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Research of Angular Vibration of Combination Machine Winding

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ABSTRACT

The article presents the results of the theoretical studies conducted on the study of the angular vibrations of the cotton top layer compacting roller of the combined machine that prepares the garden rows for single crop planting. According to it, for the given working conditions, uniform compaction of the cotton by the roller at the required level is ensured due to the correct selection of its mass, the length of the tie connecting it to the frame, the uniformity of the spring, and the point where its pressure force is applied.

INTRODUCTION. In the conditions of Uzbekistan, vegetables and other inter-row crops are grown between rows of newly established gardens for 6-8 years [1].

Nowadays, agrotechnical measures are carried out separately in the preparation of garden rows for planting crops in the spring, and this leads to an increase in labor, energy and fuel consumption, disruption of the macro-microstructure of the soil and excessive compaction, and loss of soil moisture. In addition, in the implementation of the above activities, a complex of machines and weapons, which were created long ago and imported from the CIS countries, are used, and a large amount of material costs are spent on their use and repair. [1-21].

Materials and methods. Based on the above, a combined machine was developed at QXMITI, which prepares the rows between garden rows for planting crops at once (Fig. 1).

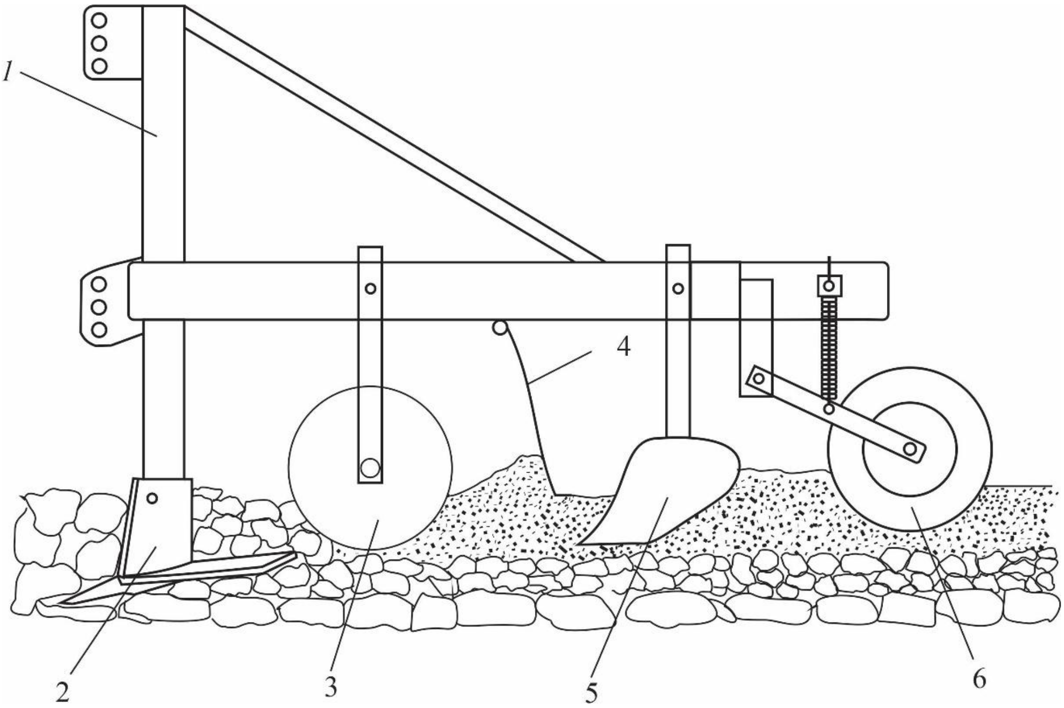


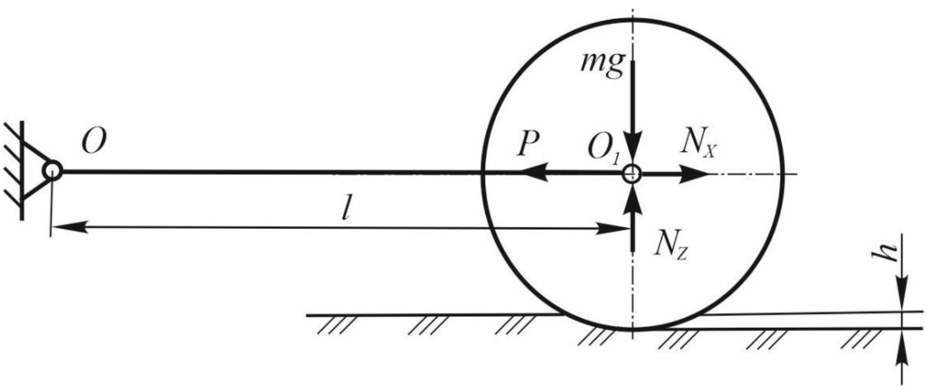
Figure 1. The construction scheme of the combined machine that prepares the garden rows for sowing crops

The combined machine consists of a frame 1 equipped with a suspension device, a softener 2, a rotary working body 3 that creates a soft soil layer, a leveler 4, a pile picker 5, a roller 6 that compacts the top layer of piles and slopes.

