Research Findings On The Optimization Of Parameters For Working Tools In Combined Units

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ABSTRACT

The article presents the design scheme and working tools of a combined unit and the results of theoretical studies to substantiate the main parameters of the working tools, as well as the arrangement scheme of the working tools for minimal processing of the upper ridge layer.

Keywords: combined unit, ridge processing, flat disk, V-shaped weep, rotary working tool, flat disk, pneumatic seeding device, marker, exhauster, seed hopper.

Introduction

Modern agricultural production requires solving the problems of increasing crop yields and maintaining soil fertility based on resource-saving technologies that ensure the implementation of several technological operations by one unit. In this case, the problem of precise seed sowing with simultaneous soil cultivation is of particular importance.

In the world, the leading place is occupied by the development of energy-saving, high-performance and high-quality equipment used in land preparation to ensure high-quality seed sowing and increase their productivity.

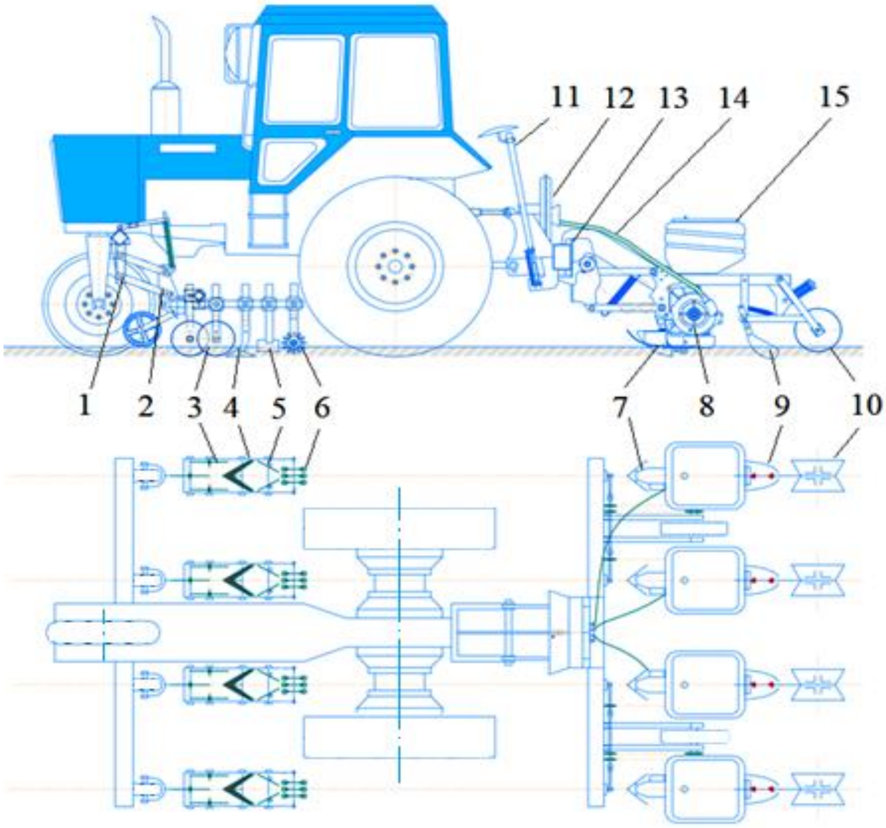
Considering that 1.8 billion hectares of land are processed and cultivated annually in the world [1], there is a need to develop energy-saving and highly productive combined units that perform high-quality technological processes for minimal soil tillage and seed sowing in one pass.

In the agricultural production of our republic, large-scale measures are being taken to save resources, reduce labor intensity and energy costs, and grow agricultural crops based on advanced technologies.

Materials and methods of research

Based on the set goals, a design of a combined unit for minimal processing of the upper part of the ridge with simultaneous precise sowing of row crop seeds was developed (Figure 1) [2].

The combined unit consists of two parts: the front part, designed for processing the upper part of the ridge, and the rear part, which carries out precise seeding of repeated crops [3].



