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LAYER TILLAGE COMBINED WORK MEMBER'S TRACTION RESISTANCE

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Abstract

In this paper the traction resistance of the layer tillage unit's combined work member has been determined as that of a single whole of the frame, bore-chisel, and plane-cutting blade. The analytically obtained results have been quite well grounded by laboratory experiment. Based on this analysis, ways for lessening the work member's traction resistance have been designed.

Key words: wedge, bore-chisel, frame, plane-cutting blade, operating depth, traction resistance.

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Introduction

The land is cultivated to increase its fertility and create favorable conditions for the development of cultural plants. Tillage also plays an important role in controlling weeds, decay, pests and plant diseases.

Adaptation of agrotechnologies to the soil and climatic conditions of crop production includes a large number of tillage options and, accordingly, tools for their implementation. The latters are of wedge-type, which according to their working surface geometry are divided into flat and curved ones. Wedges are also symmetrical (arrow-shaped blades), asymmetrical (plough share body) and so on.

The layered soil cultivation technology, unlike others, is designed for layered loosening of the soil, on top of which further cultivation and sowing are carried out. This technology is usually applied once a year during fall or spring mulching. It is necessary to sow in the cultivated layers in spring with precise sowing machines [1,2].

Currently, layer tillage technology is widely used in advanced agricultural economies such as USA, Canada, Argentine, Germany, and many other countries [1,2,3].

The layered soil cultivation technology is most effectively applied in mountainous agriculture, where in order to ensure the water resistance of the loosened layer and to prevent soil erosion, combined layer tillage units are used, equipped with appropriate operating organs.

Conflict Setting

The study of bottom deposit clay separated during the production of table salt from

In order to perform an effective layer tillage and cultivation of the soil, it is suggested a combined working unit composed of frame (1), equipped with a chisel (2) and a plane-cutting blade (3) (Fig. 1) The suggested unit can solve various technological problems due to its structural features. The chisel is located in the lower part of the framework and is designed for opening a deep crack in the soil, and the plane-cutting blade is fixed in the middle part of the framework, and serves for widespread surface tillage and cultivation of the soil.

Applying well known scientific methods, as well as taking into account the structural and operational features of the proposed cutting unit, the traction resistance of the combined working unit is determined as the sum of the traction resistances of the framework, the chisel, and the plane-cutting blade.

Research Results

A. The traction resistance of the chisel.

Consider the chisel as a simple two-edged wedge, the flat surface of which serves as a working surface, and the lower one serves as a support. The driving force can be applied to the wedge at an arbitrary angle [3,4,5,6], at both front and rear of the wedge at that. The point of application of the force is important only for the strength calculation, and the movement is determined only by the sum of the directions and magnitudes of the forces.

Obviously, from the point of view of traction resistance, it is sufficient to consider only the horizontal component in the direction of movement. The vertical component affects the vertical displacement of the wedge (in our case, the chisel).

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The chisel affects the soil under cultivation in different ways, but the essence of its work is that it does not cut with a blade (as is usually accepted), but first, compresses the soil particles and slightly displaces them, and then opens a crack in the horizontal direction [6,7,8].

V.P. Goryachkin offers the following formula for determining the resistance of a flat wedge

$$P = \frac{Nsin(\alpha+\varphi)}{cos\varphi}, \quad (1)$$

where N is the normal resistance on the working surface of the wedge (chisel), $\boldsymbol{\alpha}$ is the angle of the wedge location, φ is the friction angle.

In the case of soil-cultivating machines, the determination of normal resistance is quite complicated, so for determination of the traction resistance of the chisel, let's use the simpler expression widely accepted in practice [6, 9, 10]

$$R_1 = qV, \quad (2)$$

where q is the factor volumetric rubbing of the soil, V is the volume of rubbed soil,

$$V = \frac{b_{m.ch} h^2 tg\alpha_{m.ch}}{2}, \quad (3)$$

where $b_{m.ch}$ is the width of the chisel, $\boldsymbol{h}$ is the path traveled by the chisel during soil compaction, $\alpha_{m.ch}$ is the location angle of the chisel.

Therefore: $R_1 = 0{,}5 q b_{m.ch} h^2 tg\alpha_{m.ch}$: (4)

Let's decompose the force R_1 into two components (Fig. 1).

