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Analysis of the optimal mode of movement HIDROZAHVATA FOR Logs

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The paper analysis of the optimal dynamic and optimal energy modes of motion of the hydraulic cylinder that controls the jaws of capture.

Hidrozahvat, optimization, dynamic loads, power grabbing, jaw.

Problem. Grapple for logs - a mechanism for wood, which can be attached to the crane system manipulyatornoho loader, logging tractors, forwarders, and other machines for loading, unloading, sorting and stacking operations in warehouses or forest groves. Grapples logging tractors are widely used in the timber industry for many years. Statistics show that feller packaging with utilization rate of 75 percent [1]. However, only a few references can be found on the mechanics of design or capture grab timber. Because grasping power is a key factor used to determine the structure and parameters bunk in the design process, it is necessary to develop more sophisticated models to understand how forces act admiration.

Analysis of recent research. Application hydraulic drives are the most common seizure. They differ in terms of cylinder, with a sloping, vertical and horizontal cylinders [1]. Theoretical aspects to be considered in the design process grabs, this structural properties, parameters and kinematics motion grab mechanism [2]. Developing the concept of capturing grabs wood was first described by Tauber [3], and the definition of geometrical parameters claw mechanisms highlighted in the work of AP Asyatkyna [4] S. Hrytsiuk [5] and other authors. Research on optimization of various mechanical movement of dedicated work [6, 7, 8], which is considered optimal control traffic load, construction and handling machines. However, studies of optimization mechanisms grab movement is practically not carried out.

The purpose of research. Analyze and compare the laws of motion of the jaws grab hidrozahvata for energy and dynamic criteria.

Results. Grab device present in the form of a flat mechanism (fig. 1). It consists of five moving parts: 1 - rod cylinder; 2 - cylinder; 3 - right jaw; 4 - left jaw; 5 - the lever that provides symmetrical movement of the jaws 3 and 4 and the fixed link bunk frame construction. This mechanism has one degree of mobility, that is a leading link. That link is the cylinder rod.

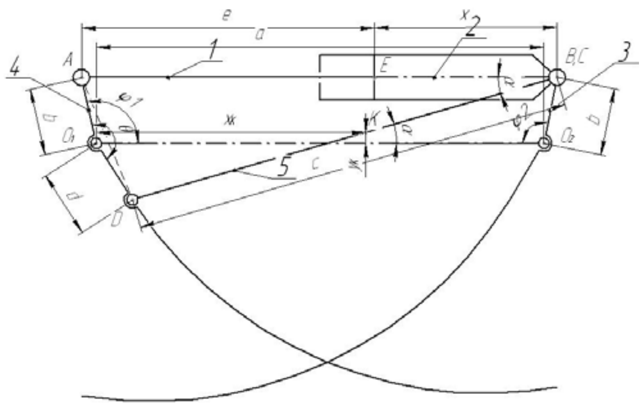

Fig. Figure 1. Grab Bucket.

Initial data defining geometrical parameters bunk is: b = d = 0,12m, e = 0.6 m, c = 0,79m, θ = 160 °, a = 0,8m.

Move the cylinder rod characterized coordinate x, and moving jaw defined by coordinates φ1 and φ2, which are defined dependencies:

$$\varphi_1 = \arccos\left(-B + \sqrt{\frac{B^2 - AC}{A}}\right) \quad (1)$$

$$\varphi_2 = \arccos\{\frac{1}{b}[a - d\cos(\theta - \varphi_1) - \frac{e+x}{2} - \frac{c^2 - b^2 - d^2 + 2bd\cos\theta}{2(e+x)}]\} \quad (2)$$

where to simplify expressions use the following equation:

$$A = b^2 - 2bd\cos\theta + d^2;$$

$$B = \frac{1}{2}(b - d\cos\theta)(e - x - \frac{c^2 - b^2 - d^2 + 2bd\cos\theta}{e + x});$$

$$C = \frac{1}{4}(e + x - \frac{c^2 - b^2 - d^2 + 2bd\cos\theta}{e + x})^2 - d^2\sin^2\theta,$$

where a - distance between the axes of rotation bunk; b, d - distance from the axis of rotation of the jaws to the axes of their connection with other parts bunk; c - the length of the lever 5; e - the length of the cylinder rod; θ - angle turn left jaw kinematic pairs between A and D.

