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DISCLOSURE OF STATE UNCERTAINTY OF THE ROLLER CHAIN BASED ON CROSS-CORRELATION

Purpose. Reducing the downtime of transport equipment due to technical malfunction of the chain transmission by disclosing the uncertainty in the friction change of the plate roller open-chain through the estimation of the chain friction coefficient at idle speed.

Methodology. To achieve the goal, the following tasks were set: to carry out a research on the change in the plate roller chain friction at idle speed; to develop a method for evaluating friction in the roller plate chain at idle speed. Research on the state of the roller plate chain in laboratory conditions is carried out on the bench by measuring the motor torque during the rotation of the chain. Data processing of the random process of changing the state of the plate roller open-chain predetermines the use of methods of mathematical statistics and correlation analysis.

Findings. The research carried out to control the state of the plate roller chain made it possible to disclose the static dependence of the change in friction per day and the correlation dependence of the change in friction in the chain for all days of the experiment. To estimate the change in the state of the conveyor chains, a method was developed for determining the friction coefficient of the plate roller chain through the torque of the motor rotating the open-chain. During the experiment, the increase in the coefficient of friction was more than 20 percent.

Originality. The relation of the change in the parameter of the "torque of the motor rotating the chain at idle speed" during the experiment due to the change in the friction of the chain or the sliding speed in the joints of the chain was disclosed.

Practical value. It consists in using the developed method for estimation of the friction in the open-chain at idle speed for planning the timing of scheduled maintenance of transport equipment. An increase in the magnitude of the motor torque that rotates the open-chain at idle speed is associated with a decrease in the sliding speed of the chain joints, an increase in the friction coefficient, which is a criterion for estimation the state of the drive chain. The results of changing the friction coefficient of the developed method showed similarity with the results of the correlation method for estimation of the state of the roller plate chain.

Keywords: *roller plate chain, sliding speed, open-chain friction, wear, correlation analysis*

Introduction. Chain drives are widely used in mining equipment, hoisting and transporting machines, drilling equipment. In chain conveyors, the main element that transmits torque from the engine is a tensioned plate chain. Also due to friction, the components of the plate chain are subject to wear. Taking advantage of new friction reduction and wear protection technologies, energy losses due to friction and wear in vehicles, machinery, and other equipment worldwide can be reduced by 40 % in the long term (15 years) and by 18 % in the short term (8 years). Globally, these savings will amount to 1.4 % of GDP per year and 8.7 % of total energy consumption in the long term [1].

An important feature of the lubricant is the ability to increase the wear resistance and endurance of the chain, as well as reduce the impact of the links on the sprocket teeth and reduce the heating temperature of the chain. The technical condition of the conveyor chains, as a rule, is checked in two cases: when a new conveyor is put into operation and when a breakdown is eliminated. There are known signs of wear on chain drives such as: lengthening the chain or increasing the pitch of the chain; destruction of rollers and bushings; wear of sprocket teeth; abnormal wear on plates and teeth. However, there are insufficient known signs of wear that can be quickly monitored while the chain drive is running. Detection of early signs of wear, which is operatively monitored during the operation of the chain transmission, the research on wear resistance is relevant for the development of automatic systems for diagnosing the technical condition during the operation of the chain transmission, will improve the planning of maintenance, reduce the likelihood of failure of the chain transmission.

An increase in the computing power of microcontrollers, widespread use, an increase in the speed of data exchange, a specific reduction in the cost of microcontrollers is a resource for increasing the efficiency of control and improving the quality of forecasting maintenance of equipment.

Literature review. Announced the results of empirical studies of chains [2–4], methods of operation status control of chains [5, 6], examples of the development of mathematical models of chains [7–9]. For the mathematical description of the change in the state of non-stationary processes, models based on fuzzy sets and neural networks can be used [10–13].

The authors, in the course of research [2] on three plate chains, when measuring the parameter motor torque using correlation, calculated the average measure of similarity. The similarity measure is estimated through the correlation function of the first and subsequent frames of the average values of the engine torque. If the measure of similarity decreases, this indicates some deterioration in the state of the chain. For three chains, during an experiment lasting from 37 days (300 hours) to 43 days (338 hours), a decrease in the similarity measure to 6 % was revealed, which is explained by an increase in chain wear.

The author proposed a method [3] for checking the validity of roller chains based on the results of monitoring the position of the chain joints protruding as much as possible above the tops of the teeth of the largest gear sprockets without dismantling the chains from the machines. For control, calibers are used, whose values are determined by the proposed formula. The advantage of the method is a decrease in the labor intensity of monitoring the suitability of roller chains.