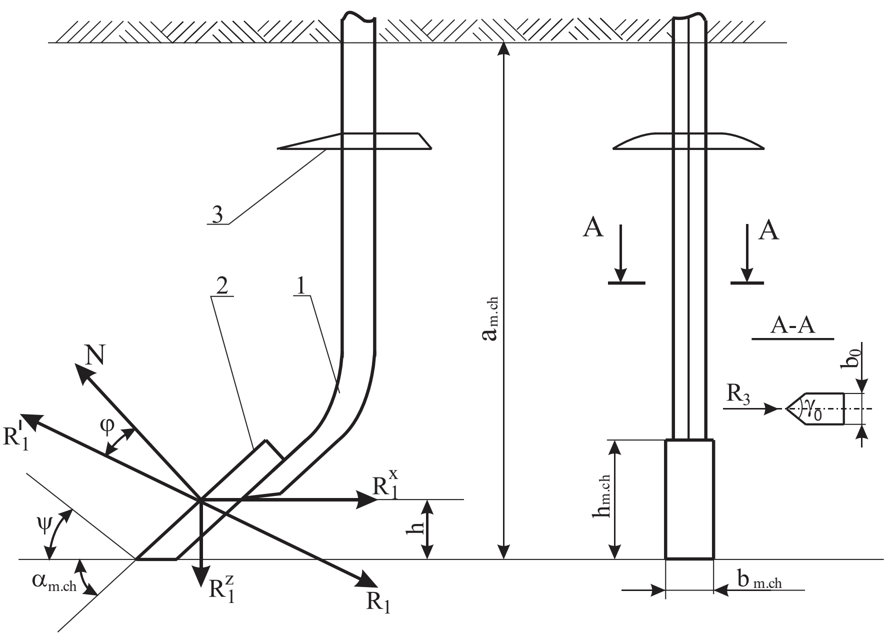

Fig. 1 Calculation scheme for determining the layer tillage chisel's traction resistance

horizontal: $$R_1^x = 0{,}5qb_{m.ch}h^2tg\alpha_{m.ch}\frac{\sin(\alpha_{m.ch}+\varphi)}{cos\varphi} \quad (5)$$

vertical: $$R_1^z = 0{,}5qb_{m.ch}h^2tg\alpha_{m.ch}\frac{\cos(\alpha_{m.ch}+\varphi)}{cos\varphi} \quad (6)$$

The following formula is recommended for determining h [6,10,11]

$$h = \sqrt{\frac{a_{m.ch}\,cos\varphi}{gtg\alpha_{m.ch}sin2\psi\cos(\alpha_{m.ch}+\psi)[ctg\psi - tg(\alpha_{m.ch}+\psi)}}\ , \quad (7)$$

where $a_{m.ch}$ is the depth of the chisel run (m).

In order to solve the problem, it is also necessary to know the angle ψ of inclination of the crack formed in the soil pressed by the chisel.

For this, the following expression is proposed [7,8,11].

$$\psi = arcsin\left(0{,}5 \pm 0{,}5\sqrt{\frac{1}{1+\left(\frac{a_1}{b_1}\right)^2}}\right)^{\frac{1}{2}}, \quad (8)$$

where a_1 and b_1 are coefficients characterizing the parameters of the chisel

$$a_1 = 2\mu - sin^2\alpha_{m.ch}(1 - 0{,}5tg\varphi), \quad (9)$$

$$b_1 = sin^2\alpha_{m.ch}(0{,}5 - tg\varphi), \quad (10)$$

where μ is the relative limit deformation of the soil

$$\mu = 1 - \frac{e^{\alpha tg\varphi}cos(\alpha_{m.ch}+\varphi)}{cos\varphi}\ . \quad (11)$$

From our justification of the parameters of the working organ of layer tillage, we have: the width of the chisel $b_{m.ch}$=0.02m, chisel mounting angle $\alpha_{m.ch}$ = 34^0, the maximum depth of the chisel run $\alpha_{m.ch}$= 0.45 m.

Let us take the friction angle $\boldsymbol{\varphi}$ = 35^0, based on the results of scientific experiments of various researchers [9,10,11].

