monitoring of the agrobiological state of the soil environment as a mechatronic system is presented on a scale. 5

The signal from the working bodies of the technical system of operational monitoring of the state of agricultural lands $F_{TCM}(t)$ turns into an analog-digital signal of the control unit of the technical system of operational monitoring of the state of agricultural lands. After amplifying this signal $U_{USB/RS232}(t)$ is transmitted to the main module of the technical system of operational monitoring of the condition of agricultural lands. For a visual display of the results of the implementation of technological operations, a display of the technical system of operational monitoring of the condition of agricultural land $U_{RS232}(t)$.

The main module of the technical system of operational monitoring of the state of agricultural land sends a signal $U_{V\_RS232}(t)$ to the driver of the technical system of operational monitoring of the state of agricultural lands. From the driver of the signal $U_{RS232}^{BM}(t)$ goes to the executive mechanism of the technical system of operational monitoring of the state of agricultural lands (servo drive), which through mechanical communication $F_{CTM}^{BPO}(t)$ provides an effect on the working body of an agricultural machine that carries out a technological operation.

$$U_\alpha^\beta(t) = U(t_\beta - t_\alpha) = \int_{t_\alpha}^{t_\beta} \left| \begin{array}{c} F_{TCM}(t) + U^{A\text{ЦП}}(t) + U_{USB/RS232}^{A\text{ЦП}-\text{ГМ}}(t) + U^{E\text{П}-\text{ГМ}}(t) + U_{RS232}^{\text{ГМ}-\text{ДП}}(t) + \\ + U_{RS232}^{\text{ГМ}-\text{ДК}}(t) + +U^{\text{ДК}-BM}(t) + U^{BM}(t) + F_{C\text{ГМ}}^{BPO}(t) + F_{C\text{ГМ}}^{\text{Я}}(t) + F_{\text{Д}}^{\text{Я}}(t) + U^{33}(t) \end{array} \right| dt \leq \mu(t_\alpha)$$

The function of optimal control will look like this:

$$U_{O\text{ПТ}}(t) = F_{TCM}(t) + U^{A\text{ЦП}}(t) + U_{USB/RS232}^{A\text{ЦП}-\text{ГМ}}(t) + U^{E\text{П}-\text{ГМ}}(t) + U_{RS232}^{\text{ГМ}-\text{ДП}}(t) +$$
$$+ U_{RS232}^{\text{ГМ}-\text{ДК}}(t) + +U^{\text{ДК}-BM}(t) + U^{BM}(t) + F_{C\text{ГМ}}^{BPO}(t) + F_{C\text{ГМ}}^{\text{Я}}(t) + F_{\text{Д}}^{\text{Я}}(t) + U^{33}(t)$$

$F_{TCM}(t)$ is a function that describes the functioning of the technical system of operational monitoring of the agrobiological state of agricultural land during the implementation of a technological operation;

$U^{A\text{ЦП}}(t)$ is a function that describes the output signal obtained from the working electrodes of the technical system for the operative monitoring of the state of agricultural lands to the analog-digital converter amplifier with the help of shielded wires;

$U_{USB/RS232}^{A\text{ЦП}-\text{ГМ}}(t)$ is a function that describes the output signal obtained from the analog-digital amplifier-converter of the technical system of operational monitoring of the state of agricultural lands, and sends a signal to the module of communication with the technical systems of operational monitoring of the state of agricultural lands using the port $RS232$ порту or to a personal computer using the port USB;

$U^{E\text{П}-\text{ГМ}}(t)$ is a function that describes the connection of the device elements with the main module of the technical system of operational monitoring of the state of agricultural lands;

$U_{RS232}^{\text{ГМ}-\text{ДП}}(t)$ is a function that describes the signal received from the main module to the display of management of the technical system of operational monitoring of the state of agricultural lands;

$U_{RS232}^{\text{ГМ}-\text{ДК}}(t)$ is a function that describes the signal received from the main module to the manager of the technical system of operational monitoring of the state of agricultural lands;

$U^{\text{ДК}-BM}(t)$ is a function that describes the output signal received from the management driver to the executive working bodies of the technical system of operational monitoring of the state of agricultural lands;

$U^{BM}(t)$ is function of changing the voltage of control of the executive mechanism of the technical system of operational monitoring (in this case, the electric motor or servo drive);

$F_{C\text{ГМ}}^{BPO}(t)$ is a function that describes the management of the executive bodies of agricultural machinery performing a technological operation (chain transmissions, variator and other mechanical parts);

$F_{C\text{ГМ}}^{\text{Я}}(t)$ is a function that describes the mechanical action of executive bodies of an agricultural machine on the quality of the technological process;

