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In the work predstavlenы Theoretically Results of research and эksperymentalnыh movement dynamics vyntovoho conveyor-mixer t START TIME.

Dynamycheskaya model optimization criterion, nadezhnost constructions.

In paper results of theoretical and experimental studies of dynamics of motion screw conveyor-mixer are presented.

Dynamic model, optimization criterion, reliability of construction.

UDC 621,867,133

METHOD OF EXPERIMENTAL RESEARCH driving dynamics Conveyor

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The basic results of theoretical research and Optimization motion mode scraper conveyor to handle the fluctuations that occur in the body of traction during launch. The method of experimental studies of the dynamics of motion scraper conveyor.

Dynamic load drive, drag coefficient, the optimal mode of movement.

Problem. While working scraper conveyors in organ and cell traction drive there are significant dynamic forces caused by starting or brake conveyor sudden jamming traction body, or during steady motion. Theoretical studies have established that such dynamic forces give rise to oscillatory processes with significant changes in speed and acceleration [5,4].

It is also known that increasing the speed of the conveyor working body leads to reduction in the resistance movement of cargo. A description of this incident friction in mechanical conveyor systems usually causes oscillatory processes in them. All these factors lead to reduced reliability and premature destruction of construction scraper conveyor. In this regard, the optimization of our conveyor motion mode that minimizes fluctuations in the levels of drive mechanism and a flexible traction body.

Analysis of recent research. Study of dynamic processes that occur in conveyors with chain traction body during start-up and steady movement and construction of mathematical models dedicated work [2,9,10].

The question of optimal traffic control mechanisms different purposes covered in [1,3,8]. The article [6] A method of solving optimization problems of motion of mechanical systems using direct variational method. Authors minimized rms dynamic component of the drive force of the mechanical system.

However, studies of optimization of motion scraper conveyors to transport agricultural goods practically not carried out.

Purpose experimental studies is to test the adequacy of theoretical studies, followed by a comparison of the experimental dependences of theoretical.

Results. Before the dynamics of experimental studies were performed scraper conveyor theoretical studies. This was built a dynamic model that corresponds to the real mechanical system and reflects its basic physical properties (Fig. 1).

When building a model made the following assumptions: all items are brand scraper conveyor solids other than transmission mechanism elements and traction body that have elastic properties; casing and conveyor rollers traction stars completely secured tightly.

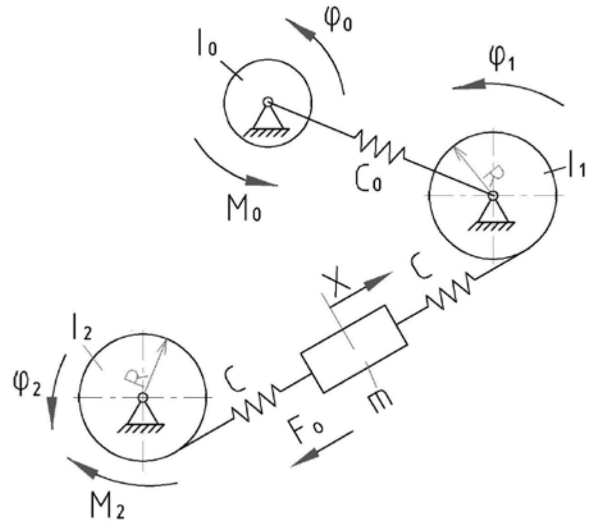


Fig. 1. The dynamic model of scraper conveyor.

The system of differential equations describing dynamic processes in scraper conveyor, prepared under the d'Alembert and has the following form:

$$\begin{cases} I_0\ddot{\varphi}_0 = M_0 - c_0\left(\varphi_0 - \varphi_1\right); \\ I_1\ddot{\varphi}_1 = c_0\left(\varphi_0 - \varphi_1\right) - cR\left(\varphi_1 R - x\right); \\ m\ddot{x} = c\left(\varphi_1 R - x\right) - c\left(x - \varphi_2 R\right) - F_o; \\ I_2\ddot{\varphi}_2 = cR\left(x - \varphi_2 R\right) - M_2, \end{cases} \tag{1}$$

