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MODELING OF THE WORKING SURFACE FORM OF THE TOPSOIL LOOSENER

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Abstract. There are shown the results of research in designing a new model of the disk tooth of the tillage tool and formulas to determine the work of crushing of the chunk of soil depending on its condition and degree of the crushing. Modeling of the working units of the tillage tools requires the shape of working surface with its complex movement in space to perform predefined effects on soil.

Keywords : presowing tillage, tillage disk ,baking, working surface, forms, the diameter of lumps, energy costs, field germination of seeds.

The problem

In agriculture loosening of the surface soil layer is made at its spring presowing tillage after the primary tillage-autumn plowing of the previous year. Agro requirements for the implementation of this key technological operation are high, because the quality of its performance has a great impact on the field germination of seeds: the level of the field germination, simultaneity / friendliness / of the rise of seeds etc. In particular, during the sowing of sugar beet / the culture , which is the most meticulous to the farming cultivation / presowing cultivation should be done immediately before the seeding, and tillage tools must provide secondary tiling depth of 3–5 cm with deviation ± 1,0 cm with the number of lumps 50 mm in diameter not less than 92 %. Abidance of the depth tillage equability promotes the formation of rigid seedbed and shallowness of the lumps factions of the treated chunk surface layer provides qualitative seed involution that leads to increased seed germination and simultaneity of germination. Obviously, the implementation of such a process is associated with increased energy costs, especially when running on hard or waterlogged soils.

Analysis of the recent research:

surfaces of the working bodies (WB) of the famous rotary tool for loosening of the surface soil of both domestic and Western European production (firms LEMKEN, ROPA – Germany; WADERSTAG – Switzerland, etc.), implemented in the form of pointed teeth of the needle or chisel-shaped type, attached on hubs, which are mounted in battery discs. Passive paws for loosening the soil of the cultivators of different brands (USMK. - 5.4 B KOZR - 8.1 etc.) still remain widespread.

The main part

Modeling of the working units of the tillage tools requires the shape of working surface with its complex movement in space to perform predefined effects on soil.

It is known that mechanical tilling of soil is conducted for improving its structure, loosening or condensation, dampness accumulation, to fight with weeds and crop pests, convolve plant residues, fertilization and so on. That's why such manufacturing operations as cutting, loosening, condensation, moving, mixing and so on are

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performed for this kind of soil tilling under the working surface of tillage machines and tools.

In its turn soil as an object of tilling is characterized by physical and mechanical properties which determine working conditions of tillage machines and have significant impact on their performance

It's necessary to take into account the fact that the extent and magnitude of soil deformation depends not only on the type of working units, but also on the physical and mechanical properties of the environment.

In its turn deformation of different soils under the influence of the same working unit will differ.

Further research of the process of soil surface loosening and review of existing national and West-European machines, which are designed for this, led to the conclusion that it is useful to develop models of working surfaces with sufficiently small square in relation to depth, namely notched disks because their penetration into the soil has the nature of the hitting process, for the creation of a stress-strain state of the soil, which economizes the energy

For example, during the studies of the working units of notched type it was found that the energy expenses in the destruction of soil by this working unit depend not only on the form of its surface, but also on physical and mechanical properties of the soil, its primary aggregative state and the degree of destruction to preset factious condition.

Along with this, previous studies have shown that for the creation of a stress-strain state of the soil, which saves energy, it is advisable to develop schemes of deformators with sufficiently small area in relation to depth of the tillage, namely tooth-frequent tools because their penetration into the soil has the nature of the shock process .

The cross section of the teeth can be square (Fig. 2a), round (Fig. 2b), ellipsoidal (Fig. 2c). During the working process tooth with the square section moves edge or oblique cut in the direction of motion, rectangular teeth are placed with the narrow or wide face in the direction of motion, and ellipsoidal – with the rounded side.

While moving WB teeth work as a wedge dihedral: they cut into the soil with the leading edge, and its lateral edges push soil to the sides and stir it.

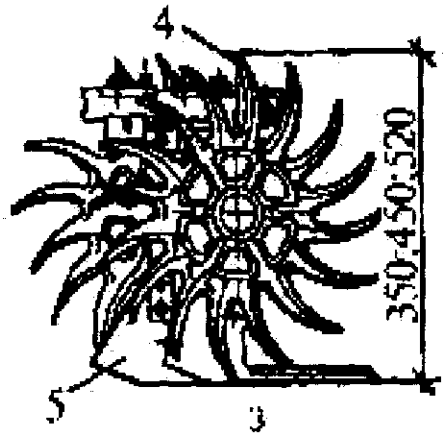

Fig. 1. The tillage disk

Modeling of the working surfaces of the given tillage tools provide communion for their forms – the similarity to the wedge, which is formed by two, three or more faces (e.g. – pyramid), or a curved surface obtained by generatrix motion (e.g. – oval) shape variable along the guide (e.g. – cycloid) or combining edge and curved surfaces.

