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Parameters Of The Innovative Apron Leveling Combined Tillage Machine

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Annotation. Under the existing system of pre-sowing soil cultivation for sowing cotton, there is an unreasonably high number of impacts on the soil, unnecessary consumption of energy and material and technical resources. Repeated passage of machine and tractor units across the field contributes to the overconsolidation of the arable layer, delaying the sowing of agricultural crops, and also leads to the loss of soil moisture and, ultimately, to the loss of cotton yield. Replacement of the existing single operating presowing machine-tools with a combined tillage machine allows, by selecting and varying the operating modes of its rotor, to achieve any quality of soil crumbling in one pass of the unit. However, the combination machine has its drawbacks associated on the one hand with the low productivity, and on the other with the unloading of the soil in front of the leveling apron. These disadvantages of the combination machine can be eliminated by using an innovative design of the rotor cover and equalizer apron. The intensity of the impact of both the forward speed and the specific load on the soil of the leveler apron on the formation of the volume of the drawing prism is significant, and it should be taken into account when optimizing the parameters of the innovative leveler apron. Research has established that within the aisles provided for the initial requirements of the machine speed, the rational value of the working length of the innovative apron-leveler, which excludes the repeated impact of the rotor knives on the already processed soil, is 205–220 mm, and the radius of curvature r from the lower rounded part of the working surface -> 101.5 mm.

Key words: combined machine, rotor, knife, apron-leveler, radius of curvature, length, specific load.

Introduction. The system of presowing soil cultivation for sowing cotton [1] includes performing such technological operations as early spring harrowing, chiseling, presowing leveling, milling, and sometimes disking. Such an unreasonably high number of impacts on the soil leads to unnecessary consumption of energy and material and technical resources [2], and repeated passage of machine-tractor units across the field contributes to the overconsolidation of the arable layer [3-5], delaying the sowing of agricultural crops, and also leads to the loss of soil moisture and, ultimately, to the loss of cotton yields [6].

A review of technical means and technologies for pre-sowing soil cultivation [7-8] showed that the creation of a combined machine replaces a whole set of single-operation pre-sowing machines-tools, and it is the most promising direction in the development of equipment and technology for pre-sowing soil cultivation in the cotton-growing region [9]. Replacing a set of serial one-operating pre-sowing machines-tools with only one combined tillage machine allows, by selecting and varying the operating modes of its rotor, to achieve any quality of soil crumbling in one pass of the unit [10, 11]. However, this combination machine has its drawbacks related on the one hand with low productivity, and on the other with the unloading of the soil in front of the leveling apron, which occurs during operation when it encounters bumps and other irregularities. As a result of such unloading, the rotor re-acts on the soil already processed by the rotor, which leads to its dispersion and unnecessary energy consumption, and this is undesirable.

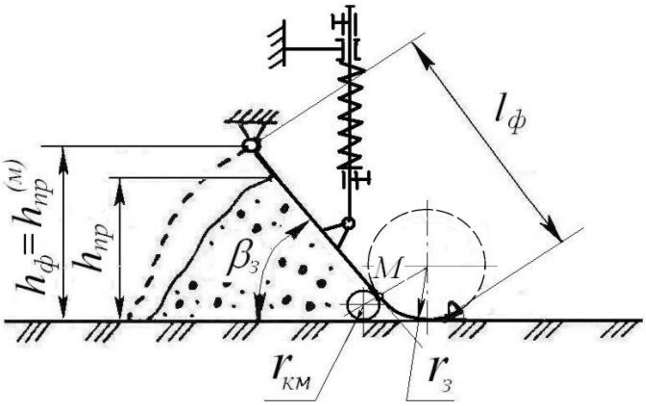
Materials and research methods. A priori analysis and preliminary experiments have shown that the disadvantages of the combined machine associated with soil unloading can be eliminated by using an innovative design of the rotor casing and the leveling apron, made according to the A.S. SU 1771550.