where I_0 - Moment of inertia of the elements of the drive mechanism to pivot axis of the drive shaft; I_1, I_2 - Moments of inertia of the drive shaft belt tensioner and respect their own axes of rotation; $\varphi_0, \varphi_1, \varphi_2$ - Angular coordinates of the rotation under the drive mechanism and a drive belt tensioner stars; x - Linear coordinate of the center of mass of the working leg assembly line; m - Weight that focuses on working branch conveyor; c_0 - Stiffness of the drive mechanism, built to the axis of rotation of the drive shaft; c - Stiffness traction chain conveyor; R - Radii drive and tension sprockets; M_0 - Driving time over, built to the axis of rotation of the drive shaft; M_2 - Moment of resistance of cargo zacherpuvannya scrapers, built to the axis of rotation of the shaft clamp; F_o - The resistance movement of the conveyor branches.

Solving the differential equation system (1) numerical method, which is implemented using software, Characteristics of velocity and acceleration are presented in the graphs (Fig. 2, 4). These charts reflect the dynamics of the scraper conveyor movement in real mode and built in such a dynamic model parameters:

$$m = 76кг;\ I_0 = 0,7435кг\cdot м^2;\ I_1 = I_2 = 0,00171кг\cdot м^2;$$
$$c_0 = 7378H\cdot м/рад;\ c = 1,3\cdot 10^6\ H/м;\ R = 0,0535м; \qquad (2)$$
$$M_2 = 0,55H\cdot м;\ F_o = 1350H;\ \upsilon = 1,5м/c;\ t_1 = 1c.$$

To optimize traffic control often use the calculus of variations, which makes it possible to get smooth control feature that allows you to "soften" mode of the system [6].

From the equations of system (1) express the linear coordinates of the center of mass of the working leg assembly line x, Angular coordinate rotation drive mechanism φ_0, Driving drum φ_1 Also moving moment M_0 Through angular coordinate φ_2 and its derivatives. This driving time is:

$$M_0 = \left(mR^2 + I_0 + I_1 + I_2\right)\ddot{\varphi}_2 + \left\{\frac{I_0}{c_0}\left[\frac{c_0}{c}\left(m + \frac{2I_2}{R^2}\right) + mR^2 + I_1 + I_2\right] + \right.$$
$$\left. + \frac{m}{c}\left[I_1\left(1 + \frac{2I_2}{mR^2}\right) + I_2\right]\right\}\overset{IV}{\varphi}_2 + \frac{mI_0I_1I_2}{c_0c}\overset{VIII}{\varphi}_2 + M_2 + F_oR. \qquad (3)$$

For evaluation criterion mode of motion of the conveyor at the site selected start standard deviation center of mass acceleration and traction scrapers body at the time of expiration of the tensioning drum:

$$I_{22} = \left[\frac{1}{t_1}\int_0^{t_1} f_{22}dt\right]^{1/2}; \qquad (4)$$

$$f_{22} = \left(\ddot{x} - \ddot{\varphi}_2 R\right)^2 = \left(\frac{I_2}{cR}\overset{IV}{\varphi}_2\right)^2. \qquad (5)$$

where t_1 - Duration of acceleration conveyor.

Since the criteria reflect undesirable properties scraper conveyor, it must be minimized. The condition of a minimum criterion (4) of the integral of expression (5) is the Euler-Poisson [11]:

$$\frac{d^4}{dt^4}\frac{\partial f_{22}}{\partial \overset{IV}{\varphi}_2} = 2\left(\frac{I_2}{cR}\right)\overset{VIII}{\varphi}_2 = 0. \qquad (6)$$

The last expression is zero when $\overset{VIII}{\varphi}_2 = 0$.

Optimization mode start conveyor made at such boundary conditions of motion:

$$при\ t = 0 \quad \Rightarrow \quad \varphi_2 = 0,\ \dot{\varphi}_2 = 0,\ \ddot{\varphi}_2 = 0,\ \dddot{\varphi}_2 = 0;$$

$$при\ t = t_1 \quad \Rightarrow \quad \dot{\varphi}_2 = \omega_y,\ \ddot{\varphi}_2 = 0,\ \dddot{\varphi}_2 = 0,\ \overset{IV}{\varphi}_2 = 0,$$

where ω_y - Set the speed of rotation of the shaft clamp.