The angle α, which shows the tilt lever 5 to the horizon is determined by the following expression:

$$\alpha = \arccos\left(\frac{(e+x)^2 + c^2 - b^2 - d^2 + 2bd\cos\theta}{2c(e+x)}\right) \quad (3)$$

The lever 5 performs plane-parallel motion - translational movement of the center of mass (point K) and rotate around the center of the angular coordinate α. The coordinates of K are determined by the relationship:

$$\begin{cases} x_K = d\cos(\theta - \varphi_1) + \frac{1}{2}c\cos\alpha; \\ y_K = -d\sin(\theta - \varphi_1) + \frac{1}{2}c\sin\alpha. \end{cases} \quad (4)$$

We find also summarized in terms of speed K:

$$\begin{cases} \dot{x}_K = \dot{\varphi}_1 d\sin(\theta - \varphi_1) - \frac{\dot{\alpha}}{2}c\sin\alpha; \\ \dot{y}_K = \dot{\varphi}_1 d\cos(\theta - \varphi_1) + \frac{\dot{\alpha}}{2}c\cos\alpha. \end{cases} \quad (5)$$

Jaws 4 and 3 perform rotational movement relative to the points O1 and O2 and characterized by angular coordinates φ1 and φ2. 1 cylinder rod performs translational motion and its mass center coordinates the coordinates of point A.

Sleeve 2 cylinder performs translational motion and its mass center coordinates the coordinates of point B. neglects possible rotating rod and cylinder liners because they are virtually absent.

Find the best power grab mode of motion capture. To do this, use the integral criterion, which is the average of the time value of the kinetic energy of motion

$$I_T = \frac{1}{t_1}\int_0^{t_1} T dt, \quad (6)$$

where t - time; t1 = 5 s - the length of the cylinder rod movement from one extreme position to another; T - kinetic energy bunk.

Define kinetic energy Grapple

$$T = \frac{1}{2}m_1 V_A^2 + \frac{1}{2}m_2 V_B^2 + \frac{1}{2}J_{O2}\dot{\varphi}_2^2 + \frac{1}{2}J_{O1}\dot{\varphi}_1^2 + \frac{1}{2}m_5(\dot{x}_K^2 + \dot{y}_K^2) + \frac{1}{2}J_K\dot{\alpha}^2, \quad (7)$$

where m1 = 15 kg, m2 = 20kg, m5 = 10kg - under weight rod, cylinder liners and instruments; JO1 = JO2 = 6,54kh · m2 - moments of inertia relative to the axes of rotation of the jaws; JK = 0,52kh · m2 - the moment of inertia of the arm relative to the center of mass; VA, VB linear velocity points A and B jaws Grapple (Fig. 1); - Horizontal and vertical components of the velocity of the center of mass of the lever ;, - angular velocity respectively left, right arm and jaw. Speed points A and B jaws bunk defined dependencies:$\dot{x}_K \dot{y}_K$ $\dot{\varphi}_1 \dot{\varphi}_2 \dot{\alpha}$

$$\begin{cases} V_A = \dot{\varphi}_1 b \\ V_B = \dot{\varphi}_2 b' \end{cases} \quad (8)$$

where b - the length of the arm cylinder of focus.

After substitution dependencies (5) and (8) in expression (7), we obtain

$$T = \frac{1}{2}(m_1 b^2 + m_5 d^2 + J_{O1})\dot{\varphi}_1^2 + \frac{1}{2}(m_2 b^2 + J_{O2})\dot{\varphi}_2^2 +$$
$$+\frac{1}{2}({m_5 c^2}/_4 + J_K)\dot{\alpha}^2 + \frac{1}{2}m_5 cd\dot{\varphi}_1\dot{\alpha}\cos(\theta + \alpha + \varphi_1). \quad (9)$$

If we accept:

$$\begin{cases} \dot{\varphi}_1 = \dot{x}\dfrac{\partial\varphi_1}{\partial x} \\ \dot{\varphi}_2 = \dot{x}\dfrac{\partial\varphi_2}{\partial x} \\ \dot{\alpha} = \dot{x}\dfrac{\partial\alpha}{\partial x} \end{cases}, \quad (10)$$

then the kinetic energy is as follows:

$$T = \frac{1}{2}(m_1 b^2 + m_5 d^2 + J_{O1})\dot{x}^2(\frac{\partial\varphi_1}{\partial x})^2 + \frac{1}{2}(m_2 b^2 + J_{O2})\dot{x}^2(\frac{\partial\varphi_2}{\partial x})^2 +$$
$$+\frac{1}{2}({m_5 c^2}/_4 + J_K)\dot{x}^2(\frac{\partial\alpha}{\partial x})^2 + \frac{1}{2}m_5 cd\dot{x}^2\frac{\partial\alpha}{\partial x}\frac{\partial\varphi_1}{\partial x}\cos(\theta + \alpha + \varphi_1). \quad (11)$$

