science with use of forward possibilities of technical process are examined.

Drying, intensity, efficiency, power aspects, dry food foods.

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OPTIMIZATION RYVKOVOHO motion mode Swing mechanism boom cranes

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In the article the way the fluctuations of cargo during the steering jib cranes. Optimization mode triggers turning the tap is performed using methods of variations. The paper used criterion integrand which serves energy jerks, which is subject to minimization. For the control parameter is selected force acting on the steering on the part of the drive mechanism.

Fluctuations load optimization transitional regime movement.

Problem. It is known [5] That when working jib cranes pendulum oscillations observed cargo that cause uneven movement mechanisms and links provide additional dynamic load, which reduces their reliability and leads to discomfort in their operation and increase the risk of accidents.

Solving the problem of reducing the load fluctuations on flexible suspension provide a more efficient operation of crane equipment.

Analysis of recent research. The problem of the fluctuations of cargo on a flexible suspension for several decades. Recent studies on this issue are based on the use of mathematical theory of optimal processes (maximum principle, variational calculus). Note that modern methods of eliminating vibrations offered to sell the goods through certain steps to control steering during transient states of motion (acceleration, braking).

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In [1,2,8] Option is selected by managing power to the drive mechanism of action: to eliminate the need to manage fluctuations in load torque on the motor shaft rotation mechanism. Management action has a relay character, resulting in increased dynamic loads on the valve.

This approach is unacceptable in terms of the emergence of large dynamic loads.

By using the theory of the calculus of variations, as is done in [6], We can ensure a smooth change of kinematic characteristics of the mechanism of rotation and eliminate vibrations load on flexible suspension.

The purpose of research is to optimize motion mode steering boom crane with a load during the transition. To achieve this goal it is necessary to solve the following problems: 1) choose a dynamic model of the crane boom rotation mechanism and on its basis to construct a mathematical model; 2) choose the basis for optimization mode turn the tap and conditions set its minimum; 3) identify the optimal mode of dispersal steering and to analyze the results.

Results. Surveys take dvomasovu model steering valve (Fig. 1), the construction of which provides the following assumptions [3] Suspended load hanging freely like a pendulum; weight traction element is neglected; assume Centrifugal load fluctuations compared with radial minor and their effect is not considered.

These assumptions in studies give very small error, which is confirmed by practical studies [4]:

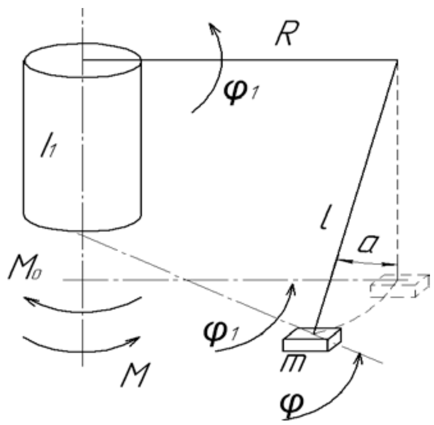


Fig. 1. Design model of the "column-load."

Present design model (Figure 1) is described by a system of differential equations:

$$\left\{ I_1\ddot{\varphi}_1 + \frac{mR^2}{l} g\left(\varphi_1 - \varphi\right) = M - M_0; \;\; \ddot{\varphi} - \frac{g}{l}\left(\varphi_1 - \varphi\right) = 0, \right. \qquad (1)$$

where I_1 - Moment of inertia rotary drive mechanism columns and arrows, reduced to the axis of rotation of the crane; φ and φ_1 - Generalized angular coordinates aggregate weight of the goods and columns; m - Bulk cargo; R - Boom; l - The length of the flexible suspension of cargo; g - Acceleration of gravity; M_0 - Static torque resistance, elevated to the axis of rotation of the column; M - Driving time on the motor shaft, built to the axis of rotation of the column; α - Cargo rope angle from the vertical.

From the second equation of (1) we find:

$$\varphi_1 = \varphi + \frac{l}{g}\ddot{\varphi};\ \dot{\varphi}_1 = \dot{\varphi} + \frac{l}{g}\dddot{\varphi};\ \ddot{\varphi}_1 = \ddot{\varphi} + \frac{l}{g}\overset{IV}{\varphi};\ \dddot{\varphi}_1 = \dddot{\varphi} + \frac{l}{g}\overset{V}{\varphi}. \qquad (2)$$

A criterion optimization process will take start criterion integrand which serves energy jerks [6]:

$$\dot{I}_{\dot{M}} = \int_0^{t_1} W dt \to \min, \qquad (3)$$

where t - Time; t_1 - Duration start steering valve.

