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In the articles presented method conducting of research vыsevnoho pneumatic mechanical apparatus with rezervnыm dispenser to Identify major indicators nadezhnosty work predlozhennoho vыsevnoho apparatus.

Vыsevnoy pneumatic mechanical apparatus, installation, tochnыy sowing, seeds, dozyrovanye.

The paper pedstavlena method conducting research pneumomechanic sowing apparatus with reserve doser to identify main indicators of reliability of work the proposed sowing apparatus.

Pneumomechanic sowing apparatus, experimental setup, exact seeding, seed, seeding, dosage.

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Improved model of driving dynamics beater combine harvesters

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Presented the finalized study dynamics of combine harvester threshing drum. Research conducted for two cases change the drive point: the time constant of the drive mechanism; Parabolic change the date. The dependence of the oscillation amplitude speed beater on the hardness of the drive.

Threshing drum drive, rigidity, speed, dynamics.

Problem. Drive beater combine harvester is a complex system. Combine during harvesting threshing selects optimal speed depending on the type of culture, Moisture, relief field, the biological characteristics of culture.

*** Supervisor - PhD VS Loveykin**

In ICE combine harvester at work there vibrations that are transmitted via a belt drive for threshing drum. In turn, as the beater often performed open, then during the threshing drum gets inside the grain, plant debris, dust and soil, resulting in their accumulation on uneven bylah and pidbylnykah. All this leads to imbalance beater and, consequently, to its unacceptable vibration that is attached to the vibration of the engine. These vibrations are transmitted to the bearing housing and the combine, which reduces its reliability, and affects the quality of threshing process.

This is undesirable, since lead to a decrease in the reliability of the beater, the deterioration of the quality of the threshing and increasing energy costs.

Therefore, in this paper as the basis of theoretical research be to solve problems related to the study of the effects of fluctuations in work beater.

Analysis of recent research. Research questions driving dynamics beater and equations describing the process of threshing and separation dedicated work VP Horyachkina, EI Lipkovycha, VG Antipina. In [1] V. Radino, SV Kuruchuk and MS Hnutov obtained equations of nonholonomic connection of the second order, which shows its properties when you turn leniksnoyi to a combine harvester thresher drive. The authors identified three phases of leniksnoyi transmission when you switch on, and for each phase of the equations of communication. The general equation ties uniting all these phases. In this paper, the authors derived the equation, but not explored the influence of parameters to drive momentum beater. In [2] Alferov investigated cases acceleration, coasting, driving and normal operation of the beater and the equations of motion beater. Here is a graph from which we can determine the optimal moment of inertia beater, while the average asking rate maximum external load and allowable value of technological requirements fall angular velocity.

In [3] the methods of dynamic analysis machines. The main attention is paid to the study of mathematical models of dynamic systems. Simplification methods are given dynamic models and simple linear and nonlinear modules which enable machines to make a mathematical model for the structural scheme. However, the dynamics of movement beater unexplored.

The purpose is to study the dynamics of combine harvester threshing drum.

Results. To study the dynamics of beater combine harvester developed a dynamic model (Fig. 1), which is a dvomasovu dynamic model. In this model, the generalized coordinates adopted angular coordinates of the first and second masses.

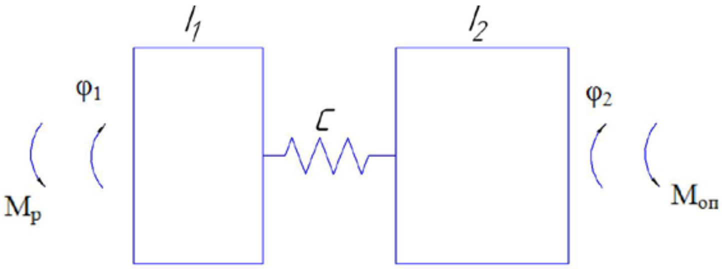


Fig. 1. The dynamic model of the drive mechanism beater.

In this model, φ1 - angular coordinate engine, built to the axis of rotation of the drum; φ2 - angular coordinate beater; J1 and J2 - moments of inertia, under the motor and drum rotation axis reduced to the drum; s - drive mechanism stiffness, reduced to the axis of rotation of the drum; Mk - driving time reduced to the axis of rotation of the drum; ILO - moment of resistance on the drum.

