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Research of Vertical Vibrations of the Chemeline Level Elevator

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ABSTRACT: The article presents the results of theoretical studies to bring the magnitude of the amplitude of the vertical oscillations of the equalizer of the chisel ripper to a minimum in order to ensure a good leveling of the field surface and uniform soil compaction.

KEYWORDS: Chisel ripper, equalizer, parallelogram mechanism, compression spring, forced vertical oscillations of the equalizer, maximum amplitude, mass of the equalizer, stiffness coefficient of the compression spring, the degree of field leveling, uniform soil compaction.

I. INTRODUCTION

We have developed a chisel cultivator consisting of loosening paws mounted on a frame in two rows, levelers, and a skating rink, and studies have been conducted to justify their type and parameters [1,2].

The loosening paws are rigidly fixed to the frame of the chisel ripper by means of special locks, and the levelers and the slatted roller are pivotally connected, respectively, by means of a parallelogram and radial mechanisms in order to ensure that the field surface irregularities are copied. The parallelogram equalizer mechanism is equipped with a compression spring.

In the process of work, the loosening paws loosen the soil to a depth of 16-20 cm, the levelers level the field surface and compact the soil layer loosened by the loosening paws to the desired degree, and the slat roller creates a finely forged layer on the field surface.

This article presents the results of studies to bring the amplitude of forced vertical vibrations of chisel ripper equalizers to a minimum in order to ensure a good leveling of the field surface and uniform soil compaction across the entire field.

Due to the irregularities of the field surface and the variability of the physicomechanical properties of the soil, the R_x (longitudinal) and R_z (vertical) forces acting on the equalizer on the soil side (see fig.) Continuously change during operation. For this reason, in addition to translational motion, the equalizer performs forced vertical oscillations, i.e. along the Z axis. These variations of the equalizer lead to a change in the degree of its impact on the soil and have a negative effect on the degree of uniformity of the field surface and soil compaction, and therefore on the uniform depth of seeding and obtaining friendly shoots.

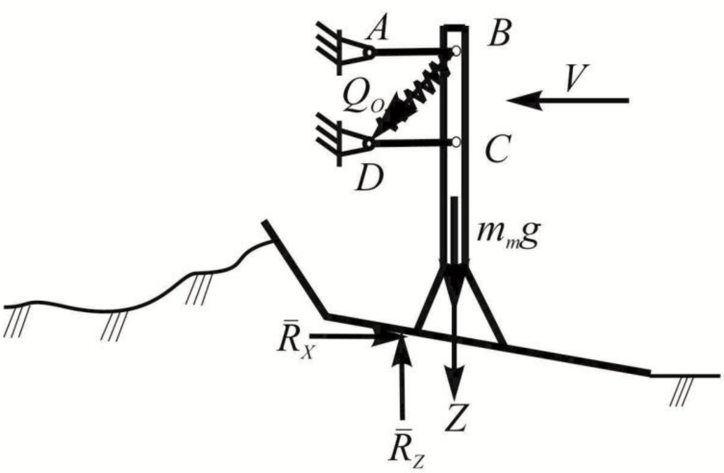

Diagram of the forces acting on the chisel equalizer

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The degree of influence of the forced vertical oscillations of the equalizer on the degree of alignment of the field surface and soil compaction mainly depends on the magnitude of the amplitude of the forced oscillations of the equalizer: the smaller the amplitude of the forced vertical oscillations of the equalizer, the less their influence on its performance. Consequently, in order for the equalizer to provide a good leveling of the field surface and the required soil compaction, the amplitude of the forced vertical oscillations of the equalizer should be as minimal as possible. To solve this problem, we compose and solve the differential equation of forced vertical oscillations of the equalizer. We assume that the unit moves in a straight line and at a constant speed, the friction forces in the hinges of the parallelogram mechanism do not have a significant effect on the vertical oscillations of the equalizer, in the equilibrium position of the equalizer, the longitudinal thrusts of the parallelogram mechanism (in the drawing of thrust AB and DC) occupy a horizontal position and in the process of work they deviate from this position by a small angle, their mass is small compared to the mass of the equalizer, and it can be neglected in the calculations.

