AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 01, Issue 08, 2023 ISSN (E): 2993-2637

Research of Vibration of the Combined Aggregate Roller in the Longitudinal-Vertical Plane

Д. Ш. Чуянов
Karshi Engineering Economics Institute (Uzbekistan)

Abstract: In the article, it was determined that the working quality of the combined aggregate roller depends on the mass of the roller, the uniformity of the pressure spring and the physical and mechanical properties of the soil.

Keywords: combined aggregate, roller, soil, work quality, spring uniformity, mass of roller, field unevenness.

Introduction. The problems of high-quality tillage of the soil with minimal energy costs for planting cash crops have been considered in many scientific works [1]. V.G.Abezin [2], V.I.Malyukov, A.D.Em, V.N.Zhukov [3] and others have conducted researches on the creation of police machines, justification of their construction, and justification of the parameters of their working bodies. The design and parameters of the machines that till the soil before planting and planting in the cultivation of field crops are based on V.G. Abezin, N.V. Aldoshin and V.I. Malyukov. These studies did not consider the issues of preparing the soil for planting rice crops in one pass with minimal tillage.

The purpose of the research is to justify the vibrations of the combined aggregate roller, which prepares the soil for sowing of field crops, in the longitudinal-vertical plane.

Materials and methods. During the movement of the roller of the combined unit [4], which prepares the soil for the planting of field crops, the vertical Nz and horizontal Nx reaction forces (Fig. 1) acting on it are constantly changing due to the unevenness of the field and changes in the physical and mechanical properties of the soil. As a result, the roller oscillates in the vertical plane relative to point O (hinge), that is, it has angular oscillations in this plane during operation. This leads to uneven compaction of the soil. In order to prevent this, the amplitude of the oscillations of the winding under the reaction forces Nx and Nz should be as small as possible. To solve this problem, we construct the differential equation of the movement of the roller in the longitudinal-vertical plane.

Results and discussion. We take the angle of deviation of the traction from the horizontal position a as a generalized coordinate, and using the differential equation of the rotational motion of a rigid body around a fixed axis [5], we have

$$J\frac{d^2\alpha}{dt^2} = (m_г g - N_z) l\cos\alpha + Q_n l_n \cos\alpha - N_x l\sin\alpha, \quad (1)$$

where J is the moment of inertia of the roller relative to point O_1, kgm2;

m_g – mass of the roller, kg;

g – acceleration of free fall, m/s2;

l – the length of the roller bearing, m;

Q_n is the pressure force of the spring, N;

l_n is the distance from the point O_1 to the point where the force Q_n is applied, m.

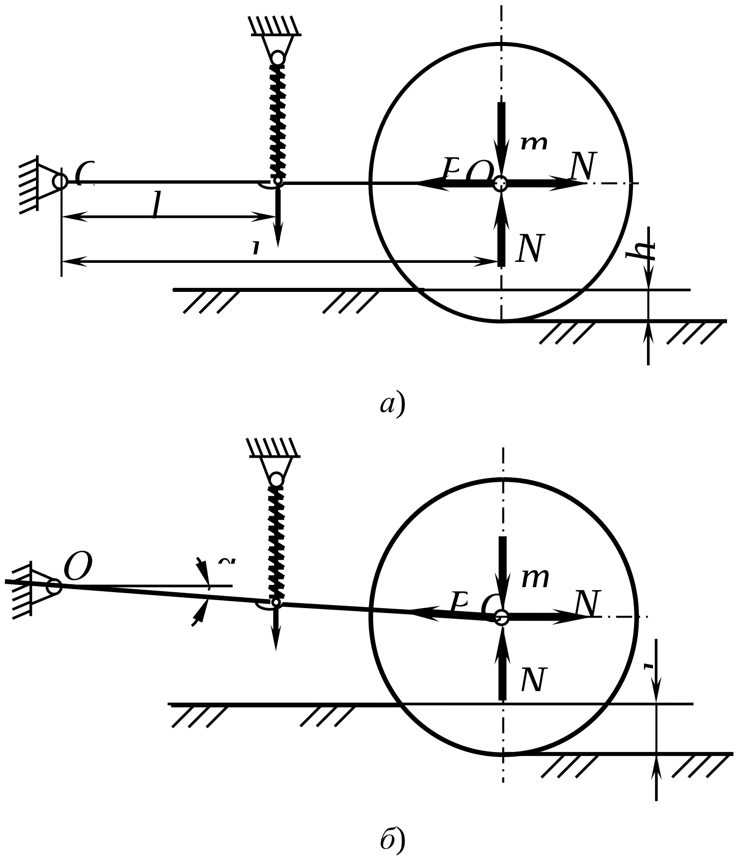

Figure 1. Scheme for the study of vibrations of the roller in the longitudinal-vertical plane: a, b - states of equilibrium and deviation of the roller from equilibrium, respectively.