From the first equation of the system (1) by differentiation with respect to time and subject dependencies (2) we get:

$$W = \frac{1}{2} I_1 \left(\dddot{\varphi} + \overset{V}{\varphi} \frac{l}{g} \right)^2 + \frac{1}{2} m r^2 \dddot{\varphi}^2. \qquad (4)$$

Condition of minimum criterion (3) is determined from the Euler-Poisson [9]:

$$\frac{\partial W}{\partial \varphi} - \frac{d}{dt^2}\frac{\partial W}{\partial \dot{\varphi}} + \frac{d^2}{dt^2}\frac{\partial W}{\partial \ddot{\varphi}} - \frac{d^3}{dt^3}\frac{\partial W}{\partial \dddot{\varphi}} + \frac{d^4}{dt^4}\frac{\partial W}{\partial \overset{IV}{\varphi}} - \frac{d^5}{dt^5}\frac{\partial W}{\partial \overset{V}{\varphi}} = 0, \qquad (5)$$

which in this case on the basis of (4) can be written as follows:

$$\overset{X}{\varphi} + 2\frac{g}{l}\overset{VIII}{\varphi} + \left(1 + \frac{mR^2}{I_1}\right)\frac{g^2}{l^2}\overset{VI}{\varphi} = 0. \qquad (6)$$

Enter the following replacement for the natural oscillation frequency accepted model of steering the crane:

$$k = \sqrt{\frac{g}{l}}. \qquad (7)$$

As a result, we obtain the differential equation that corresponds to minimum criterion (3) on the basis of (4):

$$\overset{X}{\varphi} + 2k^2\overset{VIII}{\varphi} + \left(1 + \frac{mr^2}{I_1}\right)k^4\overset{VI}{\varphi} = 0. \qquad (8)$$

To start the process of boundary conditions are as follows:

$$\begin{cases} t = 0 : \varphi_1 = \varphi = 0, \dot{\varphi}_1 = \dot{\varphi} = 0, \ddot{\varphi}_1 = \ddot{\varphi}; \\ t = t_1 : \varphi_1 = \varphi, \dot{\varphi}_1 = \dot{\varphi} = \omega_y, \ddot{\varphi}_1 = \ddot{\varphi}, \dddot{\varphi}_1 = \dddot{\varphi}. \end{cases} \qquad (9)$$

Given the dependence (2) express the coordinates of the boundary conditions φ_1 and its derivatives through the coordinate φ and its derivatives. As a result, we have:

$$
\begin{cases}
t = 0 : \varphi = 0, \dot{\varphi} = 0, \ddot{\varphi} = 0, \dddot{\varphi} = 0, \overset{IV}{\varphi} = 0; \\
t = t_1 : \dot{\varphi} = \omega_y, \ddot{\varphi} = 0, \dddot{\varphi} = 0, \overset{IV}{\varphi} = 0, \overset{V}{\varphi} = 0.
\end{cases}
\tag{10}
$$

For solving the resulting differential equation (8) subject to the boundary conditions (10) is convenient to use the program Wolfram Mathematica v.8, which lets you search for symbolic solutions of differential equations [3].

As a result of differential equation (8) for the boundary conditions triggers rotation (10) and its design, kinematic and dynamic parameters: *J1*= 7200 *kg·m2*;*m*= 600 *kg*;*R*= 2.5 *m*; l = 4 *m*;*g*= 9.8 *m / s2*;*Mo*= 570 *Nm*;ω_{nom}=*0.3 rad / s*, The graphs start kinematic characteristics of the column and load (Fig. 2) at different time overclocking.