Based on this dynamic model composed of the equations of motion, which are as follows:

$$\begin{cases} J_1 \cdot \ddot{\varphi}_1 = M_p - c \cdot (\varphi_1 - \varphi_2); \\ J_2 \cdot \ddot{\varphi}_2 = c \cdot (\varphi_1 - \varphi_2) - M_{on}. \end{cases} \quad (1)$$

To solve the equations of motion (1) consider three cases of change of the drive point:

1. Standing time drive mechanism. $M_p = const$.

2. Parabolic change since the drive mechanism $M_p = A_1 \cdot \dot{\varphi}_1^2 + A_2 \cdot \dot{\varphi}_1 + A_3$Where A1, A2, A3 - constants determined from boundary values of the driving time of the mechanical characteristics of the drive mechanism and the angular velocity.

3. Cubic change since the drive mechanism $M_p(\dot{\varphi}_1) = \tilde{A}_1 \cdot \dot{\varphi}_1^3 + \tilde{A}_2 \cdot \dot{\varphi}_1^2 + \tilde{A}_3 \cdot \dot{\varphi}_1 + \tilde{A}_4$Where A1, A2, A3, A4 - constants determined from boundary values of the driving time of the mechanical characteristics of the drive mechanism and the angular velocity.

For these three cases previously solve the system of equations (1).

Solution mathematical model and graph for constant since the drive mechanism. In the first case, in the process of starting point Mk driving time is greater than the resistance of the ILO, and after time TR (acceleration time) driving time is equal to the moment of resistance (it shows a graph of points (Fig. 2)).

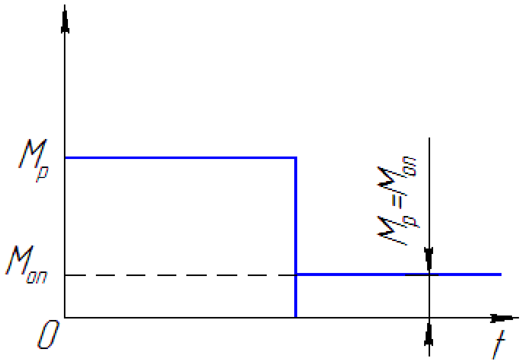


Fig. 2. Schedule changes since the resistance and the driving moment of time.

In this case, the process of moving beater in two steps. In the first stage movement driving time exceeds the time resistance. After a period of time tp, when the driving time is equal to the moment of resistance, comes the second stage, in which the driving moment is the moment of resistance.

Solve the equation of motion (1) for the first and second stages.

The first stage. At this stage, the general solution of the angular coordinates of the engine and its derivatives are as follows:

$$\varphi_1 = \frac{a_2}{2} \cdot t^2 + \left(\frac{J_2}{c} \cdot a_2 - a_1 + \frac{M_{on}}{c} \right) + a_1 \cdot \cos kt \cdot \left[1 - \frac{J_2}{c} \cdot k^2 \right];$$
$$\dot{\varphi}_1 = a_2 \cdot t - a_1 \cdot k \cdot \sin kt \cdot \left[1 - \frac{J_2}{c} \cdot k^2 \right]; \qquad (2)$$
$$\ddot{\varphi}_1 = a_2 - a_1 \cdot k^2 \cdot \cos kt \cdot \left[1 - \frac{J_2}{c} \cdot k^2 \right].$$

Coordinate beater and its derivatives:

$$\varphi_2 = a_1 \cdot (\cos kt - 1) + \frac{a_2}{2} \cdot t^2;$$
$$\dot{\varphi}_2 = -a_1 \cdot k \cdot \sin kt + a_2 \cdot t; \qquad (3)$$
$$\ddot{\varphi}_2 = -a_1 \cdot k^2 \cdot \cos kt + a_2;$$
$$\dddot{\varphi}_2 = a_1 \cdot k^3 \cdot \sin kt.$$

When solving the equations of motion were conducted following options:

$$k = \sqrt{\frac{J_1 + J_2}{J_1 \cdot J_2}};\ a_1 = \frac{M_{on}}{J_2 \cdot k^2} + \frac{a_2}{k^2}; \quad a_2 = \frac{M_p - M_{on}}{k^2 J_1 \cdot J_2} \cdot c.$$

When beater pick the desired speed, its equation of motion change. After time TR (acceleration time) driving time will be equal to the moment of resistance (Fig. 2).

