IMPROVEMENT OF TECHNOLOGICAL PROCESSES AND IMPROVING THE QUALITY OF TILLAGE IN SIBERIA

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Agricultural production and the industry is growing are you quite costly and produced cereal products are low competitive. The main component of the cost mechanism is the high energy consumption of running processes in the cultivation of crops. The reason for this is the use of outdated engine technology, based on the prevailing use of classic treatments of the soil. According to research by the FSBSI VIM only 10–15 % of farms use innovative management techniques and resource saving technology. Forecasts of this institution show that during the next 15–20 years against the background of increasing energy consumption is not expected technological breakthroughs in the provision of alternative sources of energy. Consequently, the in implementation of technological processes in the agricultural enterprises will remain copper sky energy. The way technological development will depend on the choice of a particular base technology that becomes the basis for many subsequent improvements. Statistical indicator of the intensity of technological processes is the traction resistance of agricultural machinery related to the physical properties of the soil, its hardness. Investigated the continuous on-line condition monitoring of hardness (density) of the soil because of its moisture in the soil treatment. In determining soil moisture used its relationship with the thermal radiation of the soil in the surrounding area, which is measured pyroelectric infrared sensors.

Keywords: technological process, treatment of soil, the hardness (density), moisture content, tillage machine, operational control, infrared sensors

The production of grain, a strategic product, remains dominated-conductive in the crop sector agricultural production, both Russia and Siberia. However, the implemented technologies have a high energy intensity and material intensity. In accordance with the principle of Bellman optimal trajectory of single components is also optimal. In [7] it is noted that in the cultivation of crops up to 40 % of the resource capacity is consumed for the technological process of processing of the soil, and its share of, for example, in the wheat crop, for the conditions of Ural and Siberia is close to 20 %. And more than 50 % of mechanical work is performed with deviations from agronomic requirements. This is especially true of the main and additional processing of the soil, during which the deviation is increased to 200 % [7]. According to the academician V.P. Yakushev, annual soil degradation in Russia reaches 450–500 thousand ha, due to the imperfection of the prevailing classical application of dump technologies. According to studies, I.I. Sventitskiy, the intensity of technical (anthropogenic) impacts on soil proportional to its saturation.

Analysis of tendencies of development of production in Russia shows that the rising cost of energy and material resources is outpacing the growth in number of end products – growth in productivity. The concept of increasing productivity in agro-industrial complex based on the use of intensive technologies with the use of powerful resource-technology in the modern conditions, have shown to be ineffective.

The modern state of agriculture in its strategic development focused on energy saving technologies based on minimization soil treatment up to zero, including No-Till technology. For conditions of Siberia, as follows from the above work, the abandonment of tillage leads to a reduction of 20–25 % of the total cost of implementing the technology. It is noted that the use of No-Till does not always provide a high yield, however, an important ecological and economic benefits. It is believed that agricultural intensification is the only way to ensure the world's population with food. According to L.V. Pogorelyi, creation of flexible technological systems allows to increase productivity in 2 and more times.

The aim of the study is to improve the quality of soil treatment on the basis of increasing precision of operational control of its state.

The use of ecologically-oriented energy-saving automated technologies of cultivation and sowing of grain crops provides individual need of different type of soil in complex stress, restoring their fertility. Efficiency of the adaptive tillage Assembly (ATM), and hence yields, facilitates the continuous determination of density of soil directly when performing technological operations in machine-tractor unit. Because of the spots with a sharp change in the density of the soil the process of change in the traction resistance is random non-stationary. In [1, 2, 5, 9] analyzed model of the soil and generalized model that takes into account the diversity of soils and their statistical characteristics, designed and tested in a production environment, the automatic control system as ATM, proven methods of operational control of the hardness (density) of the soil. It is shown that it is necessary to consider many factors that affect soil fertility, including its moisture content. However, the methods and technical means to ensure serving its records directly in the process of technological operations but rather studied and have no practical use. To address this shortcoming and dedicated to this work.

It is known that yield losses depend on the density (hardness) of the soil [3]:

$$P_U = k_n \rho_{md},$$

where ρ_{md} – average density of the soil.

Studies have found that between moisture and density (hardness) of soil there is a linear dependence with the increase of humidity decreases the hardness. For example, empirical relationships between the hardness y and humidity x black soil have the form [10]:

Background – couples plowing on the horizon 10...15 cm:

$$y = 2{,}792 - 0{,}042x; \quad \upsilon = 0{,}472. \qquad (1)$$

Background – stubble on the horizon 10...15 cm:

$$y = 5{,}137 - 0{,}099\,x; \quad \upsilon = 0{,}559,$$

where y is in MPa, x in percent; υ – coefficient of variation.