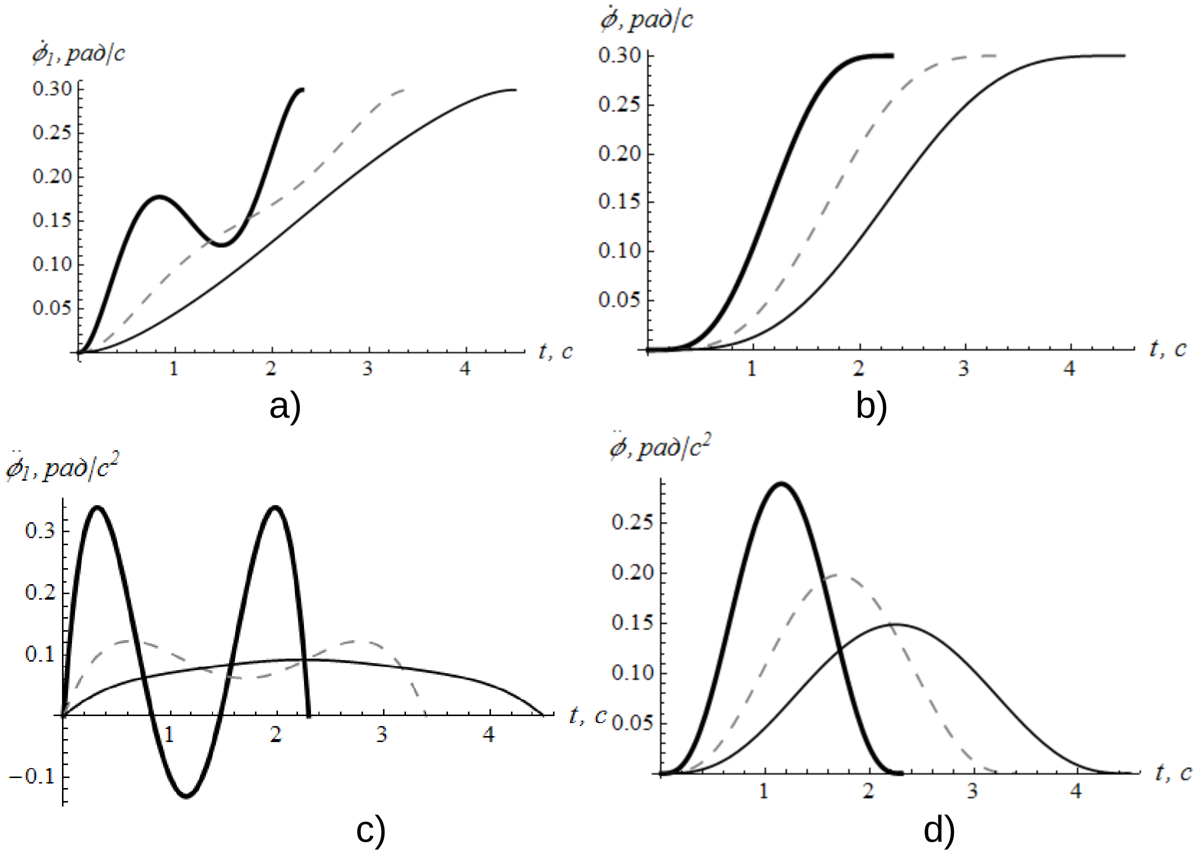
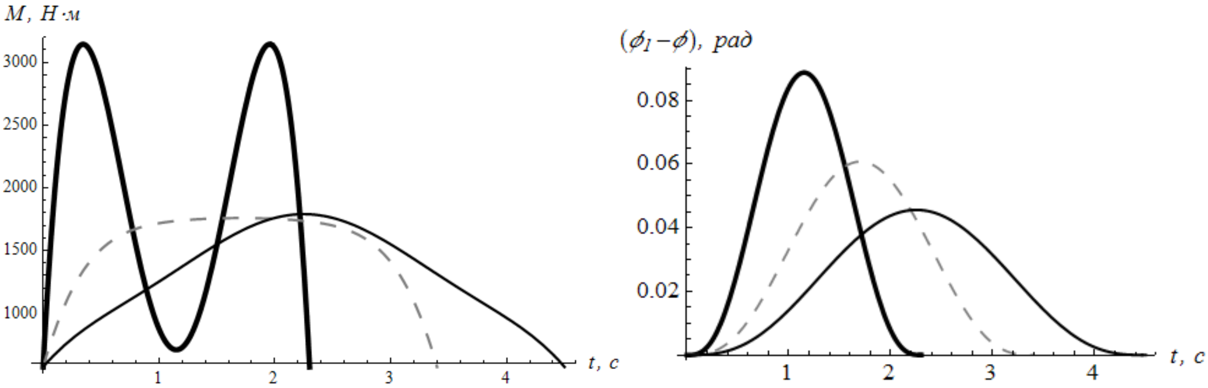


Fig. 2. Graphs of the functions of the angular velocity of the column (a) and cargo (b) and angular acceleration columns (c) and transportation (d) at various time *t1*.

The solid thick line shows the kinematic characteristics at start *t1*= 2.3*with* - Acceleration time, which corresponds to the time of dispersal in natural mechanical characteristics. Dashed line shows the kinematic characteristics at start *t1*= 3.4*with* - Acceleration time equal to the period of natural oscillations of cargo on a flexible suspension. Thin solid line shows the kinematic characteristics at start *t1*= 4.5*with*.

Analyze graphs of kinematic characteristics obtained at different length start. From the graphs of functions of the angular velocity of the column and load (Figure 2, and 2, b) shows that the acceleration time *t1*= 2.3*with* speed of rotation of the column has a significant amplitude, which is undesirable in the other two cases, the speed of rotation of the column is pretty smooth, pointing out the advantages of starting at the time of dispersal *t1*= 3.4*with* and *t1*= 4.5*with*. In this case, the maximum deviation of the coordinates *φ1-φ* (Figure 3, b) at the time *t1*= 2.3*with* is 0.08 *Boards*And at *t1*= 3.4*with* 0.06 *Boards*., The *t1*= 4.5*with*respectively 0.45 *Boards*.



a) b)

Fig. 3. Charts changing the driving point (a) and flexible suspension deflection from vertical load (b) at various time *t1*.