Taking into account the assumptions made and according to the scheme in the figure, the differential equation of forced vertical oscillations of the equalizer has the following form

$$m_в \ddot{Z} + Sb_n \dot{Z} + \left(SC_n + C_н \frac{d}{\sqrt{l_n^2 + d^2}} \right) Z = \Delta R_x(t) tg\varphi_в + \Delta R_z(t), \quad (1)$$

where $m_в$ -is the mass of the equalizer, kg;

S- is the area of the reference plane of the equalizer, m^2;

b_n - coefficient of soil resistance, referred to unit

the area of the reference plane of the equalizer, $N \cdot s/m^3$;

C_n- is the coefficient of soil stiffness per unit area.

the reference plane of the equalizer, N/m^3;

$C_н$ - the stiffness coefficient of the pressure spring parallelogram

equalizer mechanism, N / m;

d - is the vertical distance between mobile or fixed hinges parallelogram

equalizer mechanism, m;

l - length of the longitudinal parallelogram mechanism

equalizer, m;

$\Delta R_x(t)$, $\Delta R_z(t)$ - the variable components of the forces R_x and R_z, H;

$\varphi_в$ - the angle of inclination to the horizon of the longitudinal strings of the parallelogram equalizer mechanism at a position deviated from the equilibrium degree.

Solving (1) from the condition that the variable forces $\Delta R_x(t)$ and $\Delta R_z(t)$ change according to a harmonic law, we get [3]

$$Z(t) = \frac{1}{m_в} \sum_{n=1}^{n_1} \frac{(\Delta R_x^n tg\varphi_в + \Delta R_z^n)\cos(n\omega t - \delta_n)}{\sqrt{\left[\frac{C_n S\sqrt{l^2+d^2} + C_н d}{m_в \sqrt{l^2+d^2}} - (n\omega)^2 \right]^2 + \left(\frac{b_n S}{m_в} \right)^2 (n\omega)^2}}, \quad (2)$$

where ΔR_x^n, ΔR_z^n - amplitudes of the corresponding harmonics, H;

$n = 1,2, ..., n_1$ is the harmonic number (n_1-is the number of the last harmonics);

ω - is the circular frequency of change of disturbing forces, s^{-1};

t - time, s;

$$\delta_n = arctg \frac{b_n S(n\omega)\sqrt{l^2+d^2}}{(C_n S\sqrt{l^2+d^2} + C_н d) - (n\omega)^2 m_в \sqrt{l^2+d^2}}.$$

Based on the expression (2) the maximum value of the amplitude of the vertical oscillations of the equalizer will be equal to

$$A=\frac{1}{m_{в}}\sum_{n=1}^{n_1}\frac{(\Delta R_x^n tg\varphi_{в}+\Delta R_z^n)}{\sqrt{\left[\frac{C_n S\sqrt{l_{н}^2+d^2}+C_{н}d}{m_{в}\sqrt{l_{н}^2+d^2}}-(n\omega)^2\right]^2+\left(\frac{b_n S}{m_{в}}\right)^2(n\omega)^2}}. \quad (3)$$

From this expression it follows that the maximum value of the amplitude of the vertical oscillations of the equalizer, and therefore the quality of the leveling of the field surface and the uniformity of soil compaction depend on the mass of the equalizer, the amplitude and circular frequency of change of disturbing forces, stiffness coefficients and soil resistance, stiffness coefficient of the pressure spring parallelogram mechanism specified working conditions, the required performance of the equalizer on the field surface leveling and the degree of soil compaction provide Chiva by proper selection of the mass and stiffness coefficient equalizer compression spring his parallelogram mechanism.

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