To find the optimal power grab mode motion mechanism applicable classical calculus of variations. To do this, define the necessary condition for a minimum criterion (6) - Euler-Poisson [7], in view of (11). The condition is a minimum criterion IT equation:

$$\frac{d}{dt}\frac{\partial T}{\partial \dot{x}} - \frac{\partial T}{\partial x} = 0. \quad (12)$$

The resulting equation is nonlinear homogeneous differential equation of second order. The solution of the given equation is quite a challenge that can not be solved in analytical form. Therefore, use the direct variational method proposed in [10]. Define the required boundary conditions:

$$\begin{cases} x(0) = x_0; \dot{x}(0) = 0; \ddot{x}(0) = 0; \\ x(t_1/2) = q_1; \\ x(t_1) = x_0 + s; \dot{x}(t_1) = 0; \ddot{x}(t_1) = 0. \end{cases} \quad (13)$$

According to the method, we find supporting function, which is the solution of the boundary value problem:

$$x(t) = \frac{1}{T1^6}(t^3(-64q3(t - T1)^3 + s(2t - T1)(16t^2 - 37tT1 +$$
$$22T1^2)) + (64t^6 - 192t^5 T1 + 192t^4 T1^2 - 64t^3 T1^3 + T1^6)x0), \quad (14)$$

where q1 - the position of the cylinder rod; s = 0,25m - move the cylinder rod; x0 = 0,05m - initial position of the cylinder. Substituting the law of motion in the integrand of the functional (6) and find the integral. Functional turns into a complex function parameter q1. In order to minimize the value of the integral equation to be solved:

$$\frac{\partial I}{\partial q_1} = 0 \quad (15)$$

On the basis of the calculations were the least value criterion q1 = 0.1725. For this function values are kinematic motion of the jaws (Fig. 2 - Fig. 5).

To optimize the dynamic mode of motion capture use grab integral criterion, which is the average of the values of dynamic motion component power drive mechanism.

$$I_V = \frac{1}{t_1}\int_0^{t_1} V dt, \tag{16}$$

Define acceleration energy of the mechanical system Grapple

$$V = \frac{1}{2}m_1 W_A^2 + \frac{1}{2}m_2 W_B^2 + \frac{1}{2}J_{O2}\ddot{\varphi}_2^2 + \frac{1}{2}J_{O1}\ddot{\varphi}_1^2 + \frac{1}{2}m_5(\ddot{x}_K^2 + \ddot{y}_K^2) + \frac{1}{2}J_K\ddot{\alpha}^2, \tag{17}$$

Find the minimum criteria necessary condition (17) - Euler-Poisson

$$\frac{d}{dt}\frac{\partial V}{\partial \dot{x}} - \frac{\partial V}{\partial x} = 0. \tag{18}$$

Define the required boundary conditions:

$$\begin{cases} x(0) = x_0; \dot{x}(0) = 0; \ddot{x}(0) = 0; \\ x(t_1/3) = q_2; \\ x(2\,t_1/3) = q_3 \\ x(t_1) = x_0 + s; \dot{x}(t_1) = 0; \ddot{x}(t_1) = 0. \end{cases} \tag{19}$$

Find the supporting function, which is the solution of the boundary value problem:

$$\begin{aligned} x(t) = \frac{1}{8{t_1}^7}\Big(&729q_2t^3(3t-2t_1)(t-t_1)^3(3t-t_1)\big(-729q_3t^3(t-t_1)^3 \\ &+ (3t-2t_1)(st^3(141t^2 - 312tt_1 + 175{t_1}^2) \\ &+ t_1(81t^4 - 162t^3t_1 + 63t^2{t_1}^2 + 18t{t_1}^3 + 4{t_1}^4)x0)\big)\Big) \end{aligned} \tag{20}$$

where q2, q3 - position cylinder rod

Solve the system of equations to minimize the value of the integral:

$$\begin{cases} \frac{\partial I}{\partial q_2} = 0; \\ \frac{\partial I}{\partial q_3} = 0. \end{cases} \tag{21}$$

Rozvyazavshy system obtain q1 = 0,1075 and q2 = 0,2375. For these values of the criteria and construct graphs of functions (Fig. 2 - Fig. 5).