Similar dependencies were obtained at depths 0...5 cm 5...10 cm (with different coefficients). Given the temperatures at which the hardness is particularly effective in the processing of the soil complex content (including sod-podzolic, sulfur-forest, etc.), which have a strong correlation between moisture content and hardness.

There is the ambiguity of determining the hardness of dry and wet soil. Possible but seasonal or short-term increase in soil moisture. Therefore, it may be, wrong decision about the impact on soil (including the payment of ameliorants or fertilizers), suggesting that its hardness does not require exposure, although humidity is declining, its hardness increases and can exceed permissible limits, this requires who to act on the soil to change its state.

Found that the traction resistance R_a ATM linearly related to the hardness (density) of the soil [4]:

$$R_a = F_k + abmT_{md}, \qquad (2)$$

where F_k is the force of rolling, a and b are plowing depth and width, m – empirical coefficient: m = 0,014 in the case of the working bodies without sticking; m = 0,030…. 0,032 in case of sticking of the case of the working bodies of the soil; T_{md} – the average soil hardness in the depth of plowing.

In other cases [8] also use a linear relationship between the specific resistance of oriented soil κ_a and its hardness T_{md}:

$$k_a = 5,4843T_{md} - 2{,}8153. \qquad (2a)$$

Since the tractive resistance is evaluated on the working speed modes close to $n = n_{nom}$ (n – frequency of crankshaft rotation), then from the equation of power balance

$$R_a \approx \beta(N_{ep} - N_{ex}), \qquad (3)$$

where β – coefficient of proportionality, constant for a given traction vehicle and defined in the calibration by means of a traction dynamometer; the indices p and x correspond to the working (under load) and idle passages of the unit.

Using one or another indirect parameter P_N, reflecting the power of the engine it is possible to determine the traction resistance tillage units:

$$R_a \approx \beta(P_{Np} - P_{Nx}). \qquad (4)$$

From equations (2)–(4) we get:

$$T_{md} = (\beta/abm)(N_{ep} - N_{ex}) = k_{cp}(P_{Np} - P_{Nx}), \qquad (5)$$

where k_{cp} = (β/abm) – the coupling coefficient.

As a parameter P_N can be applied to the following quantities:

$$P_{N1} = |\bar{\varepsilon}_\Sigma| = |\bar{\varepsilon}_k| + |\bar{\varepsilon}_g|; \; P_{N2} = |\bar{\varepsilon}_{\Sigma_{\max}}|; \; P_{N3} = |\bar{\varepsilon}_{34}|;$$

$$P_{N4} = (\bar{\varepsilon}_{34})_{\max}; \; P_{N5} = (\bar{\varepsilon}^2_\Sigma)^{1/2}; \; P_{N6} = (\bar{\varepsilon}^2_{34})^{1/2};$$

$$P_{N7} = p_k; \; P_{N8} = \omega_T;$$

$$P_{N9} = p_{k\,input}; \; P_{N10} = \Delta p_p;$$

$$P_{N11} = |\bar{p}_{k34}|; \; P_{N12} = |\bar{p}_{k\,input34}|; \; P_{N13} = |\overline{\Delta p}_{p34}|;$$

$$P_{N14} = |\bar{\varepsilon}_{T34}|; \; P_{N15} = |p_{k34_{\max}}|;$$

$$P_{N16} = |p_{k\,input34_{\max}}|; \; P_{N17} = |\overline{\Delta p}_{p34_{\max}}|;$$

$$P_{T18} = |\bar{\varepsilon}_{T34_{\max}}|; \; P_{N19} = |\varepsilon_{TDC}|; \; P_{N20} = \varphi_{TDC};$$