Bearing in mind that the working organ of the layer tillage is intended for use in ploughed land, let's choose the volumetric rubbing coefficient determined for these soils of this type, from the range of values in the range of 500-1000 kg/m^3. Let's take q=750 kg/m^3. Using Eqs.1 to 10 and making appropriate calculations, we get: μ = 1, a_1=1.59, b_1 = - 0.15, ψ = 46^o, h = 0.05 m, and the chisel traction resistance will be R_1= 3.84 kN.

To find ways for lessening the chisel traction resistance let's make some analyses.

Traction resistance depends on a number of factors, considering soil and climatic factors out of the scope of discussion, let's study the structural parameters of the working organ. Taking into account that the main geometrical parameters were obtained by theoretical justifications and adjusted by scientific and experimental studies, let's study the influence of the chisel mounting angle $\alpha_{m.ch}$ on the traction resistance. An optimal value for that parameter was found 34°. However, this was done in the context of the general requirements to the fluffers, that is, along with deep chiselling, loosening must also be done. There is almost no loosening function on the chisel of the layer processing organ, surface tillage is carried out with plane- cutting blade. In addition to this, the loosening along the chisel movement is also favored by the frame of the layer processing organ. With these considerations, an analysis was made to find out the effect of chisel location angle change on the traction resistance of the chisel (Fig. 2).

It can be seen from the graph that decreasing the location angle of the chisel will decrease the R_1^x component, which determines the traction resistance, and the R_2^z component will increase. Taking into account the main requirement for the chisel of the working organ of the layer tillage which is to open cracks for the infiltration of surface water.

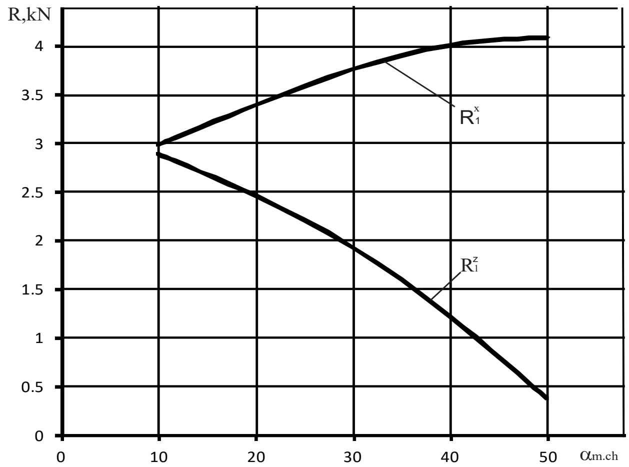

Fig. 2 The effect of the chisel location angle change on the traction resistance

We can affirm that in this case we can deviate from the range of values assigned to the parameters of the looseners and reduce the traction resistance by reducing the mounting angle of the chisel. In particular, by reducing the angle $\alpha_{m.ch}$ from the specified 34^0 to the minimum allowable value of 9^0 (that is, make it almost a flat cutter), then the traction resistance of the chisel will decrease by about 1kN or 26%.

B. The traction resistance of the flat cutter.

Let's also consider the plane-cutting blade of as a simple two-edge wedge. The simple components of the soil resistance force on the working surface of the plane-cutting blade are affected by the force R_2^{xz}, which is located on the longitudinal axis of symmetry (Fig. 3).

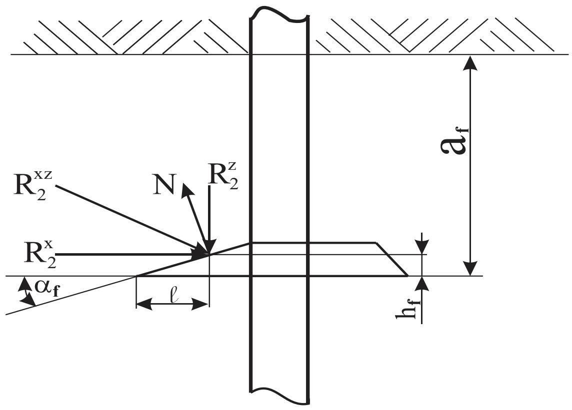

Fig. 3 Calculation scheme of the traction resistance of the plane-cutting blade of the working organ of the layer tillage unit

R_2^{xz} projection of force R_2^z characterizes the deepening ability of the flat cutter, and R_2^x projection characterizes the traction resistance. The direction of the resultant force is determined by the ψ angle of crack propagation, the point of application is determined by the dimensions h_f and ℓ.