1-cultivator frame; 2-parallelogram mechanism; 3-flat disk; 4-V-shaped weep; 5-leveler; 6-rotary working tool; 7-coulter; 8-pneumatic seeding unit; 9-harrow; 10-pressing roller; 11-marker; 12-exhauster; 13-seeder frame; 14-hose; 15-seed hopper

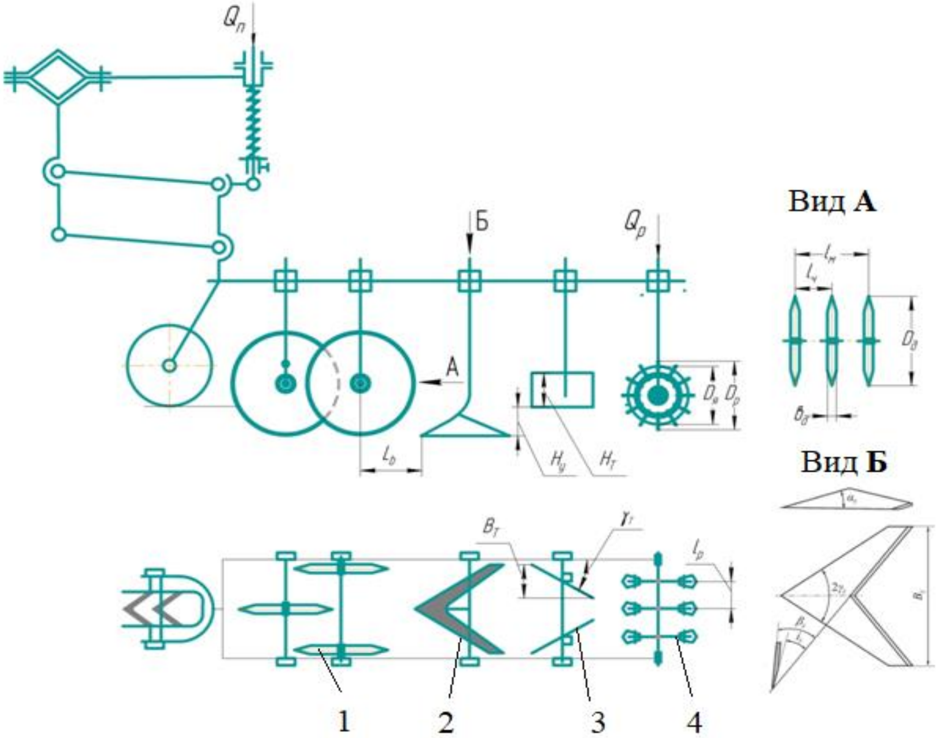
Figure 1. Structural diagram of combined unit

The front part of the unit is mounted on the front part of the tractor and is developed on the basis of the existing KKHU-4 cultivator, the parallelogram mechanism 2 installed on its frame 1 has three flat disks 3, V-shaped weep 4, a leveler 5 and a rotary working tool 6.

The rear seeding part of the unit consists of a pneumatic seeder, which is mounted on the rear hitch mechanism of the tractor. It consists of a coulter 7, a pneumatic seeding unit 8, a harrow 9, a press roller 10, a marker 11, an exhauster 12, a frame 13, a hose 14, a seed hopper 15 and support and drive wheels that drive the seeding units.

During operation, three flat cutting discs cut off the tops of the ridge, while the V-shaped weep loosens it, the leveler levels out the unevenness formed on the top of the ridge, and the rotary ripper crushes the lumps formed on it [4].

Below are the main parameters of the working tool section for minimum processing of the upper ridge layer (Figure 2):



1-flat disk; 2-V-shaped weep; 3-leveler; 4-rotary ripper

Figure 2. Scheme of arrangement of working tools for minimum tillage of the upper layer of the ridge

- diameter of flat disks - D_d, transverse distances between them - l_c and l_m, thickness - b_d, blade thickness and sharpening angle - $2\varepsilon_d$, vertical load applied to the disks - Q_d;

- crushing angle of the V-shaped weep β_y, wing opening angle - $2\gamma_y$, angle of entry into the soil - α_y, width of capture - B_y, sharpening angle of its blades - i_y and thickness of its blade - δ_y;

- longitudinal distance between flat disks and V-shaped weeps L_b;

- angle of installation of levelers in relation to the direction of movement γ_t, height H_t, width of capture B_t, installation height H_{yt} in relation to the V-shaped weeps;

- the diameter of the rotary cultivator D_p, the diameter of its flat disk D_r, the distance between the flat disks of the rotary cultivator l_p, the number of flat disks installed on it Z_p, the number of blades installed on the flat disks n_p, the vertical load applied to the rotary softener Q_p;

- the spring pressure force of the parallelogram section of the mechanism of working tools Q_n.