Consistently integrating equation $\overset{VIII}{\varphi_2} = 0$ Given boundary conditions on the movement area start we get optimum law of motion tensioning drum. With this mode, using the equation system (1) Optimum motion modes other parts of the conveyor belt.

Schedules angular velocity $\dot{\varphi}_2$ (Fig. 3) and angular acceleration $\ddot{\varphi}_2$ (Fig. 5) on the shaft sprocket stretch for optimal motion mode under the same parameters of the dynamic model (2). The change in angular velocity and angular acceleration other parts conveyor has the same character as shown in Fig. 2, 5.

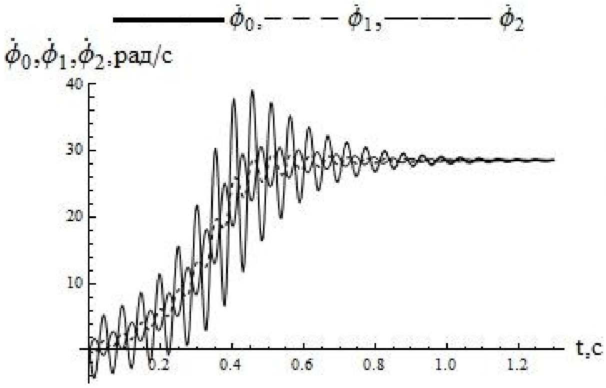


Fig. Figure 2. The change of angular velocity $\dot{\varphi}_0, \dot{\varphi}_1, \dot{\varphi}_2$ no optimization mode start.

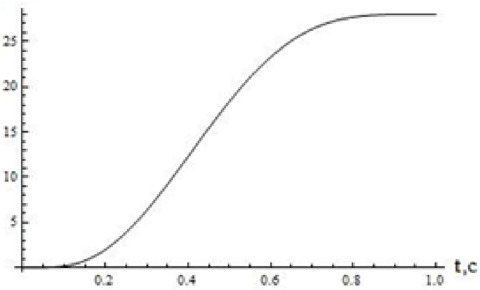


Fig. Figure 3. The change of angular velocity $\dot{\varphi}_2$ for the optimal law

Comparing the optimal schedule of change of angular velocity and angular acceleration conveyor chains with graphs without optimization, it can be concluded that such a regime made it possible to start to minimize fluctuations in the levels of the drive mechanism and a flexible scraper conveyor traction body caused by dynamic loads and ensure a smooth change of angular velocity and acceleration scraper conveyor chains.

Experimental studies were conducted on the real object (full scale simulation) because it allows most reliably identify patterns passage protsese investigated.

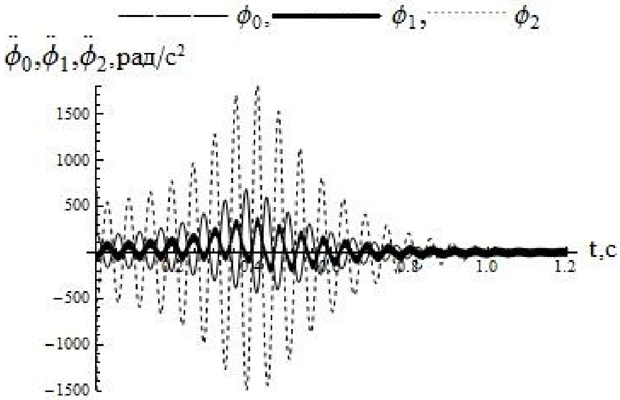


Fig. Figure 4. The change of angular acceleration $\ddot{\varphi}_0, \ddot{\varphi}_1, \ddot{\varphi}_2$ no optimization mode start.

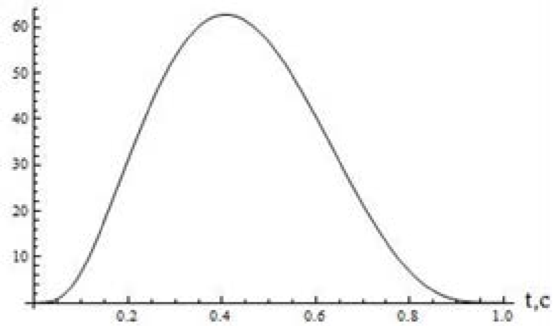


Fig. 5. Schedule changes angular acceleration $\ddot{\varphi}_2$ for the optimal law.