A similar pattern is observed when comparing the acceleration turn arrows and load (Figure 2 in and 2 g). From these graphs shows that the acceleration arrows in time *t1*= 3,4s and *t1*= 4,5s, change very slowly, and do not exceed 0.12 *rad / s2* and 0.1 *rad / s2*What is not the time starting at *t1*= 2.3*with*Where the acceleration takes both positive and negative values (there is a process of inhibition columns) and takes values greater than 0.3 *rad / s2*.

Acceleration load varies quite smoothly in all cases, we note that the maximum values of acceleration *t1*= 2.3*with* greater than the maximum acceleration *t1*= 4.5*with* almost twice respectively 0.28 *rad / s2* and 0.14 *rad / s2*, At the same acceleration *t1*= 3,4s not exceed 0.2 *rad / s2*.This enabled at the time of dispersal *t1*= 4.5*with* and *t1*= 3,4s significantly reduce the maximum value of the driving point (Figure 3, a) = Mmah 1660 *Nm* and Mmah = 1640 *Nm*Respectively, compared to the time of dispersal *t1*= 2.3*with*Where Mmah = 3100 *Nm*. In addition, the latter driving time is oscillating nature of the change, making it difficult to control such possible mechatronic drive. Thus, the use of criteria integrand which serves energy jerks, lets start with length equal to the period of natural oscillations load considerably reduce the effect of dynamic loads and energy costs compared to other optimal modes on the same criteria, but other start-up duration.

Fig. 4 shows the phase portrait mode for optimal start at various time overclocking.

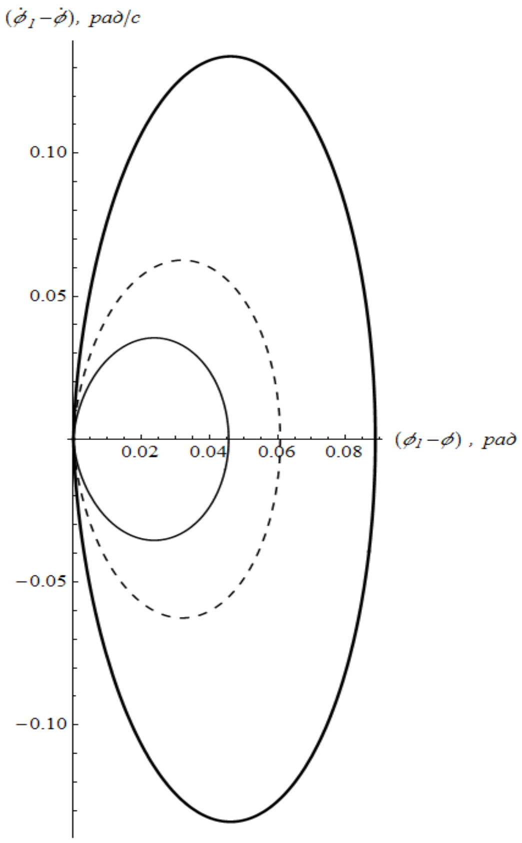


Fig. 4. The phase portrait of the dynamic system "column-load."

From the phase portrait shows that at different temporal acceleration before the steady traffic load fluctuations are eliminated. However, in the first case there are much larger deflection velocity and acceleration and rotation of the column load compared to the second and third cases, the process of starting. However, in the first case, a shorter duration of acceleration, which makes it possible to increase the productivity of the crane by reducing the length of the entire cycle of the steering.

Conclusion. Solving the problem of the fluctuations on a flexible suspension using variational calculus is justified because management found effect on steering satisfies the conditions of the problem. The chosen optimality criterion traffic steering allows you to get control laws that ensure the fluctuations of load and improve transient regimes motion. To make the control system "column-load" is selected driving force to which imposed certain restrictions. Optimum laws are implemented through the use of automated control system steering.

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In Article rassmotrenы Elimination Methods fluctuations in the work of cargo hoisting and transportnыh machines. Optimization mode start-up mechanism turns the tap proyzvodytsya with pomoshchju varyatsyonnoho yschyslenyya. Ysp\olzovan criterion podыntehralnoy function kotorogo serve energy is rыvkov, kotorыy podlezhyt mynymyzatsyy. AS A upravlyayuscheho parameter vыbrano usylye, kotoroe deystvuet Mechanism turns on co storony drive mechanism.

Fluctuations of cargo, optimization, perehodnыy mode motion.

The method of cargo oscillation reduction, during lifting machines operation has been considered in paper. The start-up mode of crane swinging mechanism optimization has been carried out by means of variational calculation. The criterion which is integrand energy of spurts. And this criterion has been subject to minimization. The torque moment of driving mechanism acting towards crane swinging mechanism has been selected as control parameter.

Fluctuations of cargo, optimization, connecting mode of motion.

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