For flat cutters, $h_f = 0{,}2a_f$ [3,7], where a_f is the depth of soil cultivation with a flat cutter, we accept up to 10 cm. Therefore h_f= 2 cm.

In order to keep the soil layer above the flat cutting blade intact as much as possible during the determination of the parameters of the layer processing unit, we have chosen the minimum value of the angle α_f of the blade crushing: $\alpha_f = 9^0$.

Therefore $\ell = \frac{h_f}{tg\alpha_f} = 12{,}6$cm.

The resultant R_2^{xz} is proportional to the normal pressure and the friction forces of the soil with the working surface, and the direction depends on the loosening angle α_f and the friction angle φ.

From Fig.3 we have the following calculation scheme $\psi = \frac{\pi}{2} - (\alpha_f + \varphi)$. The friction angle φ depends on the condition of the soil and varies widely (from 14 to 35°).

While grounding the parameters of the working organ of layer processing, in order to make it compatible, we stopped at the limit values of the parameters, including the friction angle φ =35°. Therefore, $\psi = \frac{\pi}{2} - (9 + 35) = 46°$.

R_2^x component of the force R_2^{xz} acting on the planer blade is determined by the formula of which $R_2^x = k\alpha_f\ b_f$, where k is the specific resistance of the soil, of which the range of values is k=15-50 kN/m^2, α_f is the planer blade depth of cultivation, b_f - coverage width b_f= 36 cm.

Let's assume the optimal absolute moisture of the soil is 22% and the specific resistance of the corresponding soil is 30 kN/m^2.

The refore we get $R_2^x = 1.08$ kN.

In practical calculations, the traction resistance for stony soils is assumed to be: $P = (3-5)R_2^x$, in the case of ordinary cultivated soils, where hardened or superhardened traces, clods, etc. can be encountered, which negatively affect the traction resistance $P = 2R_2^x$ is accepted.

C. Traction resistance of the framework

Let's consider the framework of the working organ as a two-edge wedge arranged in a vertical longitudinal plane, which has two symmetrical working surfaces. To calculate the resistance of the framework, the following expression was used [4,5,11]

$$R_3 = \frac{a_r b_0}{sin\beta}\left(\rho_1 + \rho_1 f ctg\frac{\alpha}{2} + \rho_2 f\frac{2d_0}{b_0} - \frac{\rho_2 f}{tg\frac{\gamma_0}{2}}\right), \tag{12}$$

where a_r is the actual depth of the framework, b_0 is the thickness of the framework, β is the angle of inclination of the framework with respect to the bottom of the furrow, ρ_1 and ρ_2 are the specific pressure of the soil on the resistance part and side surface of the framework, respectively, d_0 is the width of the framework, f is the coefficient of friction between the soil and the steel, α is the angle of inclination of the pointed part of the framework, γ_0 is the angle of the wedge expansion.

The actual depth of the framework run is

$$a_r = a_{m..ch} - h_{m.ch} - h_f , \tag{13}$$

where $a_{m..ch}$ is the actual maximum depth of the chisel - $a_{m..ch} = 0.45$m, $h_{m.ch}$ is the height of the chisel

$$h_{m.ch} = \ell_{m.ch} \cdot \sin\alpha_{m.ch}, \tag{14}$$

where $\ell_{m.ch}$ is the length of the chisel, h_f is the thickness of the flat cutter. Therefore, you will get

$$a_r = 30 \text{ cm}.$$

From the justification of the parameters, we have: b_0 = 0.02 մ, β = 90°, ρ_1 =70 kN/m², ρ_2= 5 kN/m², d_0= $3b_0$=0.06 m f = 0,4, γ_0=68 °: , α=$\alpha_{m.ch}$=34°

After the appropriate calculations, we get R_3=0,46 kN.

To lessen the traction resistance of the chisel, its location angle should be reduced from 34^0 to 9^0 and framework operating height will increase by about 7cm and traction resistance 0,09kN at that.

