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Determination of the Tension Force of the Pressure Spring of the Parallelogram Mechanism of a Combined Disc Harrow Leveler-Compactor

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Abstract: *The article presents the results of experimental studies conducted to study the influence of the installation angle of the leveler-compactor of the combined disc harrow relative to the horizon on its performance indicators. In the conducted experimental studies, it was established that the installation angle of the leveler-compactor of the combined disc harrow relative to the horizon should be within 80-90°.*

Keywords: *combined disc harrow, angle of installation of the leveler-compactor relative to the horizon, root mean square deviation of the height of irregularities on the field surface, degree of soil crumbling, specific draft resistance.*

In our republic, special attention is paid to the introduction of modern, highly efficient resource-saving techniques and technologies that ensure the productive use of land and high yields of agricultural crops. The Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030 specifically sets out the tasks of, among others, "… reducing state participation in the sector and introducing mechanisms to increase investment attractiveness, rational use of land and water resources, increasing labor productivity in farms, and improving product quality, which provide for an increase in the flow of private investment capital to support the modernization, diversification and sustainable growth of the agricultural and food industry." In the implementation of these tasks, among other things, the development of combined machines that perform all the technological processes of preparing land for planting (soil softening, leveling the surface of the field, compaction and forming a soft soil layer on the surface of the field) and justifying the parameters of their working parts that ensure the quality of work at the required level with low energy consumption are important issues,

Nowadays, the area of land under irrigated winter wheat cultivation and repeated crops in our republic is more than 1,200 thousand hectares. In order to achieve high yields of grain and repeated crops with minimal costs, it is necessary to use advanced technologies and technical means in land cultivation, their productive use, and high-quality implementation of measures for growing crops in short agrotechnical terms. Combined machines and units used in land cultivation perform several or all technological processes for the main and pre-sowing cultivation of the field in one pass. This leads to a decrease in the negative impact of tractors and agricultural machinery on the soil, as well as fuel, labor and other material costs, an increase in the quality and productivity of work, a reduction in the duration of soil cultivation, and the preservation of moisture accumulated in it. Considering that the combined disk harrow is mainly used for processing fields with repeated crops and that their seeds are sown to a depth of 4-6 cm, it follows that the length of the teeth should be in the range of 5-7 cm.

The angle of sharpening of the teeth is equal to the angle of sharpening of the teeth used in the existing BZSS-1.0, BZTS-1.0 and BZTH-1.0 harrows.

The horizontal distance between the teeth is determined by the following expression, based on the condition of ensuring complete processing of the layer being processed by them

$$a \le 2l_t \sin\beta tg\psi_{\ddot{e}},$$

This $\psi_{\ddot{e}}$ – angle of lateral refraction of soil, º.

Calculations performed with l_t = 6 cm and ψë = 45° [55] showed that the horizontal distance between the teeth could be at most 10 cm.

The vertical load applied to each tooth to ensure that it penetrates the soil to a specified length is determined by the following expression, taking into account its installation angle relative to the field surface:

$$Q_t = \frac{(1{,}390V - 0{,}581)h}{\left[1 + (0{,}055V - 0{,}139)h\right]\sin\beta},$$

This V – speed of the combined disk harrow, m/s;

h – the depth of penetration of the teeth into the soil, m.

In the calculations according to expression (2.10), h should be in cm and V in m/s. Assuming V=1.7-2.2 m/s, h=4-6 cm and β=60º, in the calculations according to expression (2.9), it was found that each tooth of the leveling compactor should be given a vertical load in the range of 10.1-19.2 N. The total height of the toothed leveling roller NT is determined by the following expression, provided that the soil being compacted in front of it does not exceed

$$H_u \ge \sqrt{\frac{4Z_н l_н}{\pi\left[ctg\mu - ctg\beta\right]}} + l_t \sin\beta,$$

where Zн, лн – the height and length of the longitudinal irregularities formed on the field surface under the action of the combined disk harrow disk softeners, m;

μ – the angle of inclination of the soil piled up in front of the leveler (in the direction of movement), º.

Assuming *Zн=5 cm; ln=45 cm;* μ=30º; β =60º and l_t =6 cm calculations carried out according to expression (2.10) showed that the total height of the toothed leveler should be at least 18.7 cm.