The authors of [4] for polymer roller chains discuss the mechanisms of chain wear, including abrasive and adhesive wear of the pin, bushing, roller, and track. The relevance of test benches for the reproducible determination and measurement of chain wear is noted.

The application of methods of operational control to assess the technical condition of the chain is known. The article [5] notes the idea that when the mooring chain is perfect and has no defects, the temperature is distributed along the chain evenly and smoothly, except for welds. But when there is a crack in the chain, the even distribution of temperature along the chain will be disrupted. Therefore, the discontinuous profile can be observed from the fracture region in the thermal image. Moreover, it has been found that the larger the fracture size is, the more obvious the fracture can be. In general, based on these experimental results, it can be concluded that a crack in the mooring chain can be easily detected using thermographic techniques. A criterion was developed to quantify the crack that occurs in the mooring chain, with temperature measurements at two specific locations. The proposed method of quantitative assessment makes it possible to successfully predict the presence and growth of a crack.

The method of an infrared photoelectric sensor is known for monitoring chain wear [6] for accurate measurement of the distance between the leading edges of each central link of the chain. With accurate measurements between links, these monitors can easily identify individual links or contacts that show signs of abnormal wear. These monitors can monitor the chain in motion, allowing inspection without stopping production. The device is capable of controlling all combinations of 3-, 4- and 6-inch chains. The scanning infrared photovoltaic system provides accuracy within 0.02 inches.

The author of [7] presented a model of a chain drive operating at medium and high speed, which allows calculating the vibrations and forces generated in the chain drive. The article aims to take into account geometry in a dynamic model that contains inertial forces emanating from the chain, and thus to research the influence of microgeometry on the basic behavior of the chain and vice versa. The results show that the inertial forces in the chain cannot be neglected at higher speeds. The importance of the influence of chain tension and lateral vibrations in the sagging interval on the model of dynamic forces in a chain drive is noted.

The author of [8] presented a kinematic and dynamic model of a roller chain rotating between two sprockets. External transverse excitation of spans occurs due to polygonal action and is processed by kinematic action on the moving boundaries of the string. The analysis of model disturbances is carried out by the method of multiple scales. The results show a variety of internal and external resonance conditions and provide some examples of both decoupled and coupled motion.

The author of [9] performed modeling and analysis of a low-speed roller chain drive of a marine engine. The developed model includes friction and rotation damping, which makes the model more realistic.

In [10], the prediction and control of the state of degradation of rolling bearings were carried out based on such quality indicators as correlation, monotony, and reliability. Experimental studies of bearing degradation tests have confirmed the effectiveness of the degradation prediction method.

In [11], a multi-parameter model for assessing the quality of a technological process was developed, including fuzzy parameters that are easily estimated by people but are difficult to measure technically. The model can be an example of integrating many parameters into one integral process quality criterion. For a complex system, which cannot do without human decision-making, the use of this technique will improve the quality control process.

In [12], to improve the quality of the control system for a nonlinear technological process, a technique was developed using neuro-fuzzy filters to predict the state of a control object.

The work [13] considers the development of information technology for group diagnostics of asynchronous electric motor equipment based on an intelligent decision support system using spectral analysis and neural networks. The method of equipment identification is used based on creating a reference sample of an asynchronous electric motor and comparing it with the current one, analyzing the complex spectral noises of the object under research without stopping the technological process.

In [14], a method for parametric identification of mathematical models of non-stationary anomalous diffusion processes based on iterative optimization procedures in an analytical form is proposed. The solution is reached in no more than 10 iterations. The possibility of solving the problem of parametric identification for linear and nonlinear models of nonstationary anomalous diffusion processes with a deviation not exceeding 0.2 % is substantiated.

A well-known criterion for chain wear is chain elongation. If the elongation of the chain exceeds the elongation standard, then the chain must be replaced. Regardless of the number of sprocket teeth, the standard for chain elongation for agricultural machinery is 3–5 % of its nominal value [15]. The wear of the chain is determined by the elongation of 10 links in at least three sections. The maximum value obtained is taken as the measurement result. Links with defects should not be included in the measured area. When measuring conveyor chains, at least two special links must be included in the controlled area, to which scrapers or strips are attached. When measured, the chain must be tensioned with a force of 300–400 N (30–40 kg), which is achieved by using a roller chain stretcher. Measurement of the length of 10 links should be carried out with calipers with graduation of 0.1 mm.