$F_{\text{Д}}^{\text{Я}}(t)$ is a function that describes information from a quality performance sensor for a technological operation placed on an agricultural machine with operational quality management, depending on the technical monitoring system;

$U^{33}(t)$ is a function that describes the feedback from the parameters and operating modes of the executive working bodies of agricultural machines and is synchronized with the data of an analog-digital amplifier of the technical system of operational monitoring of the state of agricultural lands and transmitted to the main module;

ПК is a personal computer that receives information from the function $U_{USB/RS232}^{A\text{ЦП}-\text{ГМ}}(t)$, which describes the output signal received from the analog-digital amplifier-converter of the operational system technical monitoring system

In the general case, the dependence of the current flowing through the surface of the working electrode executed in the form of a disk and contact disk-ground can be expressed as follows:

$$I=f(S, P, U),$$

where S is a contact area of the disc with the soil,

P is a normal component of the pressure of the soil-disk in the contact area,

U is a speed relative to the slip of the surface of the disk on the surface of the soil in the contact area.

To find the components that are included in the dependence of the passage of current through the interface between the disk and the ground, it is necessary to determine the kinematic and dynamic values in the zone of contact interaction of the disk with the soil. Such a problem is reduced to the solution of the contact problem of the interaction of an absolutely non-deformable solid with a deformable semi-space.
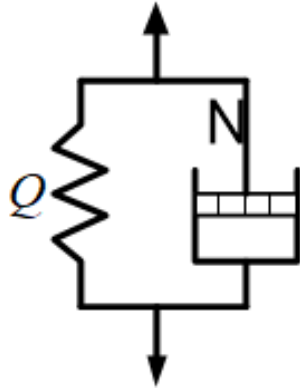

Fig. 5. Mechanical model of proportional deformed viscous medium (soil)

When analyzing the interaction of a working electrode executed in the form of a thin-walled disk ("disk-probe") with soil we accept the following assumptions and simplifications:

- the disk is a completely solid non-deformable body;

- the disk shape is an ellipsoid with such coefficients of the equation that the disk section is (practically) a wedge, that is, the value of the coefficients of the ellipsoid equation brings it closer to the plane disk;

- for simplicity of formalization and the possibility of solving the problem by analytical methods, the soil is represented as a medium for which deformation is associated with the voltage directly proportional to the proportionality factor of a similar modulus of Hooke's elasticity and has a viscous resistance similar to the support of the Newton's body, that is, the model similar to the simplified Gerstner model or the Kelvin-Voigt body [9, 10] .

- the motion of the disk is flat-parallel, and the direction of its motion is perpendicular to the axis of rotation of the disk.

Under accepted assumptions it is necessary to use the basic equations of the mechanics of a continuous medium, namely:

- equation of the dynamics of a continuous medium, which has the form (1), where $\sigma_x, \sigma_y, \sigma_z, \tau_{xy}, \tau_{xz}, \tau_{yz}$ are the components of normal and tangent stresses respectively, ρ is a the density of the medium (soil), u, v, w are the components of the velocity of moving the medium in projections on the coordinate axis; X, Y, Z are the projection of common forces on the corresponding coordinate axes.

Taking into account that the change in overall forces can be neglected due to their small values, as well as what is happening in the process of interaction with the constant speed of the disk

$$(u, v, w)=const, (du/dt, dv/dt, dw/dt)=0 \quad (1)$$

- Geometric equations of communication of components of velocities of relative deformations with absolute displacement velocities of elements of the medium (2), where $\dot{\varepsilon}_x, \dot{\varepsilon}_y, \dot{\varepsilon}_z, \dot{\gamma}_{xy}, \dot{\gamma}_{yz}, \dot{\gamma}_{zx}$, are the components of velocities relative to deformations.

- equilibrium equilibrium on the surface or conditions on the surface in the form of (3) where l_d, m_d, n_d Cosines of the inclination angle are normal to the surface of the disc in accordance with the axes of coordinates $\xi\eta\zeta$ idem x, y,z; $\overline{X}, \overline{Y}, \overline{Z}$ projection of distributed forces (pressure) on the corresponding coordinate axes.

Projection of distributed forces (pressure) on the corresponding coordinate axes.

The physical equations of the voltage components with relative deformations (deformation rates) must be connected to equations (1) - (4). These equations can be obtained on the basis of the accepted soil formalization as a quasi-whole medium, such an assumption is legitimate due to the fact that the volumes of soils in which the changes in voltage and deformation are considered exceed the size of the volumes of the largest particle of the soil at least by an order of magnitude.