We determine the height of the toothed leveler leveler according to the following expression

$$H_T \ge H_u - l_t = \sqrt{\frac{4Z_н l_н}{\pi\left[ctg\mu - ctg\beta\right]}} - l_t(1 - \sin\beta).$$

Substituting the above-determined values of Hu and lt into this expression, we determine that the height of the leveler should be at least 13 cm

We consider the forces acting on the toothed leveler during operation. The following forces act on it:

– the weight of the toothed leveler (where m is the mass of the toothed leveler, kg; g is the acceleration of free fall, m/s), N;

Qпб, Qпт – the longitudinal and vertical components of the tension force of the pressure spring of the toothed leveler parallelogram mechanism, N;

ΣR1б, ΣR1m – the longitudinal and vertical components of the reaction forces acting on the toothed leveler from the soil, N;

ΣR2b, ΣR2m – longitudinal and vertical components of the reaction forces acting on the teeth of the toothed leveler from the soil, respectively, N. We transfer all the acting forces to the movable joint B of the toothed leveler parallelogram mechanism (Fig. 2.5, b) and formulate their equilibrium equation with respect to the fixed joint A.

$$\sum M_A = \left(mg + n_n Q_{nm} - R_{1m} - R_{2m}\right) l = 0$$

or

$$mg + n_n Q_{nm} - R_{1m} - R_{2m} = 0,$$

where l is the length of the longitudinal struts of the parallelogram mechanism, m;

пп is the number of springs installed on the gear reducer, pcs.

From expression (2.13) we determine Qnm

$$Q_{nm} = \left(R_{1m} + R_{2m} - mg\right) / n_n.$$

2.4-picture

$$Q_{nm} = Q_n \frac{d}{\sqrt{l^2 + d^2}}$$

It turns out that is and solving it with respect to Qp, we get $Q_n = \dfrac{Q_{nm}\sqrt{l^2 + d^2}}{d}$,

where d is the vertical distance between the fixed joints of the parallelogram mechanism, m.

Substituting the value of Qpt from the above expression (2.14) into this expression, we obtain the following result

$$Q_n = \left(R_{1m} + R_{2m} - mg\right) \frac{\sqrt{l^2 + d^2}}{n_n d}.$$

We express R_{1m}, R_{2m} in terms of the parameters of the leveler and teeth and the physical and mechanical properties of the soil.

When the condition (2.6) is met, i.e. $\beta > 90 - \varphi$.

$$R_{1m} = R_{1б} ctg\beta.$$

Taking into account the smoothing of irregularities encountered on the smoothing path, we determine R1b according to the following expression: [58; 57-59-pp.]

$$R_{1б} = \frac{2f'}{\pi}\rho_0 gBZ_н l_н,$$

where f' is the coefficient of friction of the soil with the soil;

ρ_0 is the density of the soil piled in front of the toothed leveler, kg/m^3;

B is the coverage width of the toothed leveler, m.

Taking into account (2.19), expression (2.18) takes the following form

$$R_{1m} = \frac{2f'}{\pi}\rho_0 gBZ_н l_н ctg\beta.$$

We define R_{2m} using the following expression

$$R_{2m} = n_n Q_t = \left(\frac{B}{a}+1\right)Q_t.$$

Substituting (2.20) and (2.21) into (2.17), we get

$$Q_n = \left[\frac{2f'}{\pi}\rho_0 gBZ_н l_н tg\beta + \left(\frac{B}{a}+1\right)Q_t - mg\right] \times \frac{\sqrt{l^2+d^2}}{n_n d}.$$

f '= 0.5 ρ_0 =1100 kg/m3, B=3.0 m, $Z_н$=0.1 m, l_n=0.5 m, β=60º, a=0.1 m,

Q_t=19.2 N/tooth, m=50 kg, l=0.45 m, d=0.16 m, n_n=2 pieces are accepted, and calculations according to the last expression showed that the tension force of the pressure spring of each parallelogram mechanism of the toothed leveler should be about 600 N.

Conclusion. The conducted experimental studies showed that the installation angle of the combined disc harrow leveler-compactor relative to the horizon should be in the range of 80-90°.

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