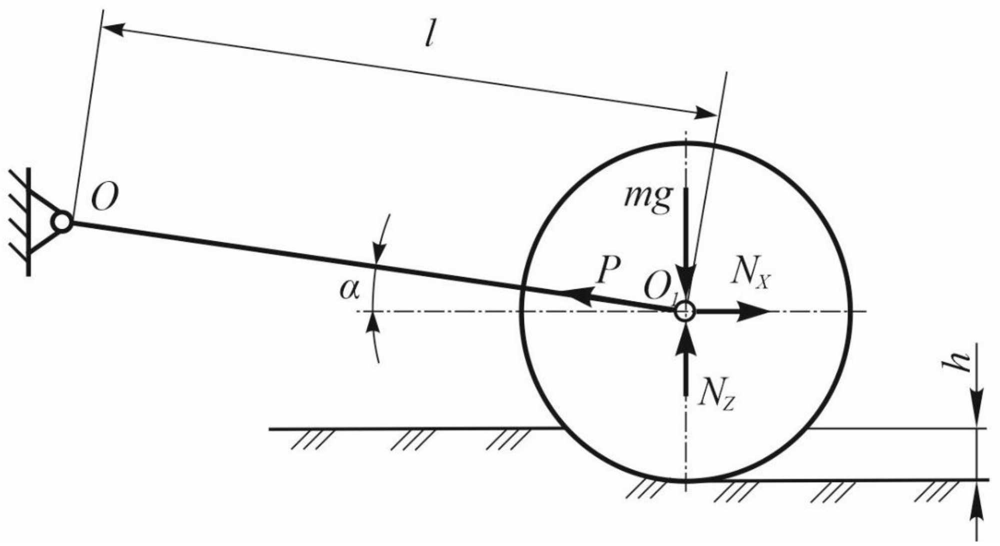
The working process of the combined machine that prepares the developed garden rows for single crop planting is as follows: when the unit moves along the field, its softener softens the soil between the garden rows, and the rotary working body grinds the soil softened by the softener and forms a soft soil layer. The leveler smoothes the surface of the area where the soft soil layer is softened to the level of agrotechnical requirements. After that, paddy is formed with the help of a paddy picker, and then with a roller, its upper layer and slopes are compacted to the level of agrotechnical requirements and are made ready for planting.

In this paper, the angular oscillations of the machine spindle during operation are theoretically investigated.

During the movement of the machine, the horizontal N_X and vertical N_Z reaction forces (Fig. 2) acting on the roller are constantly changing due to the changes in the physico-mechanical properties of the soil and the unevenness on the



a)



b)

Figure 2. Scheme for the study of angular oscillations of the roller

top and slopes of the pile. As a result, in the process of work, the roller, in addition to the forward movement with the machine, also oscillates around the point "*O*" (hinge) connected to its frame. The oscillating movement of the roller around point "*O*" changes its effect on the pad, and as a result, its uniform compaction is not ensured.

The amplitude of the angular oscillations of the roller around the "*O*" point should be as small as possible to ensure uniform compaction of the punch. To solve this problem, we formulate and solve the differential equation of the angular oscillations of the coil about the point "*O*". We accept the following restrictions:

- during work, the machine moves in a straight line with the same speed;
- frictional forces in the "*O*" joint are small and do not affect the angular oscillations of the roller;
- vibrations of the machine frame do not affect the angular vibrations of the roller;
- the mass of the cable that connects the roller to the frame of the machine is very small and can not be taken into account;
- the equilibrium position of the pulley connecting the reel to the frame is horizontal, and its deviation from this position is a small angle.

Results and discussion. Taking into account these restrictions, the differential equation of the angular oscillations of the coil will have the following form [5]

$$J\frac{d^2\alpha}{dt^2} = (mg - N_z)l + Q_p l_p - N_x l\alpha, \quad (1)$$

where J – is the moment of inertia of the coil relative to point O;

α – the angle of deviation from the equilibrium position of the tie rod connecting the roller with the machine;

m – the mass of the coil;

g – free fall acceleration;

l – the length of the string connecting the reel to the frame;

Q_p – the compression force of the coil spring;

l_p – distance between points O and O_1.