The program includes a series of experimental studies necessary works that allow to confirm previous theoretical principles of improving the efficiency of the assembly line by reducing the dynamic loads acting on the traction elements of belt and drive through traffic optimization. Also, experimental research is expected to identify the impact speed of the traction body, scrapers and gutter material by a factor of resistance to movement.

According to the program of experimental research includes:

- development and production of full-scale model of the scraper conveyor;
- selection and development of measurement and recording equipment to determine the parameters of the basic model of field;
- software development to implement the optimal full-scale model law of motion;
- experiments to determine the parameters of the scraper conveyor with real traffic and when driving at optimum law;
- experiments to study the dependence of the resistance on the speed traction body, the physical and mechanical properties of cargo transported on the material trough and scrapers;
- choice of methods to handle an array of experimental data.

Experimental studies were conducted on Conveyor type TS-40 (Fig. 6), which consists of two traction chains with 9 attached to them scrapers 10, drive 7 and 8 stars stretch. Driving station consists of the induction motor 1, 2 pulleys, 3 stars klynopasovoyi transmission and 4, 5 chain of transmission.

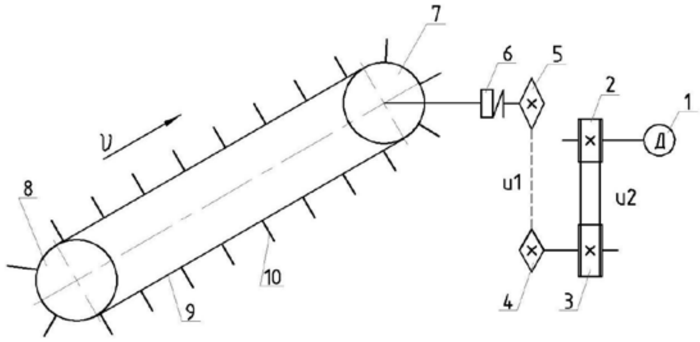


Fig. 6. The kinematics scraper conveyor.

In operation, the scraper conveyor there is considerable traction resistance, which causes rapid wear of traction and the emergence of significant energy costs. Therefore, scrapers and scraper conveyor trough bottom is made of high polyethylene, which has the following properties: low coefficient of surface friction, high impact strength, resistance to chemically aggressive media interaction and corrosion, the presence of "samozmaschuyuchoho" effect, resistance to high dynamic loads.

General view of the experimental setup improved scraper conveyor type TS-40 measuring and registering equipment is shown in Fig. 7.

Drive scraper conveyor is made of an asynchronous motor AIR90L2. Motor control by means of frequency converter Mitsubishi FR-D740 (Fig. 8). The design of the experimental setup scraper conveyor allows for both manual and computer control of movement.

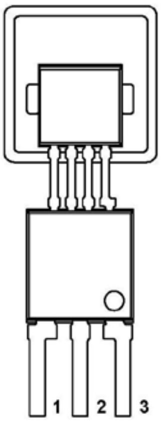
With computer-controlled frequency converter connected to the motor terminals, enabling feed motor current with a frequency will vary for a given law. This control provides the start to stop scraper conveyor for optimum law with all the variables.

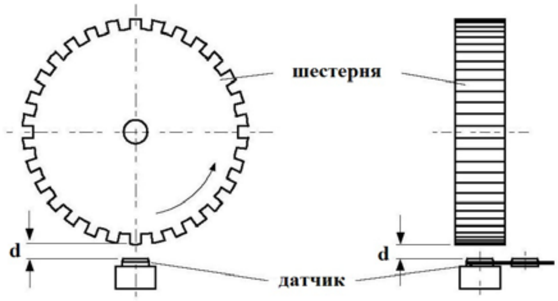
Fig. 7. A general view of the experimental setup of measuring and registering equipment.

Fig. 8. Frequency converter Mitsubishi FR-D740 for traffic control scraper conveyor.