Even if the maintenance of the conveyors is performed periodically, the disadvantage is the duration of equipment downtime and personnel errors when a malfunction is detected due to the presence of a human factor. Reducing the duration of equipment downtime and reducing the influence of the human factor when detecting a malfunction of the conveyors is relevant. The use of operational methods for diagnosing the state of friction of chains when the conveyors are idling in automatic/automated mode will allow detecting violations of the quality indicators of machines at early stages, will reduce the consumption of material resources and the use of human resources, and will significantly increase the efficiency of maintenance.

The wear of the rubbing bodies is greatly influenced by lubrication. Dry friction is possible in chain joints having a reciprocating movement of rubbing surfaces, i.e. friction with incomplete lubrication and direct contact of rubbing surfaces. As the effect of the lubricant on the rubbing surfaces decreases, the sliding speed decreases. The authors consider it relevant to research the friction in the chain joints with a minimum effect on the chain joints of the specific pressure, i. e. no load to look for early signs of chain drive wear. The friction of the chain is understood as the resistance that the chain provides to the motor when rotating at a constant speed due to the change in the sliding speed of the roller relative to the chain sleeve.

Purpose. The goal of the work is to reduce the downtime of transport equipment due to a technical malfunction of the chain transmission by disclosing the uncertainty in the change in the friction of the plate roller chain through the assessment of the friction coefficient of the chain at idle. This will provide an opportunity to improve the efficiency of diagnostics of the technical condition of roller chain drives.

To achieve the goal, the following tasks were set:

- to research the change in the friction of the chain at idle;
- to develop a method for evaluating friction in a roller plate chain at idle speed.

Methods. The research test platform contains one roller plate chain stretched between two sprockets. The driving sprocket is connected to an induction motor, the second sprocket mounted on the shaft is driven (Fig. 1).

Roller chain contains 100 links, link pitch l = 9.525 mm, chain weight 397 grams. The roller chain is directly connected

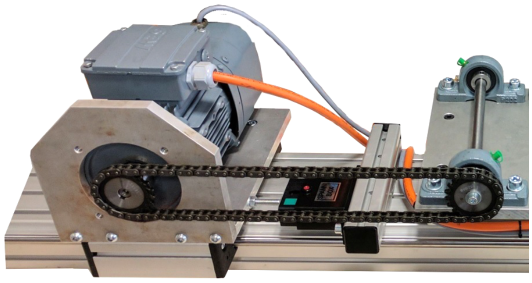


Fig. 1. Bench for research on the roller plate chain

to two identical sprockets with a diameter of 0.06 m, the number of sprocket teeth z = 20 with the same pitch l. The rated values of the induction motor are motor power 0.37 kW, motor torque T_R = 2.56 Nm, motor rotation speed n_R = 1380 rpm. During the experiment, the constant motor rotation speed is n_R = 400 rpm, which corresponds to the calculated speed of the chain as v_c = 1.27 m/s. This motor speed was chosen arbitrarily. The values of the motor torque (MT) are stored in the memory of the monitoring system, approximately every 13 minutes, 8192 values of the analog-to-digital conversion (ADC) codes of the motor torque are recorded. The chain is tensioned by hand. To obtain a more rapid change in friction, the chain is not lubricated, and the excess factory grease is removed. The chain rotates 8 hours a day, the duration of the experiment is 114 days, which amounted to about 912 hours of operation. The process of dividing the measured parameter 'motor torque' into frames by 8192 values during the research is shown in Fig. 2.

The research on the physical model of the roller plate chain on the bench ensures the constancy, repeatability of the experimental conditions, and increases the reliability of the results obtained.

The results of the study of changes in the sliding speed in the chain joints at idle speed. It seems reasonable to start analyzing the change in the state of the chain during the experiment with the analysis of the change in the state of the chain in one day of the experiment. The graph of changes in the average values of the motor torque (MT) for the second and penultimate days of the experiment is shown in Fig. 3.

As can be seen from Fig. 3, motor torque values decrease in one day from the beginning to the end of the day. Note that this is typical for all days of the experiment. A decrease in the values of the motor torque at the end of each day is associated with the running-in of the chain links, that is, an improvement in the mobility of the connections between the chain links. The difference between the values at the beginning and the end of an individual day of the experiment decreases for all 114 days of the experiment, which indicates a decrease in the sliding speed of the chain joints, an increase in the friction in the chain. Comparing Figs. 3, *a, b* shows a twofold increase in the standard deviation of the motor torque. Further, it seems expedient to analyze the state of the chain by calculating the mean value, dispersion, standard deviation of the measured parameter of the motor torque at the end of the day (Table 1).