Mechanical model of the body, in which the relative deformations are directly proportional to the coefficient and the voltage changes, and the rates of deformation are proportional to the modulus of viscosity and the change in the stresses presented in Fig. 1. This model is an analogue of the elastic-viscous medium of the Kelvin-Voigt model.

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} + \rho\frac{du}{dt} = X; \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} + \rho\frac{dv}{dt} = Y;$$

$$\frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \sigma_z}{\partial z} + \rho\frac{dw}{dt} = Z, \tag{1}$$

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} = 0; \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} = 0; \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \sigma_z}{\partial z} = 0. \tag{1.a}$$

$$\dot{\varepsilon}_x = \frac{\partial u}{\partial x}; \dot{\varepsilon}_y = \frac{\partial v}{\partial y}; \dot{\varepsilon}_z = \frac{\partial w}{\partial z}; \dot{\gamma}_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}; \dot{\gamma}_{yz} = \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}; \dot{\gamma}_{zx} = \frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}, \tag{2}$$

$$\sigma_x l_d + \tau_{xy} m_d + \tau_{xz} n_d = \bar{X}; \sigma_y m_d + \tau_{yz} n_d + \tau_{xy} l_d = \bar{Y}; \sigma_z n_d + \tau_{xz} l_d + \tau_{yz} m_d = \bar{Z}, \tag{3}$$

$$\frac{\partial^2 \dot{\gamma}_{xy}}{\partial x \partial y} = \frac{\partial^2 \dot{\varepsilon}_x}{\partial y^2} + \frac{\partial^2 \dot{\varepsilon}_y}{\partial x^2}; \quad \frac{\partial^2 \dot{\gamma}_{yz}}{\partial y \partial z} = \frac{\partial^2 \dot{\varepsilon}_y}{\partial z^2} + \frac{\partial^2 \dot{\varepsilon}_x}{\partial y^2}; \quad \frac{\partial^2 \dot{\gamma}_{zx}}{\partial z \partial x} = \frac{\partial^2 \dot{\varepsilon}_z}{\partial x^2} + \frac{\partial^2 \dot{\varepsilon}_x}{\partial z^2};$$

$$2\frac{\partial^2 \dot{\varepsilon}_x}{\partial y \partial z} = \frac{\partial}{\partial x}\left(-\frac{\partial \dot{\gamma}_{yz}}{\partial x} + \frac{\partial \dot{\gamma}_{zx}}{\partial y} + \frac{\partial \dot{\gamma}_{xy}}{\partial z}\right); 2\frac{\partial^2 \dot{\varepsilon}_y}{\partial z \partial x} = \frac{\partial}{\partial y}\left(\frac{\partial \dot{\gamma}_{yz}}{\partial x} - \frac{\partial \dot{\gamma}_{xz}}{\partial y} + \frac{\partial \dot{\gamma}_{xy}}{\partial z}\right);$$

$$2\frac{\partial^2 \dot{\varepsilon}_z}{\partial y \partial x} = \frac{\partial}{\partial z}\left(\frac{\partial \dot{\gamma}_{yz}}{\partial x} - \frac{\partial \dot{\gamma}_{xz}}{\partial y} + \frac{\partial \dot{\gamma}_{xy}}{\partial z}\right). \tag{4}$$

The general equation of the voltage relation with relative deformations and velocities of relative deformations can be obtained by summing up the components of generalized equations similar to the generalized Hooks equations.

The equation of connection of voltage changes with relative deformations can be represented in the following form (5)

$$\sigma_x = \lambda\theta + 2Q\varepsilon_x; \sigma_y = \lambda\theta + 2Q\varepsilon_y;$$
$$\sigma_z = \lambda\theta + 2Q\varepsilon_z; \tau_{xy} = Q\gamma_{xy}; \tag{5}$$
$$\tau_{xz} = Q\gamma_{xz}; \tau_{yz} = Q\gamma_{yz},$$

where $\theta = \varepsilon_x + \varepsilon_y + \varepsilon_z$ is a relative volumetric deformation; $\varepsilon_x, \varepsilon_y, \varepsilon_z$ are the components of relative linear deformations; γ_{xy}, γ_{xz}, γ_{yz} are the components of relative landslide deformations; $\lambda = \frac{2Qv}{(1-2v)}$, Q is a coefficient of proportionality of relative displacement deformations; v is a coefficient of the ratio of transverse deormations to the longitudinal (analogous to the Poisson coefficient).

CONCLUSION

The technology of decision-making support in the conditions of uncertainty in the design of technological processes is proposed. The result of using the proposed technology is an increase in profits by 20-30% due to optimization of seed rate of technological material, taking into account the agrobiological state of agricultural lands.

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