Kinematic motion characteristics beater look like:

$$\begin{aligned}
\varphi_2 &= a_3 \cdot (\cos kt - 1); \\
\dot{\varphi}_2 &= -a_3 \cdot k \cdot \sin kt; \\
\ddot{\varphi}_2 &= -a_3 \cdot k^2 \cdot \cos kt; \\
\dddot{\varphi}_2 &= a_3 \cdot k^2 \cdot \sin kt,
\end{aligned} \tag{4}$$

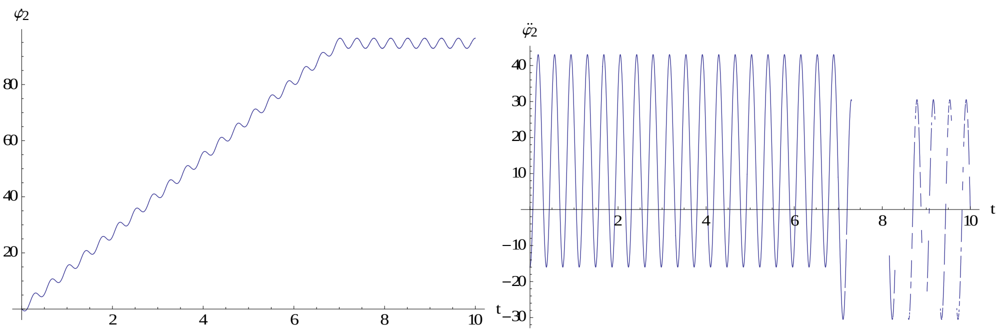
and depending on the characteristics of the motor movement after time TR:

$$\begin{aligned}
\varphi_1 &= a_3 \cdot \cos kt \cdot \left(1 - \frac{J_2}{c} \cdot k^2\right) + \frac{M_{on}}{c} - a_3; \\
\dot{\varphi}_1 &= -a_3 \cdot k \cdot \sin kt \cdot \left(1 - \frac{J_2}{c} \cdot k^2\right); \\
\ddot{\varphi}_1 &= -a_3 \cdot k^2 \cdot \cos kt \cdot \left(1 - \frac{J_2}{c} \cdot k^2\right).
\end{aligned} \tag{5}$$

To find these relationships had been replaced:

$$a_3 = \frac{M_{on}}{J_2 \cdot k^2}.$$

Equation (2) - (5) can be solved by Mathematica package. To combine with parameters: J1 = 10,82 khm2; J2 = 5,22khm2; Mp = 433 nm; Mop = 173.3 nm. For the first case were constructed plots of velocity beater of time (Fig. 3). Depending on changes in the rigidity of the drive mechanism, the amplitude of oscillation speed beater not change significantly (Fig. 3).



a) b)

Fig. 3. Charts dependence of the angular velocity (a) and acceleration (b) beater from time to time of constant drive mechanism for the angular velocity surface of Bill 30 m / s.

We reduce the equation (1) for a given species, dividing the first equation system for I1, the second - in I2:

$$\begin{cases} \ddot{\varphi}_1 = \frac{M_p}{J_1} - \frac{c}{J_1} \cdot (\varphi_1 - \varphi_2); \\ \ddot{\varphi}_2 = \frac{c}{J_2} \cdot (\varphi_1 - \varphi_2) - \frac{M_{on}}{J_2}. \end{cases} \qquad (6)$$

Subtract the first equation of (6) second, then:

$$\ddot{\varphi}_1 - \ddot{\varphi}_2 = \frac{M_p}{J_1} + \frac{M_{on}}{J_2} - \left(\frac{c}{J_1} + \frac{c}{J_2}\right) \cdot (\varphi_1 - \varphi_2).$$

Denote $\psi = \varphi_1 - \varphi_2$, Then:

$$\ddot{\psi} + c \cdot \left(\frac{I_1 + I_2}{I_1 \cdot I_2}\right) \cdot \psi = \frac{M_p}{J_1} + \frac{M_{on}}{J_2}.$$

Denote $\frac{c \cdot (I_1 + I_2)}{I_1 \cdot I_2} = \Omega^2$.

$$\ddot{\psi} + \Omega^2 \cdot \psi = \frac{M_p}{J_1} + \frac{M_{on}}{J_2}. \qquad (7)$$

Solve the equation (7) to start phase (Mp = const; Mon = const; Mp> Mon).

$$\psi = A \cdot \sin \Omega t + B \cdot \cos \Omega t + \left(\frac{M_p}{I_1} + \frac{M_{on}}{I_2}\right) \cdot \frac{1}{\Omega^2}.$$

