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IMPROVED RESISTANCE TO TRACTION OF CHISEL-CULTIVATOR WORKING BODIES

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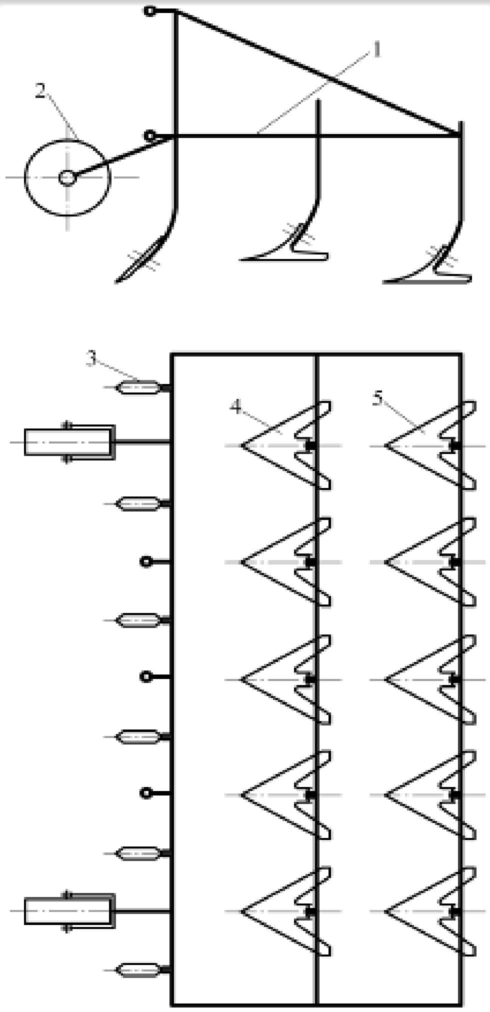
Abstract: ***In order to determine the traction resistance of the improved chisel-cultivator working bodies in the direction of increasing the quality of work and reducing the energy consumption, an analytical expression was derived and analyzed, taking into account their working conditions and the arrangement scheme in the frame. Calculations based on the obtained expression showed that the resistance of the improved chisel-cultivator working bodies at a working speed of 6-9 km/h is 8.2-8.6 kN/m, corresponding to its coverage width of one meter.***

Key words: ***improved chisel-cultivator, softening claw, bullet claw, traction resistance, working speed, open cutting condition, closed cutting condition.***

Introduction. Chisel-cultivators ChKU-4 and ChK-3.0 are widely used in all regions of our country for pre-planting cultivation [1-10]. But these chisel-cultivators have been produced for a long time without any significant changes. For this reason, they do not meet modern requirements such as economical tillage, they are material and energy-intensive, and in many cases they do not provide soil grinding at the required level during one pass through the field. On the basis of these, researches were conducted in our institute in the directions of increasing the performance of chisel-cultivators and reducing their energy consumption, and based on them, an improved chisel-cultivator was developed (see the picture). It consists of a frame, supporting wheels and working bodies installed on it, and is used on driving tractors.

The developed chisel-cultivator differs from the existing ones in the following ways: firstly, its working bodies located in the first row are made in the form of a two-sided narrow flat blade, i.e. in the form of a narrow softening claw with a flat surface, and the working organs located in the second and third rows are made in the form of a three-sided flat blade, i.e. in the form of a bullet-shaped claw, From the second to the first and second rows, the working bodies are arranged in a checkerboard pattern, and the working bodies located in the second and third rows are installed in a row, from the third to the first and third rows, the working bodies are placed at the same depth of processing, and the working bodies in the second row are shallow processing compared to them. installed in depth. These highlights are the decrease in the energy capacity of the chisel-cultivator and

leads to the improvement of the quality of the soil.



1 – a frame equipped with a suspension device; 2 – support wheel; 3 – softening paw;
4, 5 – arrow-shaped paw
Scheme of an improved chisel-cultivator

Methods and materials. The traction resistance of the improved chisel-cultivator working bodies was determined based on the theory of pona [11, 12].

Research results. The traction resistance of the working bodies of the developed chisel-cultivator can be expressed as follows based on the scheme shown in the picture:

$$R = n_1 R_1 + n_2 R_2 + n_3 R_3 \qquad (1)$$

or

$$R = \left(\frac{B}{2a} + 1\right) R_1 + \frac{B}{2a}(R_2 + R_3), \qquad (2)$$

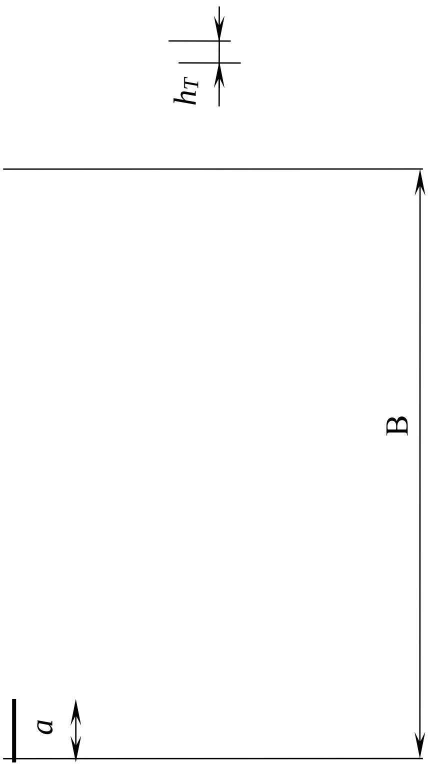
in this R – overall resistance to traction of chisel-cultivator working bodies;

n_1, n_2, n_3 – the number of working bodies located in the first, second and third rows of the chisel-cultivator, respectively;