Taking $J = ml^2$, we reduce the expression (1) to the following form

$$ml\frac{d^2\alpha}{dt} = mg - N_Z + Q_p\frac{l_p}{l} - N_X\alpha. \quad (2)$$

We consider that the force N_Z in this expression consists of the sum of the soil elasticity N_e, resistance (damping) N_d and variable forces $N_{o'}$ depending on the irregularities on the top and slopes of the pile and the physical-mechanical properties of the soil [6]

$$N_Z = N_e + N_d + N_{o'}. \quad (3)$$

Taking this into account, expression (2) takes the following form:

$$ml\frac{d^2\alpha}{dt^2} = mg - (N_e + N_d + N_{o'}) + Q_p\frac{l_p}{l} - N_X\alpha. \quad (4)$$

In the state of static equilibrium of the roller (Fig. 2, a)

$$N_e = h_t C_t B; \ (5) \quad N_d = 0; \ (6) \quad N_{o'} = 0; \ (7) \text{ ва } Q_p = Q_0, \ (8)$$

where h_t – deformation of the soil under the influence of rolling;

C_t – coefficient of compaction of the soil per unit width of the roller;

B – coverage width of the reel;

Q_0 – initial (specified) tension force of the coil spring.

When the coil deviates from the static equilibrium position (Fig. 2, b)

$$N_e(h_t + l\alpha)C_t B; \ (9) \quad N_d = b_t Bl\frac{d\alpha}{dt}; \ (10)$$

$$N_{o'} = -\Delta R_Z(t) \ (11) \text{ ва } Q_p = Q_0 - C_p l_p \alpha, \ (12)$$

where b_t – the coefficient of resistance of the soil per unit coverage width of the roller; C_p – is the coefficient of elasticity of the spring.

Taking into account expressions (9)-(12), expression (4) has the following form

$$ml\frac{d^2\alpha}{dt^2} = mg - \left[(h_t + l\alpha)C_t B + b_t Bl\frac{d\alpha}{dt} - \Delta R_Z(t) \right] +$$

$$+\left(Q_0 - C_p l_p \alpha\right)\frac{l_p}{l} - N_X \alpha. \quad (13)$$

In the state of static equilibrium of the winding $mg - h_t C_t B + Q_0 \frac{l_p}{l} = 0$

Taking this into account, we write equation (13) as follows

$$ml\frac{d^2\alpha}{dt^2} + b_t Bl\frac{d\alpha}{dt} + \left(C_t Bl + C_p\frac{l_p^2}{l} + N_X\right)\alpha = \Delta R_Z(t). \quad (14)$$

Since the force N_X is variable, this expression represents parametric fluctuations. However, due to the large damping property of the soil, parametric oscillations of the roller are not observed in practice, and it mainly acts as a forced oscillation under the influence of force $\Delta R_Z(t)$ [6]. Therefore, we assume that the force N_X is constant and equal to its average value, and we study the forced oscillations of the coil under the influence of the force $\Delta R_Z(t)$. For this, we consider that the force $\Delta R_Z(t)$ changes according to the following harmonic law

$$\Delta R_Z(t) = \sum_{n=1}^{n_i} \Delta R_Z^n \cos n\omega t, \quad (15)$$

where ΔR_Z^n – $\Delta R_Z(t)$ is the amplitude of the corresponding harmonic of the force;

n=1, 2, … , n_i – number of harmonics;

ω – $\Delta R_Z(t)$ frequency of alternating power.

Taking into account the expression (15), the equation (14) has the following form

$$ml\frac{d^2\alpha}{dt^2} + b_t Bl\frac{d\alpha}{dt} + \left(C_t Bl + C_p\frac{l_1^2}{l} + N_X\right)\alpha = \sum_{n=1}^{n_i} \Delta R_Z^n \cos n\omega t. \quad (16)$$

The solution of this equation and the amplitude of forced angular oscillations of the coil are respectively expressed as follows [5]

$$\alpha(t) = \frac{1}{ml}\sum_{n=1}^{n_i} \frac{\Delta R_Z^n \cos\left(n\omega t - \delta_n\right)}{\sqrt{\left[\frac{C_t Bl + C_p\frac{l_p}{l} + N_X}{ml} + (n\omega)^2\right]^2 + \frac{b_t B^2}{m^2}(n\omega)^2}}; \quad (17)$$

$$A = \frac{1}{ml}\sum_{n=1}^{n_i} \frac{\Delta R_Z^n}{\sqrt{\left[\dfrac{C_t Bl + C_p \dfrac{l_p}{l} + N_X}{ml} + (n\omega)^2\right]^2 + \dfrac{b_t^2 B^2}{m^2}(n\omega)^2}}, \quad (18)$$

where $\delta_n = arctg \dfrac{b_t\, Bl\, n\omega}{C_t Bl + C_p \dfrac{l_p}{l} + N_X - ml(n\omega)^2}$

Conclusion. The analysis of the expressions (17) and (18) shows that for the given working conditions, uniform compaction of the bushing by the roller at the required level is ensured by its mass, the length of the tie connecting it to the frame, the uniformity of the spring, and the correct selection of the point where its pressure force is applied.

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