The diameter of flat disks can be determined by the following expression, based on previous studies [5].

$$D \geq \frac{d_y[1+cos(\varphi_{1y}+\varphi_{2y})]+2\text{h}_d}{1-cos(\varphi_{1y}+\varphi_{2y})}; \qquad (1)$$

where d_y is the diameter of the cross-section of plant residues, m; φ_{1y}, φ_{2y} are respectively the friction angles of the disk and soil on plant residues, °; h_d is the depth of immersion of the disk in the soil, m;

When condition (1) is met, flat disks cut plant residues and weeds lying on the surface of the field, or partially bury them in the soil. This prevents them from jamming. As a result, the quality of work and productivity increase.

The sharpening angle of flat disks is determined by the following expressions [6]

$$\varepsilon_d = 45^{\circ} - \frac{\varphi}{2}; \qquad (2)$$

where φ is the friction angle, °.

The thickness of the disk is taken from the condition that its strength is sufficient, and the thickness of the disk blade ensures the cutting of plant residues [7].

Taking d_y = 0.015 m, φ_{1y} = 30°, φ2ў = 40°, h_d = 0.08 m and φ = 30°, the calculations performed using expressions (1)-(2) show that the diameter of the disks should be at least 273 mm, the sharpening angle within 55-65°. Based on the results obtained, we take D = 280 mm and 2ε = 60°.

The vertical load applied to the flat disks of the working tool section is determined by the following expression, provided that the depth of penetration is specified [8].

$$Q_d = n_d q_0 (1 + kV^2)\left\{\delta_d R_d \left[\sqrt{2R_d h_d - {h_d}^2} - (R_d - h_d)\, arccos\frac{R_d - h_d}{R_d}\right] + \right.$$
$$\left. + \frac{1 + f ctg\varepsilon}{cos\,\varepsilon}\left[{R_d}^2 - \left(R_d - \frac{b_d - \delta_d}{2} ctg\varepsilon\right)^2\right]\left[\sqrt{\left(R_d - \frac{b_d - \delta_d}{2} ctg\varepsilon\right)^2 - (R_d - h_d)^2} - -(R_d - h_d)\, arccos\frac{R_d - h_d}{\left(R_d - \frac{b_d - \delta_d}{2} ctg\varepsilon\right)}\right]\right\},$$
(3)

where n_d is the number of flat disks installed in the section of the working tool, pcs; q_0 is the coefficient of static volumetric compression of the soil, N/m^3; k is the proportionality coefficient, s^2/m^2; V is the speed of movement, m/s; δ_d is the thickness of the disk blade, m; R_d is the radius of the flat disk, m; b_d is the thickness of the flat disk, m; f is the coefficient of friction of the soil against the pointed part of the flat disks.

Taking n_d = 3 pcs., q_0 = 15 106 N/m^3, k = 0.08 s^2/m^2 [9], R_d = 0.14 m, δ_d = 0.0005 m, f = 0.5 we obtain the following values of the parameters according to expression (3) at the unit speed of 1.5-2.0 m/s, the diameter of the flat disk is 280 mm, the sharpening angle is 55-65°, the vertical load applied to the flat disks of the working tool section is 1354.1-1514.7 N.

Conclusion

Thus, according to the results obtained above, the diameter of the flat cutting disks of the working tool section is 280 mm, the sharpening angle is 60°, the thickness is 2-3 mm, the thickness of the blades is 0.5 mm, and the vertical load applied to them should be within the range of 1354.1-1514.7 N.

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