Since the angle α is small, sin*α* = α, cos*α* = 1, and we change the expression (1) to the following form

$$J\frac{d^2\alpha}{dt^2}=(m_{г}g-N_z)l+Q_nl_n-N_xl\alpha. \quad (2)$$

We consider the vertical component of the soil reaction force N_z to be composed of the sum of the forces N_d and N_t, which are linearly dependent on the amount and speed of soil deformation, and Nt, which are caused by the unevenness of the field and the variability of the physical and mechanical properties of the soil [2], i.e.

$$N_z=N_{\partial}+N_m+N_t. \quad (3)$$

Taking into account this expression, the expression (5.7) takes the following form

$$J\frac{d^2\alpha}{dt^2}=\left(m_{г}g-N_{\partial}-N_m-N_t\right)l+Q_nl_n-N_xl\alpha. \quad (4)$$

In the state of static equilibrium of the coil

$$N_{\partial}=h_{\partial}C_{mг}B_{г}; \quad (5)$$

$$N_m = 0; \qquad (6)$$

$$N_t = 0; \qquad (7)$$

$$Q_n = Q_0, \qquad (8)$$

where h_d is the vertical deformation of the soil when the roller is in a state of static equilibrium, m;

C_{mg} - is the compactness of the soil applied to a unit coverage width of the working body, N/m^2;

B_g - is the covering width of the roller, m;

Q_0 - is the initial tension force of the pressure spring, N.

When the tension connecting the pulley to the frame deviates from the equilibrium position by an angle a under the influence of the forces acting on it

$$N_\partial = \left(h_\partial + l\alpha\right) C_{m\varepsilon} B_\varepsilon; \qquad (9)$$

$$N_m = b_{m\varepsilon} B_\varepsilon l \frac{d\alpha}{dt}; \qquad (10)$$

$$N_t = -\Delta R_z(t); \qquad (11)$$

$$Q_n = Q_0 - C_n l_n \alpha, \qquad (12)$$

where b_{mg} is the resistance coefficient of the soil per unit coverage width of the roller, $\frac{H \cdot c}{м^2}$;

C_n – coefficient of friction of the compression spring, $\frac{H}{м}$.

Substituting the values of N_d, N_m, N_t and Q_n into (4) according to expressions (5)-(12), we get the following

$$J\frac{d^2\alpha}{dt^2} = \left[m_\varepsilon g + (Q_0 - C_n l_n \alpha)\frac{l_n}{l} - (h_\partial + l\alpha)C_{m\varepsilon}B_\varepsilon - b_{m\varepsilon}B_\varepsilon l\frac{d\alpha}{dt} + \Delta R_z(t)\right] l - N_x l\alpha. \qquad (13)$$

In the state of static equilibrium of the coil

$$\left(m_\varepsilon g - h_\partial C_{m\varepsilon} B_\varepsilon\right) l + Q_0 l_n = 0. \qquad (14)$$

Taking this expression into consideration, the expression (13) will have the following form

$$J\frac{d^2\alpha}{dt^2} = \Delta R_z(t) l - C_n l_n^2 \alpha - C_{m\varepsilon} B_\varepsilon l^2 \alpha - b_{m\varepsilon} B_\varepsilon l^2 \frac{d\alpha}{dt} - N_x l\alpha \qquad (15)$$

or

$$J\frac{d^2\alpha}{dt^2} + b_{m\varepsilon} B_\varepsilon l^2 \frac{d\alpha}{dt} + \left(C_{m\varepsilon} B_\varepsilon l + C_n \frac{l_n^2}{l} + N_x \right) l\alpha = \Delta R_z(t) l. \qquad (16)$$

This expression is a second-order inhomogeneous differential equation with variable coefficients due to the variation of N_x.

It is known from the theory of oscillations [6], expression (16) represents parametric oscillations. But due to the large damping property of the soil, parametric oscillations of the coil are not observed. Basically, it is forced to oscillate under the influence of a variable force *ΔR(t)*.