Initial conditions: $\psi\big|_{t=0} = \dot{\psi}\big|_{t=0} = 0$. Hence:

$$\begin{cases} B + \left(\frac{M_p}{I_1} + \frac{M_{on}}{I_2}\right) \cdot \frac{1}{\Omega^2} = 0 \Rightarrow B = -\left(\frac{M_p}{I_1} + \frac{M_{on}}{I_2}\right) \cdot \frac{1}{\Omega^2}; \\ A = 0. \end{cases}$$

So the solution of (7) has the form:

$$\psi = \left(\frac{M_p}{I_1} + \frac{M_{on}}{I_2}\right) \cdot \frac{2}{\Omega^2} \cdot \sin^2\left(\frac{\Omega t}{2}\right) \qquad (8)$$

The amplitude:

$$\psi_0 = \frac{2}{\Omega^2} \cdot \left(\frac{M_p}{I_1} + \frac{M_{on}}{I_2}\right).$$

So in this case there are "beating» ψ, with amplitude ψ0, which reach a maximum (ψ0) at time $t_n = \frac{\pi \cdot (2n-1)}{\Omega}$, N = 1, 2, 3, 4, ...

That this mode the system is disadvantageous.

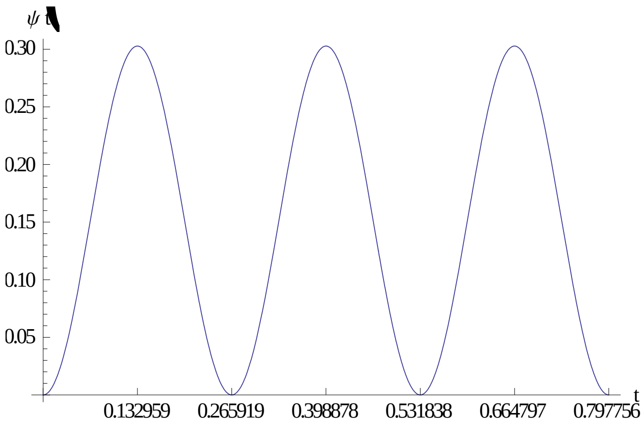


Fig. 4. Dependence of the difference of angular coordinates beater motor and on time.

Solution mathematical model for parabolic changes since the drive mechanism. In this case, the drive time varies according to the parabolic dependence (Fig. 5):

$$M_p = A_1 \cdot \dot{\varphi}_1^2 + A_2 \cdot \dot{\varphi}_1 + A_3 . \qquad (9)$$

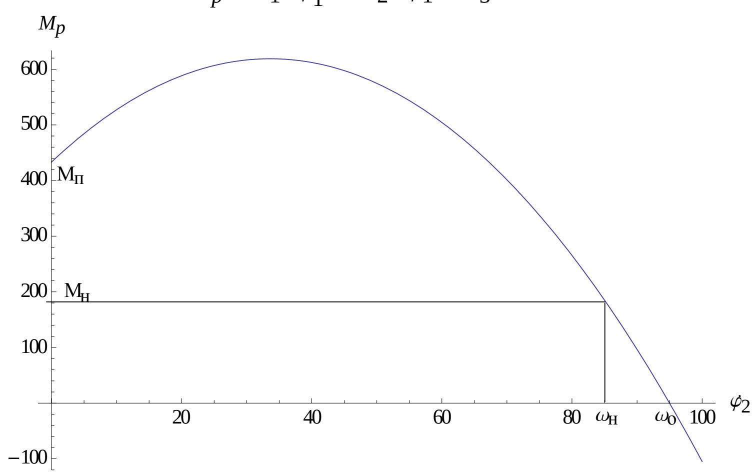


Fig. 5. Parabolic change since the drive mechanism.

When you change the drive since the parabolic constants A1, A2, A3 are the conditions:

$$M_p\Big|_{\omega=0} = M_п ; M_p\Big|_{\omega=\omega_н} = M_н ; M_p\Big|_{\omega=\omega_о} = 0; \ .$$

Based on the boundary conditions will have a system of equations:

$$\begin{cases} A_3 = M_п ; \\ A_1\omega_н^2 + A_2\omega_н + A_3 = M_н ; \\ A_1\omega_о^2 + A_2\omega_о + A_3 = 0. \end{cases} \qquad (10)$$