$$P_{N21} = I_g; \; P_{N22} = U^*_g,$$

where $|\bar{\varepsilon}_k|$, $|\bar{\varepsilon}_g|$, $|\bar{\varepsilon}_\Sigma|$, $|\bar{\varepsilon}_{34}|$ – average rectified value components of the angular acceleration of the crankshaft: compressor, gas, thermodynamic, are multiples of 3...4 th harmonics of the rotation frequency of the crankshaft; in P_{N2}... P_{N6} applied the maximum and mean square values $|\bar{\varepsilon}_{\Sigma}|$, $|\bar{\varepsilon}_{34}|$; p_k – boost pressure; ω_T and ε_T – angular velocity and acceleration of the turbocharger rotor; $p_{k\ input}$ – air pressure upstream of the compressor; Δp_p – suction air at the compressor inlet; in P_{N11}...P_{N18} with index 34 – average rectified and index 34_{max} – maximum values are p_k, $p_{k\ input}$, Δp_p, ε_T, are multiples of 3...4 th harmonics of the rotation frequency of the crankshaft; in P_{N19}...P_{N20} applied offset the total acceleration of the crankshaft relatively instantaneous acceleration of the crankshaft when passing piston at TDC (the zero line) ε_{TDC}, which simultaneously leads to a shift by φ_{TDC} crank angle or time interval, corresponding to the angle between the TDC and the point of transition instantaneous acceleration through zero; in P_{N21}...P_{N22} used values I_g and I_{ng} or $I_g = I_d$; $U_g^* = U_g$ or $U_g^* = U_d$ (I_{ng} and U_g – load voltage and DC current generators with parallel and independent excitation; I_d and U_d – rectified load current and voltage rectifier generator with independent excitation).

Established between soil moisture and thermal radiation (flux) of soil in the surrounding space there is a linear correlation. For example, in dynamic mode, when the evaporation of moisture from the soil:

$$m_c(dE/dt) = G_b = k_T Q_m, \qquad (6)$$

where m_c is the mass of absolutely dry soil; E – liquid coefficient of the soil; G_b – the flow of evaporated water; Q_m – heat flow; k_T – coefficient of proportionality.

In static mode, the heat flow Q_m is associated with the moisture evaporating from the empirical relation:

$$Q_m = (597 + 0{,}45T_b)G_b, \qquad (7)$$

where T_b is the temperature of the evaporated moisture; G_b – the flow of evaporated water, *kg/h*.

Therefore the measured thermal radiation of the soil to assess its moisture content and to determine the hardness of the soil based on its moisture content. To measure the thermal radiation of the soil can be used pyroelectric infrared sensors that convert the energy of the absorbed thermal radiation into an electrical signal (for example, Japanese sensor company IRA IRA-E410 QW1 angle 17° or IRA-E710 ST1 with a viewing angle of 45°). Depending on the width of the working bodies of tillage mouth-line is selected from multiple pyroelectric infrared sensors to ensure the desired angle.

Previously for a specific type of ATM is measured by a tachometer frequency of rotation of the crankshaft of the internal combustion engine and the transmission of working set. When idle passage ATM alternately set and measured parameters P_{Nx}, reflection engine power and then on the same program at the same engine speed is similar to set and measure the parameters P_{Np}, reflected-of damaging the engine power at an operating passage ATM. Simultaneously, via the traction dynamometer measured tractive resistance. Determined in accordance with (4) the coefficients of proportionality β between the traction accompanied and the difference parameters $P_{Np} - P_{Nx}$. As a result of a series of measurements determined by the mean value of coefficients of β. Then, when the con-controlling the passage of this unit on a particular field, the extent of sticking the RA working bodies, *m* (2). With the help of the device coupling coefficient is introduced into the determinant of the hardness of the soil alternately the corresponding values of the coupling coefficient of the k_{cp} (5). With humidity setpoint coefficient and hardness of the soil is introduced manually into the soil moisture determinant factors known in advance, according to (6) and (7) based on soil temperature and soil hardness determinant based humidity – according to relations (1) and the like. Carry out basic treatment of soil on the working transmission. With the speed of the crankshaft sensor and tachometer control speed, which should be equal to that at which the determined coefficients β and k_{cp}.

Continuous operational control of soil condition in the course of its processing can improve flexibility, significantly increase the accuracy and reliability of the determined division-soil hardness because of its moisture, resolve the ambiguity in the definition of soil hardness and provide quality tillage soil tillage implements in use, motor-vehicle comprising an internal combustion engine. Roughly, in comparison with the known solution [6], the accuracy of determining the hardness of the soil is reduced by 10...20 %.

Insights

1. It is established that the production of grain products is expensive, due to high energy consumption. The static intensity of technological processes in machine technology is the tractive resistance of the prima taken of the agricultural, having a linear relationship with the rate of chopping of the soil.

2. The obtained expression, taking into account the relationship of the traction resistance of agricultural machinery with the main indicators of physical – mechanical soil properties – its hardness and humidity.

3. Proposed solution for an operational definition of indicators, taking into account the hardness of the soil moisture.

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