Therefore, we assume that the force N_x is constant and equal to its average value, and we consider the forced oscillations of the winding under the influence of a variable force. In this case, we assume that the power changes according to the sinusoidal law, i.e

$$\Delta R_z(t) = \Delta R_z \sin \omega t, \tag{17}$$

where ΔR_z - is the amplitude of the alternating force, N;

ω - is the rotation frequency of alternating power, s^{-1}.

Taking (17) into account, the expression (15) has the following form

$$J\frac{d^2\alpha}{dt^2} + b_{m\text{г}} B_{\text{г}} l^2 \frac{d\alpha}{dt} + \left(N_x + C_{m\text{г}} B_{\text{г}} l + C_n \frac{l_n^2}{l} \right) l\alpha = \Delta R_z l \sin \omega t \tag{18}$$

or

$$\frac{d^2\alpha}{dt^2} + 2n\frac{d\varepsilon}{dt} + k^2\varepsilon = H \sin \omega t, \tag{19}$$

in this $n = \dfrac{b_{m\text{г}} B_{\text{г}} l^2}{2J}$; $k = \sqrt{\dfrac{\left(N_x + C_{m\text{г}} B_{\text{г}} l + C_n \frac{l_n^2}{l} \right) l}{J}}$ ва $H = \dfrac{\Delta R_z l}{J}$.

In equation (19), the solution representing the forced oscillations of the coil is written as follows.

$$\alpha(t) = \frac{\Delta R_z \sin(\omega t - \delta_1)}{m_{\text{г}} l \sqrt{\left[\dfrac{\left(N_x + C_{m\text{г}} B_{\text{г}} l + C_n \frac{l_n^2}{l} \right) l}{m_{\text{г}} l^2} - \omega^2 \right]^2 + \left(\dfrac{b_{m\text{г}} B_{\text{г}}}{m_{\text{г}}} \right)^2 \omega^2}}, \tag{20}$$

and the maximum angle of deviation of the spool tension from the equilibrium position

$$\alpha_{\max} = \frac{\Delta R_z}{m_{\text{г}} l \sqrt{\left[\dfrac{N_x + C_{m\text{г}} B_{\text{г}} l + C_n \frac{l_n^2}{l}}{m_{\text{г}} l} - \omega^2 \right]^2 + \left(\dfrac{b_{m\text{г}} B_{\text{г}}}{m_{\text{г}} l} \right)^2 \omega^2}} \tag{21}$$

in this $\delta_1 = arctg \dfrac{b_{m\text{г}} B_{\text{г}} l\omega}{N_x + C_{m\text{г}} B_{\text{г}} l + C_n \dfrac{l_n^2}{l} - m_{\text{г}} l\omega^2}$.

Conclusion. The analysis of the obtained expressions (20)-(21) shows that the uniformity of the depth of immersion of the roller into the soil, and therefore the density of the soil, is related to its mass, the length of the tie connecting it to the frame, the uniformity of the pressure spring, the amplitude of the variable force DR(t) and the physical and mechanical properties of the soil depends, and the quality of work at the required level for the given working conditions is achieved due to the correct selection of the mass of the roller and the stiffness of the pressure spring.

Reference

1. Mirzaev B, Mamatov F, Chuyanov D, Ravshanov X, Shodmonov G, Tavashov R and Fayzullayev X. Combined machine for preparing soil for cropping of melons and gourds XII International Scientific Conference on Agricultural Machinery Industry. doi.org/10.1088/1755-1315/403/1/012158.
2. Абезин В.Г. и др. Механизация возделывания бахчевых // Картофель и овощи. – 1977. – № 5. – С. 44-45.
3. Малюков В.И. Механизация бахчеводства. – Волгоград, Ниж.-Волж. Кн. изд-во, 1982. – С. 6-14.
4. Маматов Ф.М., Чуянов Д.Ш. Энерго-ресурсосберегающий комбинированный агрегат для подготовки почвы к посеву бахчевых культур // European Applied Sciences. – Stutgart, 2015. – №10. – pp. 55-57.
5. Бутенин Н.В., Лунц Я.Л., Меркин Д.Р. Курс теоретической механики. Т. II: Динамика (3-е изд., исправленное). – Москва: Наука, 1985. – 496 б.
6. Пановко Я.Г. Введение в теорию механических колебаний. – Москва: Наука, 1980. – 272 с.