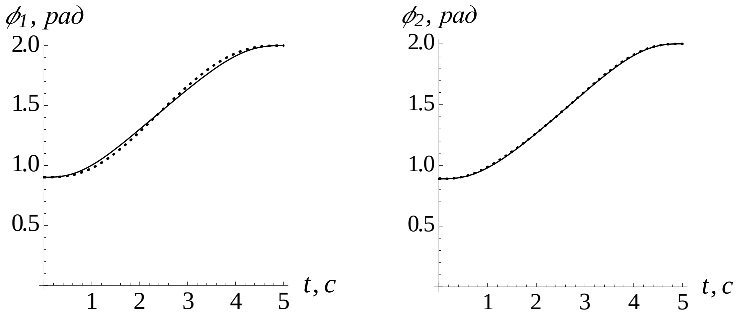

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Fig. 2. Graphs changing angles and angular coordinates - φ1 (t); b - φ2 (t).

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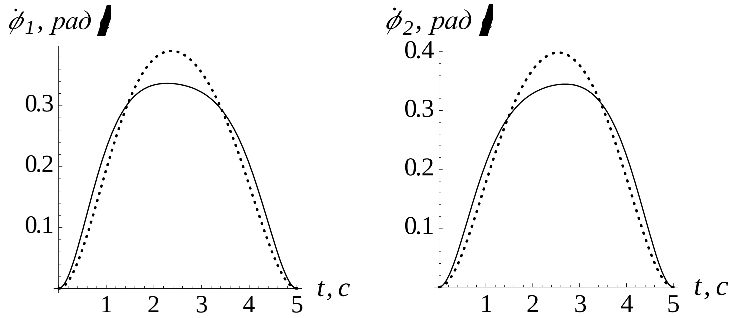

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Fig. 3. Charts angular velocities: a - 1 (t); B - 2 (t).$\dot{\varphi}\dot{\varphi}$

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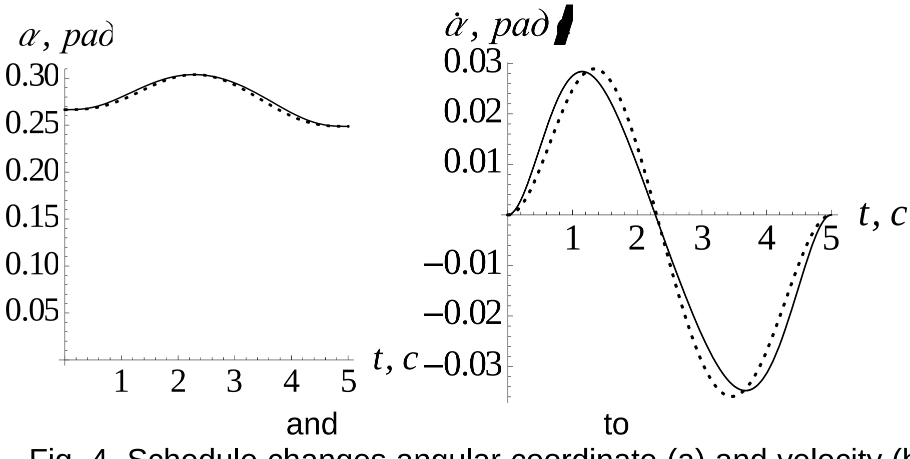

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Fig. 4. Schedule changes angular coordinate (a) and velocity (b) of the handle.