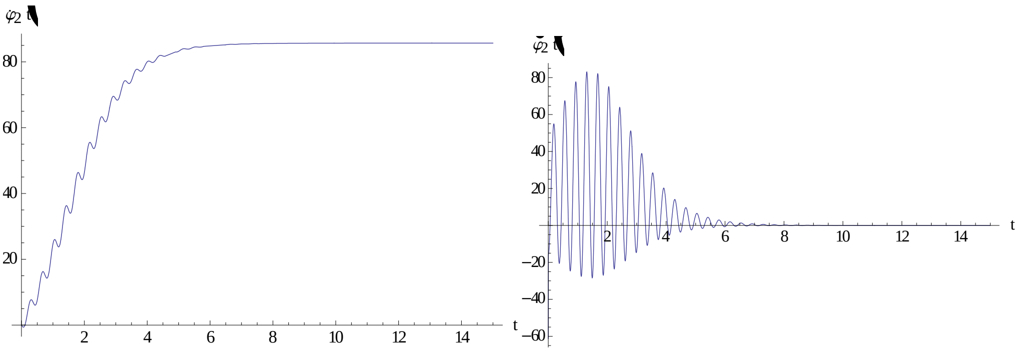
Solving this system by substitution, we get:

$$A_1 = -\frac{M_{п}(1-\omega_{н}/\omega_{o})-M_{н}}{\omega_{н}(\omega_{o}-\omega_{н})}; \quad A_2 = \frac{M_{п}}{\omega_{o}} - \frac{M_{п}(1-\omega_{н}/\omega_{o})-M_{н}}{\omega_{н}(\omega_{o}-\omega_{н})}; \quad A_3 = M_{п}. \qquad (11)$$

Thus we have the parabolic law Mk ω0 (ω0):

$$M_p(\omega) \equiv M_p(\dot{\varphi}_1) = -\frac{M_{п}(1-\omega_{н}/\omega_{o})-M_{н}}{\omega_{н}(\omega_{o}-\omega_{н})} \cdot \dot{\varphi}_1^2 + \left(\frac{M_{п}}{\omega_{o}} - \frac{M_{п}(1-\omega_{н}/\omega_{o})-M_{н}}{\omega_{н}(\omega_{o}-\omega_{н})}\right) \cdot \dot{\varphi}_1 + M_{п}. \qquad (12)$$

Solve equation (1) with regard to dependence (12) using Mathematica package and build graphs of the angular velocity beater from time to threshing speed of 30 m / s (Fig. 6).



a) b)

Fig. 6. characteristics depending angular velocity (a) and acceleration (b) beater on timefor parabolic changes since the drive mechanism for the angular velocity surface of Bill 30 m / s (stiffness of 1000 Nm / m).

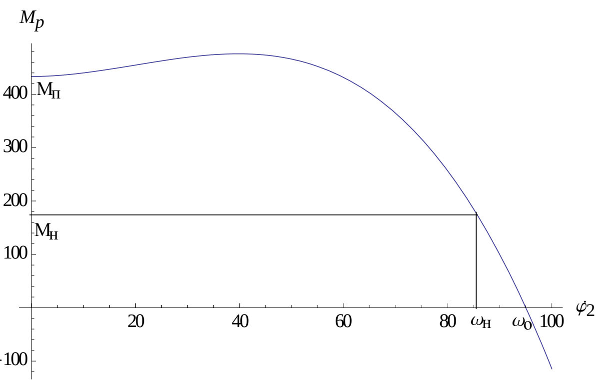


Fig. 7. Cubic change since the drive mechanism.

Solution mathematical model for cubic change since the drive mechanism. More interesting is the cubic polynomial in $\dot{\varphi}_1$. It satisfies the conditions of "smoothness" change of function $M_p(\omega) \equiv M_p(\dot{\varphi}_1)$ at the beginning of the movement (when $\omega = \dot{\varphi}_1 = 0$). That is:

$$M_p(\dot{\varphi}_1) = \tilde{A}_1 \cdot \dot{\varphi}_1^3 + \tilde{A}_2 \cdot \dot{\varphi}_1^2 + \tilde{A}_3 \cdot \dot{\varphi}_1 + \tilde{A}_4 . \qquad (13)$$

Terms of constants in the expression (13):

$$M_p\Big|_{\dot{\varphi}_1=0} = M_n ; \frac{dM_p}{d\dot{\varphi}_1}\Big|_{\dot{\varphi}_1=0} = 0; M_p\Big|_{\dot{\varphi}_1=\omega_н} = M_н ; M_p\Big|_{\dot{\varphi}_1=\omega_o} = 0.. \qquad (14)$$

From (11) we obtain the system of equations:

$$\begin{cases} \tilde{A}_4 = M_n ; \\ \tilde{A}_3 = 0; \\ \tilde{A}_1 \cdot \omega_н^3 + \tilde{A}_2 \cdot \omega_н^2 + \tilde{A}_3 \cdot \omega_н + A_4 = M_н ; \\ \tilde{A}_1 \cdot \omega_o^3 + \tilde{A}_2 \cdot \omega_o^2 + \tilde{A}_3 \cdot \omega_o + A_4 = 0. \end{cases}$$