The innovative leveling apron works in conjunction with the rotor casing in the valve mode, which is triggered by the pressure created by the excess than optimal volume of the drag prism formed in front of the leveling apron. Such a design of the leveler apron and the rotor casing allows the excess part of the drag prism formed when unloading the soil in front of the leveler apron to be removed from the rotor blade impact zone [12]. The possibility of repeated exposure of the rotor knives to the already cultivated soil largely depends on the dimensions of the dragging prism formed in front of the leveler apron, which in turn depend on the parameters of the latter.

Research results and their discussion. The drawing prism formed in front of the leveler apron is in dynamic equilibrium during normal operation of the combined machine. When the dynamic equilibrium is disturbed, the volume of the dragging prism increases extensively and the soil is unloaded in front of the leveling apron. As a result, some part of it is repeatedly exposed to the action of the knife rotor, and this, as already mentioned, is undesirable.

Analysis of the results of preliminary experiments showed that the formation process and the heighth_{np}drawing prisms (Fig. 1) have a significant effect on the radius of curvature of the lower rounded part of the working surface, ie. radius of curvature$r_з$, as well as height and overall length$l_{кф}$leveling apron and its specific load $P_{уд}$on the ground.

During the operation of the combined machine, there is a deviation of the leveling apron relative to the hinge from the initial position in one direction or another under the influence of the cultivated soil. The rational values of these deviations should be determined from the condition of pinching large clods and excluding soil unloading. This condition is achieved in the case when, at maximum compression of the soil in front of the lower folded part of the leveler apron, soil lumps are not unloaded, and the volume of the drag prism will be minimal.



Picture 1. Design scheme for determining the length of the aligner apron and the radius of curvature

During operation of the combination machine, a soil roller with a height of$h_{пр}$. It is partially pushed down and partially moved in the direction of travel of the leveling apron. The volume of the part that is pressed down depends mainly on the radius of curvature $r_з$the lower part of the working surface of the leveling apron, the rational value of which is determined, as already mentioned, from the condition of ensuring that soil particles slide downward during the jamming of lumps, i.e.

$\beta_з < \varphi_c + \varphi_n$, (1)

where $\beta_з$ – lump clamping angle, degree;

φ_c , φ_n – respectively, the coefficients of friction of the soil against steel and against the soil.

From fig. 1 it can be seen that at the point of contact "M" the ordinate of the apron-equalizer$Z_ф$and a lump$Z_{км}$is equal to each other:

$Z_м = Z_ф = Z_{км}$ (2)

or

$r_з (1 - \cos\beta_з) = r_{км} (1 + \cos\beta_з)$, (3) where$Z_м$ – ordinate of the point (M) of contact of the soil lump with the leveling apron, m;

$r_{км}$ – lump radius, m

Satisfaction of condition (1) for the critical case corresponding to the pinching of the soil lump by the leveling apron occurs when

$$r_з \geq \frac{r_{км}[1+\cos(\varphi_c+\varphi_n)]}{1-\cos(\varphi_c+\varphi_n)}. \quad (4)$$

Analysis of equations (4) shows that to ensure the sizes of soil lumps (<100 mm) admissible by agrotechnical requirements, the value of the radius of curvature $r_з$must be at least 101.5 mm.

Rational working lengths$l_ф$and heights $h_ф$the leveling apron is determined from the dimensions of the drawing prism, which is in dynamic equilibrium. When an excessive portion of soil comes in during the meeting of the rotor with bumps or other obstacles, in order to prevent unloading of the soil and the repeated impact of the rotor on the already worked soil, the excess part of the cultivated soil volume must be removed from the zone of influence of the rotor. This can only happen when the excess part of the volume of the drawing prism is poured over the upper edge of the aligner apron, i.e. provided$h_ф \leq h_{пр}^{(м)}$, (5)

where$h_{пр}^{(м)}$ – the maximum value of the height of the drawing prism, which is in dynamic equilibrium, m.

According to fig. 1, this condition is satisfied in the case when $l_ф = \dfrac{h_{пр}^{(м)}}{\sin\alpha_н}$,

(6)

where $\alpha_н$ – the maximum permissible angle of inclination of the leveling apron relative to the horizon, degrees.