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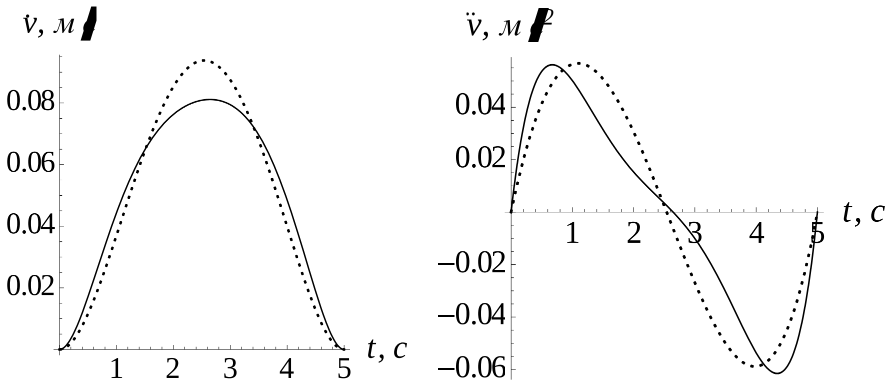

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Fig. 5. The graphics speed (a) and acceleration (b) rod cylinder.

—— оптимальний динамічний режим ····· оптимальний енергетичний режим

From the graph shows data obtained optimal modes of motion cylinder ensure a smooth change of angular velocity jaws that provide minimum criteria chosen the mean value of the dynamic component of the power drive mechanism and the mean value of the kinetic energy in motion.

Conclusion. After analyzing motion graphics functions jaws and cylinder hidrozahvata with different modes of motion shows that the change of angular coordinates almost identical, but the optimal dynamic mode motion peak velocity are less important than the optimal energy. So we can conclude that the optimal dynamic motion mode is more suitable for this mechanism, as during the movement of the present law, the reduced dynamic forces that positively affect the durability of parts and service life of the mechanism.

References

1. *Wang, J. and G. Li.* 1993. A review of log grapple used in China. J. of Forest Engineering. 4 (2): 33-36.
2. *Wang, J.* 1990. Study on the theories of log grapples. Ph.D. Dissertation. Northeast Forestry University, Harbin, China. 311 p.
3. *BA Tauber* Hreyfernые Mechanisms. Theory, calculation and constructions / BA Tauber. - M .: Mashinostroenie, 1967. - 424 p.
4. *Asyatkyn AP* Study of major konstruktyvnыh and эkspluatatsyonnыh parameters for napornыh hreyferov of loading silo zhyvotnovodcheskyh on farms. Author. Thesis. candidate. Sc. Science / AP Asyatkyn. - Krasnodar, 1966. - 25 p.
5. *Hrytsiuk SI* Methods proektyrovochnoho calculation of hydraulic grapple for steblevыh cargoes / SI Hrytsiuk // Traktorы and SH machine. - 1975. - № 12. - P. 22-24.
6. *Grigorov OV* Optimal traffic control hoisting machines [Text] / EV Grigorov, VS Loveykin. - K .: CMD PA, 1997. - 262 p.

7. *Loveykyn VS* Raschetы optimal regimes of motion mechanisms of building machines / VS Loveykyn. - K .: CMD PA, 1990. - 168 p.
8. *Modeling* dynamics of hoisting machines [Text] / [VS Loveykin, Y. Chovniuk, SI Pastushenko]. - K .: Nauka, 2004. - 285 p.
9. *Loveykin VS* Optimization of transient states of motion of mechanical systems direct variational method [Text] / VS Loveykin, AV Loveykin, JO Romasevych // Bulletin TDTU. - 2010 - Vol 15. - №1. - C. 201-206.
10. *Loveykin VS* Optimization of transient states of motion of mechanical systems direct variational method / VS Loveykin, JO Romasevych. - Nizhin: Publisher PE "Lysenko MM", 2010. - 184 p.

In the work provedёn poluchennыh optimal Dynamic analysis and optimal power machinery regimes movement cylinder, kotorыу upravlyaet mouth capture.

Hydrozahvat, optimization, Dynamic load, power capture, mouth.

In paper the analysis of optimal dynamic and optimal energy modes of motion of hydraulic cylinder that controls the jaws of capture.

Hydraulic grips, optimization, dynamic forces, gripping force, jaw.

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PERSPECTIVES OF NONPILOT FLYING DEVICES IN ORGANICAL FARMING USAGE

V.O. Dubrovyn, V.G. Myronenko

In paper indicated the perspective tendency of technical production practice development of ecological and clean plant products in the system of organic farming. As well as determinate scientific and organizational measures of effective usage unmanned flying devices in biological plant protection technologies.

Ecologically clean products, organic farming, unmanned flying devices, effectiveness.

Problem. Solving the problem of quality food human guarantee in a condition deterioration of the ecological state of the environment requires a comprehensive restructuring of agriculture-based bioenergy and conversion to organic farming.