The essence of computer management is that from a personal computer to a frequency converter receives the value of output frequency voltage motor. Frequency converter changes the output frequency and the motor shaft rotation speed changes in law that corresponds to the optimal mode of motion of the scraper conveyor. During steady movement frequency converter maintains a constant frequency, which corresponds to the rated speed of the conveyor. This method allows you to control the movement smooth starting and braking scraper conveyor, providing minimize fluctuations in levels of traction drive mechanism and body. The main parameters of the experimental setup motion scraper conveyor determined using measurement and recording equipment. Experiments were conducted for both real-mode traffic, and for optimal controlled by law.

To determine the angular velocity sensor used KMI16 / 1 (Fig. 9 a). This magnetoresistive sensor, the principle of which is based on the fact that the signal from the output of the sensor changes depending on the position of the metal gear teeth, changing direction as the magnetic field lines. Taki From each tooth gears have one period change signal from the output of the sensor. Therefore, the drive shaft scraper conveyor gear was installed (Fig. 9,). To guard the conveyor by means of brackets were mounted sensor that signals zchytuvav of gear teeth over time. Treating the signals received rotational speed metal gears, and hence the drive shaft scraper conveyor.

a) 

b) 

c) 

Fig. 9. Angular velocity KMI16 / 1: a) the appearance of the sensor; b) the location of the sensor; c) the sensor on the experimental setup.

To determine the energy arising in the process of scraper conveyor, it is necessary to investigate the change of power depending on the mode of operation (optimal or sub-optimal). Power on the drive shaft was determined indirectly by the values of voltage and current.

The current value obtained from the linear current sensor Noneywell CSLA1CD open, which operates on the Hall effect. Designed for non-contact measurement of DC, AC and pulse currents in the range of ± 57 ... ± 950 A and has an analog output. The sensor was connected in series to a single phase motor (not zero); its location on the experimental setup is shown in Fig. 10.

Voltage determined precision digital multimeter Mastech MS8218AC (Fig. 11), which is connected to a personal computer (PC) via RS-232 via cable. The software allows you to automatically calibrate the device and a PC to process the data. Measures rms value of constant or variable voltage.

Fig. 10. Current sensors

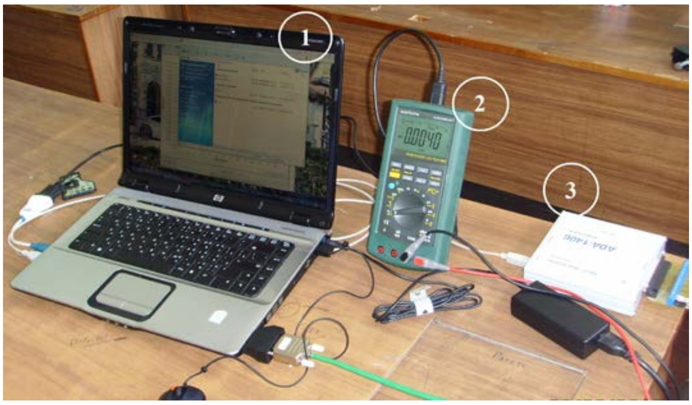


Fig. 11. Equipment collect data from the experimental setup: 1) PC; 2) Multimeter; 3) Module ADA.

To collect data from sensors used multifunctional module IO analog and digital signals ADA-1406 (Fig. 11), which connects to the PC. Collection and transfer data to a PC is via USB channel for further processing.

Conclusions

As a result of research:

- a program of experimental studies of the dynamics of motion scraper conveyor;
- improved existing design scraper conveyor type TS-40, which allows to investigate: mode of movement of the conveyor at the site at the actual start mode (suboptimal) and in driving traffic for optimal law; dependent coefficient of resistance of speed, material scrapers and gutters;
- chosen measurement and filing equipment to determine experimentally the basic parameters of field motion model.

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Pryvedenы Main Results Theoretically research. Optymyzyrovano mode motion scraper conveyor for Elimination fluctuations, kotorыe voznykayut in traction body in the period starting. Method is designed эksperymentalnыh conducting of research scraper conveyor movement dynamics.

Dynamic load, drive, Resistance Factor, optymalnыy mode motion.

The main results of theoretical researches are given. Movement modes of scraper conveyor for elimination of fluctuations which arise in traction body during start-up are optimized. Technique of carrying out pilot studies of motion dynamics of scraper conveyor is devised.

Dynamic loadings, drive, resistance coefficient, optimum movement modes.