It has been experimentally established that when the height of the drawing prism is more than 200 mm, due to the ingress of some part of the drawing prism onto the rotor, the rotor blades re-act on the soil and the soil is thrown forward in the direction of the machine. Therefore, in order to eliminate repeated impact and soil rejection, it is necessary either to reduce the height of the drag prism, or to increase the distance between the rotor and the leveling apron. however, in the latter case, the overall dimensions increase, hence the weight of the machine, which is undesirable.

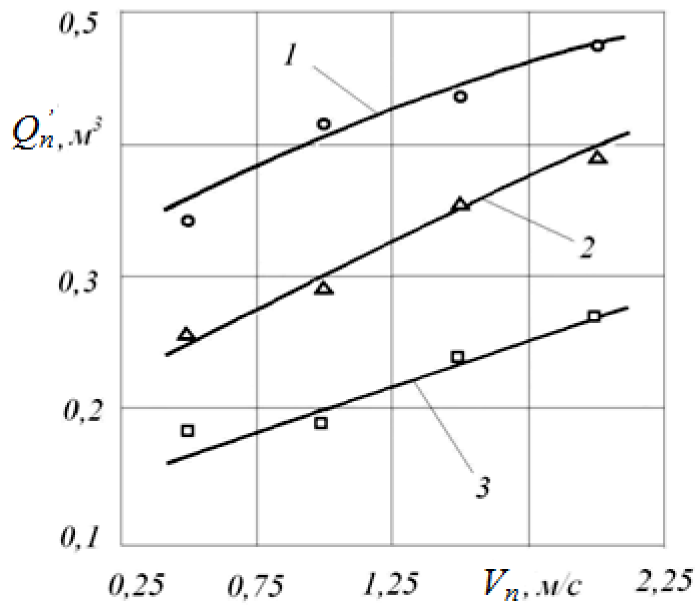
Thus, the rational value of the working length of the apron-leveler, ensuring the uninterrupted flow of the technological process of the combined machine, is 205–220 mm, and the value of the radius of curvature$r_з$ ensuring the pinching of the soil lump by the leveling apron must be at least 101.5 mm.

Based on the justified parameters of the apron-leveler at the experimental plant BMKB "Agromash", a prototype of a combined machine equipped with an apron-leveler, working together with the rotor casing in the valve mode (Fig. 2), was made and laboratory-field experiments were carried out with it. ... In laboratory-field experiments, the influence of the translational speed of the prototype of the combined machine and the load on the apron-leveler on the volume of the dragging prism of the soil unloaded in front of the apron-leveler was studied.

Picutere 2. Combined machine equipped with an innovative leveling apron

Experiments have shown that an increase in both the specific load on the soil of the leveling apron $P_{уд}$, and its translational speed is accompanied by an increase in the volume of the drawing prism (Fig. 3). Moreover, the intensity of the impact on the volume of the prism of drawing of the translational speed is uniform, while the specific load of the apron-leveler acts on it with different intensity.

So, for example, at a fixed specific load, an increase in$V_п$from 0,5 to 2,0 m / s led to an increase in the volume of the drawing prism by an average of 0,1 m^3. Meanwhile, at a fixed translational speed $V_п$ = 2,0 m / s, an increase in the specific load from 250 to 500 N / m led to an increase in the volume of the drawing prism by more than 0.2 m^3.



Rice. 3. Influence of the translational speed of movement on the specific volume of the drawing prism $Q_п'$ **for** $P_{уд}$ **equal:** 500 (1); 375 (2); 250 Н/м (3)

But despite the above differences, the intensity of the impact of the influence as $V_п$, so and $P_{уд}$ to increase the volume of the drawing prism is significant and they should be taken into account when optimizing the parameters of the aligner apron

Results.

The results of the study have established that the intensity of the impact of both the forward speed and the specific load of the apron-leveler on the soil on the increase in the volume of the drawing prism is significant, and it should be taken into account when optimizing the parameters of the apron-leveler. The rational value of the working length of the leveler apron, which ensures the flow of the technological process of the combined machine without unloading, is 205–220 mm, and the radius of curvature $r_з$ from the lower rounded part of the working surface is> 101.5 mm.

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