Solve the system of equations by substitution:

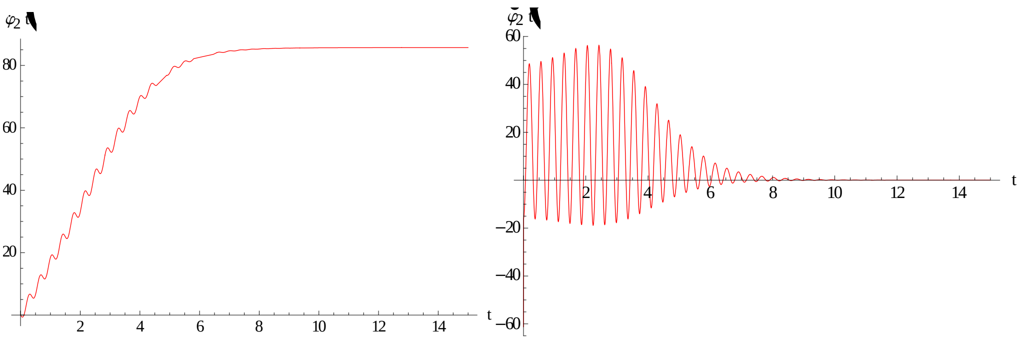
$$\tilde{A}_1 = \frac{M_n \cdot \left(1 - \omega_н^2 / \omega_o^2\right) - M_н}{\omega_н^2 \cdot \left(\omega_н - \omega_o\right)} ; \tilde{A}_2 = -\frac{M_n}{\omega_0^2} - \frac{M_n \cdot \left(1 - \omega_н^2 / \omega_o^2\right) - M_н}{\omega_н^2 \cdot \left(\omega_н - \omega_o\right)} \cdot \omega_o ; \tilde{A}_3 = 0; \tilde{A}_4 = M_n .$$

Thus, we have a cubic polynomial in $\dot{\varphi}_1$ type:

$$M_p(\dot{\varphi}_1) = \frac{M_n \cdot \left(1 - \omega_н^2 / \omega_o^2\right) - M_н}{\omega_н^2 \cdot \left(\omega_н - \omega_o\right)} \cdot \dot{\varphi}_1^3 - \left(\frac{M_n}{\omega_0^2} + \frac{M_n \cdot \left(1 - \omega_н^2 / \omega_o^2\right) - M_н}{\omega_н^2 \cdot \left(\omega_н - \omega_o\right)} \cdot \omega_o \right) \cdot \dot{\varphi}_1^2 + M_n . \qquad (15)$$

Constants Mn, Mn, ωn, ωo, are given.

Solve equation (1) with regard to dependence (15) to change the drive cubic moments using Mathematica package and build graphs of the angular velocity and acceleration beater from time to threshing speed of 30 m / s (Fig. 8).



a) b)

Fig. 8. characteristics depending angular velocity (a) and acceleration (b) beater on timefor cubic change since the drive mechanism for the angular velocity surface of Bill 30 m / s (stiffness of 1000 Nm / m).

Conclusion. After analyzing the graphs you will notice that there are fluctuations in angular velocity and acceleration beater. These fluctuations are undesirable because they result in a beater vibration transmitted to the drive and the entire structure threshing unit bearings and very combiner. It was established that the increase in stiffness drive mechanism increases the frequency of oscillation angular velocity and acceleration beater. Also found that the constant drive moment since there are "beating" and so this mode of operation is not profitable. Movement beater is firmer at parabolic or cubic change since the drive mechanism. This oscillation angular velocity and acceleration beater is less than a constant point of the drive mechanism.

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Predstavlenы Studies movement dynamics beater zernouborochnoho combine. Studies were conducted for two cases Changed drive points: Constant time drive mechanism; Changing parabolic moment. Installed dependence amplytudы velocity fluctuations beater and engine from zhestkosty drive.

Molotylnыy drum drive, zhestkost, velocity, dynamics.

The research of dynamic motion in threshing drum of combine harvester is conducted. The research was conducted for two cases of change the drive point: constant moment of drive mechanism; parabolic changing moment. The dependence of vibration amplitude of speed in the threshing drum and the engine from drive stiffness is established.

Threshing drum, drive, stiffness, speed, dynamic.