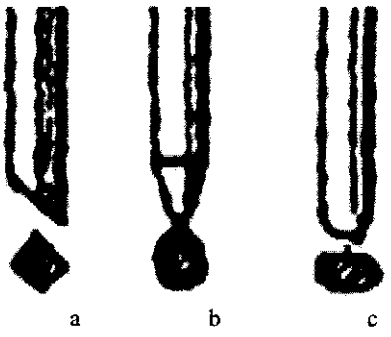

Fig. 2. Existing forms of cross-sectional needle-like teeth of the tillage tool

Based on the foregoing, a new WB of the tillage tool (a disk) was developed , which characteristic feature is that the cross-section of each of the edges of the disc is made as an equilateral trapezoid EFKH, and quartered – as a right triangle ABC (Fig. 3).

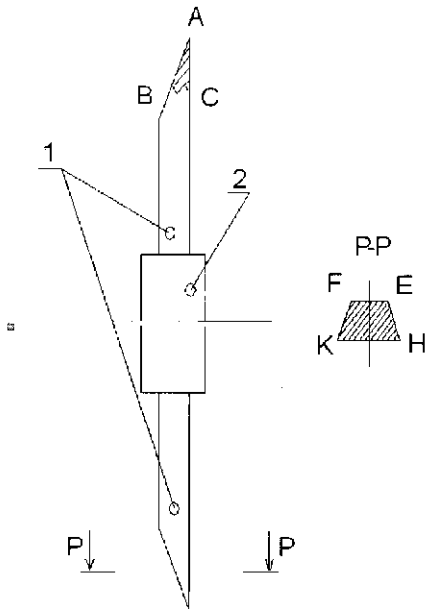

Fig. 3. Disc of the tillage tool

Rib of the proposed construction stretches the tillable soil layer in a longitudinal direction and simultaneously compresses in the cross direction, creating a stress - strain state of the soil, which according to the theory of Coulomb - Mohr provides the increase of technological parameters of the soil monolith crumbling and reduce energy costs, especially when running on hard or frozen soils. Shredding (crumbling) of the soil is the destruction of links between parts of the soil as a result of effect of the WB surface and further loosening is the separation of soil particles from one another. From the standpoint of classical mechanics crumbling of the soil is the process of converting mass M of a sample of the soil lump of some volume:

$$V = abv\,, \tag{1}$$

where: a – depth, m; b – width of the tool, c; v – distance, passed by the machine per unit of time, m.

According to the Rittinger's hypothesis, the work spent on fracture of solid body is proportional to the resulting surface of the particles. The total surface of lumps formed by the pass of the tillage machine per unit of time equals:

$$s_k = abv\sum_{i=1}^{n}\frac{P_i}{d_i}\,, \tag{2}$$

where: n – number of factions; P_i – proportion of faction (%); d_i – weighted average size of the lump in the fraction.

Generalized Rebinder law for the definition of work when the soil is crumbling:

$$A = K_s S + K_v V\,, \tag{3}$$

where: K_s – specific surface energy, K_v – proportionality factor, which depends on the solidity of the soil and is equal in magnitude to the volumetric strain.

The formula of work, which is spent on crumbling of the given volume of soil, after substituting in (3) expressions (1) and (2) and performance of the relevant transformations will look like:

$$A = \frac{d_{\text{гр}}^2}{4E}\sigma^2 \ln\xi\,, \tag{4}$$

where: $\xi = \frac{d_n}{d_{\text{гр}}}$ – degree of the soil crumbling; d_n - initial diameter of the lump; $d_{гр}$ – average diameter of the lump after loosening; σ – stress (temporary resistance) of the soil during the compression, g/cm^2; E – modulus of elasticity, MPa.

So, work spent on the crumbling of the soil increases with the degree of crumbling and temporary resistance during the compression.

Conclusions

Modeling of the working surface forms of agricultural machines allowed to create new (patents on the inventions of Ukraine №№ 47743, 55133, 5132) possibility to improve their working bodies, which in its turn is important for the agricultural machinery.

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