Thus, based on findings obtained by the theoretical study, the general traction resistance of the layer tillage working unit will be

R= $R_1^x + R_2^x + R_3^x$ = 3.84 + 1.08 + 0.46 = 5,38 kN when $\alpha_{m.ch}$= 34°

R= 2.84 + 1.08 + 0.55 = 4,47 kN when $\alpha_{m.ch}$= 9°

To estimate engineering and operating parameters of the proposed working organ effectively applicable in the layer tillage process, Natioal Agrarian University of Armenia carried out laborator experiments with the result that the traction resistance was 5.06 kN (when $\alpha_{m.ch}$=34°). The deviation from the theoretically obtained value is about 6% (Fig. 4).

Fig. 4 An episode from the laboratory tests of a layered processing worker's organ

Conclusion

1. The traction resistance of the layered processing tool, as determined by theoretical research, is 5.38 kN, of which 3.84 kN is for the chisel, 1.08 kN is for the flat cutter, and 0.46 kN is for the stand. The outcomes of laboratory tests support the aforementioned information. The deviation is less than 6%.
2. The analysis of the traction resistance of the layer processing working member revealed that the most practical method of reduction is thought to be the reduction of the chisel's location angle.

   We can assert that, in the case of the working member of the layered cultivation, we can deviate and reduce the angle of the chisel bit to reduce the drag resistance because the chisel of the working organ of layered cultivation needs to open a crack in the soil layer for the removal of surface water. Additionally, in that scenario, the chiseling rig's angle is maintained according to the main technological requirement $\alpha_{m.ch}$ < 90 - φ.

   Our recommendation is to move the chisel's location angle from the set 34^0 to 9^0, or almost flat, which will reduce the chisel's traction resistance by 1.0 kN or 26%. It's true that in that situation, the stand's working height will rise by about 7 cm to about 37 cm, increasing its traction resistance by 0.09 kN as a result. This means that by lowering the chisel's location angle to 9^0, the working organ's overall drag resistance will actually decrease by 0.91 kN, or 16.9%.

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ՀՈՂԻ ՇԵՐՏԱՎՈՐ ՄՇԱԿՄԱՆ ԿՈՄԲԻՆԱՑՎԱԾ ԲԱՆՈՂ ՕՐԳԱՆԻ ՔԱՐՇԱՅԻՆ ԴԻՄԱԴՐՈՒԹՅՈՒՆԸ

Տոնապետյան Պ.Ա.[1,2], Գասպարյան Պ.Յու.[2], Տոնապետյան Ա.Պ.[1], Նիկողոսյան Հ.Հ.[2]
[1] Հայաստանի ազգային ագրարային համալսարան
[2] Շուշիի տեխնոլոգիական համալսարան

Որոշվել է հողի շերտավոր մշակման ագրեգատի կոմբինացված բանող օրգանի քարշային դիմադրությունը, որպես երեք տարրերի՝ կանգնակի, հորատադուրի և հարթահատ թաթիկի ամբողջություն:

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Քարշային դիմադրության տեսականորեն ստացված արդյունքները հիմնավորվել են լաբորատոր փորձերով, կատարվել է համապատասխան վերլուծություն, որի հիման վրա նախանշվել են բանող օրգանի քարշային դիմադրության նվազեցման ուղիները:

Բանալի բառեր. սեպ, հորատադուր, կանգնակ, հարթահատ թաթիկ, ընթացքի խորություն, քարշային դիմադրություն:

ТЯГОВОЕ СОПРОТИВЛЕНИЯ КОМБИНИРОВАННОГО РАБОЧЕГО ОРГАНА ПОСЛОЙНОЙ ОБРАБОТКИ ПОЧВЫ

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Определена сопротивление тяги комбинированного рабочего органа агрегата слоистой обтаботки почвы как целостность трех элементов: стойки, долота и плоскорезной лапы.

Теоретические результаты сопротивления тяги были обоснованы лабороторными экспериментами, проводилось соотвествуюший анализ на основе чего предначертаны способы снижения тягового сопративления рабочего органа.

Ключевые слова: клин, долото, стойка, плоскорезная лапа, глубина хода, тяговое сопротивление.

- Հետազոտությունն իրականացվել է ՀՀ գիտության կոմիտեի ֆինանսական աջակցությամբ՝ 21T - 4B008 ծածկագրով գիտական թեմայի շրջանակներում:

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