R_1, R_2, R_3 – respectively, resistance to traction of the working bodies located in the first, second and third rows of the chisel-cultivator;

B – coverage width of the chisel-cultivator;

a– width of traces of working bodies. Placing the chisel-cultivator developed in the work process in the first row gan working bodies,



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, i.e. softening claws, affect solid soil, that is, they work in closed cutting conditions, and working bodies located in the second and third rows affect soil slabs with softened zones on both sides (formed by working bodies located in the first row). Taking these into account, R1, R2, R3 are expressed through the parameters of the working bodies and the physical-mechanical properties of the soil and hT=0.5h (where hT is the vertical distance between the blades of the cylindrical claws located in the second and third rows; h is the processing depth) was accepted and had the following final formula

$$R = \left(\frac{B}{2a}+1\right)\left\{Tt_T^{ю} b_{ю} + k_c \frac{\left[b_{ю} + htg\left(\frac{\pi}{4}-\frac{\varphi_2}{2}\right)\right] h\cos\varphi_2 \sin(\alpha_{ю}+\varphi_1)}{\cos^2\frac{1}{2}(\alpha_{ю}+\varphi_1+\varphi_2)} + \right.$$

$$\left. + b_{ю} h\rho(l_{ю} g + V^2 \sin\alpha_{ю}) tg(\alpha_{ю}+\varphi_1)\left(1+\frac{W}{100}\right)\right\} + \frac{B}{a}\left\{\frac{Tt_T^{y} b_y}{2\sin\gamma_y} + \right.$$

$$+ k_c\left\{a - \left[\sqrt{k_c^2 + 4q_0 k_c a \frac{tg\alpha_y \sin(\alpha_y+\varphi_1)}{\cos\varphi_1 \cos(\gamma_y+\varphi_1)}} - k_c\right]\frac{\cos(\gamma_y+\varphi_1)\cos\varphi_1}{2q_0 tg\alpha_y \sin(\alpha_y+\varphi_1)}\right\} \times$$

$$\times \left[\sqrt{k_c^2 + 4q_0 k_c a \frac{tg\alpha_y \sin(\alpha_y+\varphi_1)}{\cos\varphi_1 \cos(\gamma_y+\varphi_1)}} - k_c\right]\frac{\sin(\alpha_y+\varphi_1)+\cos\gamma_y+\sin\varphi_1}{q_0 \sin\gamma_y tg\alpha_y \sin(\alpha_y+\varphi_1)} \times$$

$$\times \cos^2\varphi_1 + 0{,}5hb_y\rho\left\{l_y g \frac{\sin\alpha_y + tg\varphi_1(\cos\gamma_y ctg\gamma_y + \sin\gamma_y \cos\alpha_y)\sin(\alpha_y+\varphi_1)}{\cos\alpha_y(\cos\alpha_y - \sin\gamma_y \sin\alpha_y tg\varphi_1)} + \right.$$

$$\left.\left. + V^2 \frac{\sin^2\gamma_y\left[\sin\alpha_y + tg\varphi_1 \sin\gamma_y(ctg\gamma_y + \cos\alpha_y)\right]}{ctg\alpha_y - \sin\gamma_y tg\varphi_1}\right\}\left(1+\frac{W}{100}\right)\right\}, \quad (3)$$

where T is the hardness of the soil of the treated layer; $t_T^{ю}$, t_T^{y} – the thickness of the blades of the softening and arrow-shaped claws, respectively; $b_{ю}$ – width of softener pawl; k_c – relative resistance of soil to displacement; φ_1, φ_2 – internal and external soil friction angles; $\alpha_{ю}, \alpha_y$ – the grinding angles of the softener and the arrow-shaped claws, respectively;

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ρ – soil density; $l_ю$ – the length of the softening claw working surface; g – free fall acceleration; V – speed of work; W – soil moisture; γ_y – the angle of installation of the wings of the arrow-shaped claw relative to the direction of movement; b_y – coverage width of softener pawl; q_0 – volume compression coefficient of the soil; l_y – the width of the working surfaces of the arrow-shaped claw wings.

As can be seen from the expression (3), the traction resistance of the improved chisel-cultivator working bodies changes depending on their parameters, the width of their tracks, the physical-mechanical properties of the soil, and the speed of aggregate movement.

a =0,20 м, T=3·10^6 Па, $t_T^ю = t_T^y$ =0,0005 м, k_c =2·10^4 Па, ρ =1200 кг/м^3, $b_ю$ =0,05 м, b_y =0,25 м, h=0,2 м, $l_ю$ =0,14 м, l_y =0,05 м, $\alpha_ю = \alpha_y$ =30º, γ_y φ_1 =30º, φ_1 =30º, φ_2 =40º and W =18 % accepted, the calculations carried out according to the expression (3) showed that the traction resistance of the improved chisel-cultivator working bodies at working speeds of 6-9 km/h is 8.2-8.6 kN corresponding to its coverage width of 1 m.

Conclusion, suggestions and recommendations. On the basis of the conducted research, it is possible to note the following: the traction resistance of the developed chisel-cultivator working bodies depends on their parameters, the width of their traces, the physical and mechanical properties of the soil, and the speed of aggregate movement, at working speeds of 6-9 km/h, each of their chisel-cultivator the tensile strength corresponding to one meter of coverage is 8.2–8.6 kN.

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