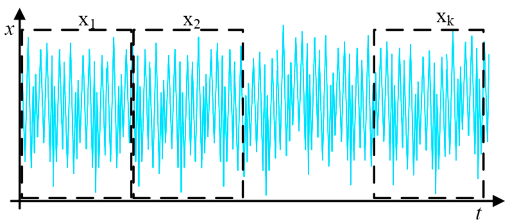
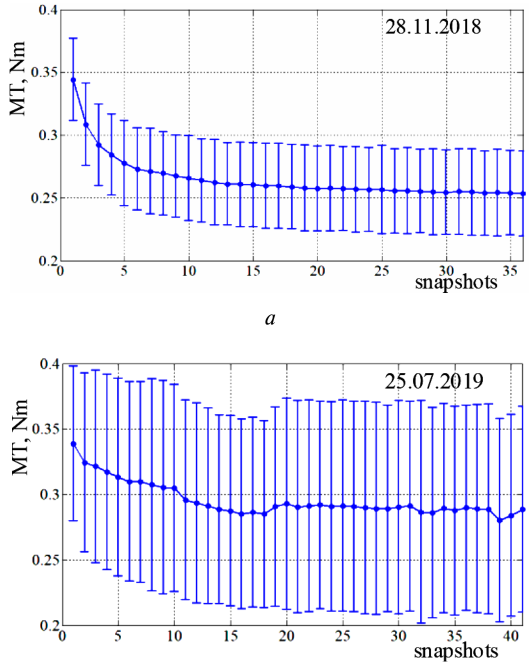


Fig. 2. The process of dividing the measured parameter 'motor torque' into frames



a

b

Fig. 3. Graph of changes in the average value of the motor torque (MT) per day:

a – the 2nd day of the experiment; b – 113 days of the experiment

Table 1

Numerical values of motor torque at the end of the day

Time, hour	200	400	600	800
Mean value, Nm	0.228	0.274	0.278	0.282
Dispersion, 10^{-3}	1.1287	3.038*	3.272	5.075
Standard deviation, Nm	0.034	0.055	0.057	0.071

Table 1 shows the change in the values of the mean value; dispersion and standard deviation of the motor torque are continuously increasing. The values of the standard deviation of the motor torque from the minimum value of $1.38 \cdot 10^3$ doubled to the value of $2.74 \cdot 10^3$.

Fig. 4 shows the changes in the mean values of motor torque (MT) at the beginning and the end of the day. Each point represents the mean value of the motor torque for a sample of 8192 values. In Fig. 4, it can be seen that in the first hours of the experiment (up to 180 hours), the values of the motor torque decreased at the beginning and at the end of the day, i.e., the friction in the chain decreased.

After 180–200 hours of chain operation (Fig. 4), the motor torque readings only increased at the beginning and the end of

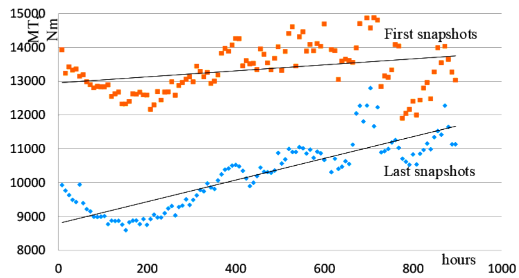


Fig. 4. Changes in the mean value of the motor torque (MT) in time at the beginning of the day and the end of the day of the experiment

the day, that is, the friction in the chain increased. Two graphs of the mean values of the motor torque at the beginning of the day and the end of the day of operation converge to each other for all days of the experiment. This means that for a day of work at the end of the experiment, the chain runs in less, the friction in the chain increases.

The idea of researching the change in the numerical value of friction in the chain is to assess the similarity of a series of values of the motor torque on the first and subsequent days. To calculate the similarity of the state of the chain to the state of the chain on the first day, we will use cross-correlation. The same trend in the change in motor torque values per day (Fig. 3) on all days of the experiment suggests that the values are important only at the beginning and at the end of the day. To calculate the similarity and cross-correlation of the motor torque current on different days (d_1–d_m) of the experiment, we will use separate frame numbers (x_1–x_k) for each day of the experiment. For example, the first frame of the day (x_1) and the last frame of each day (x_k) of the experiment according to formulas (1, 2).

$$r_{d_1 d_m}(x_1)=\sum_{n=0}^{N-1} x_{1d1}(n)\cdot x_{1dm}(n); \quad r_{d_1 d_1}(x_1)=\sum_{n=0}^{N-1} x^2_{1d1}(n);$$

$$r_{d_m d_m}(x_1)=\sum_{n=0}^{N-1} x^2_{1dm}(n), \tag{1}$$

where $r_{d_1 d_m}(x_1)$ is cross-correlation of frame x_1 day d_1 and frame x_1 day d_m, $r_{d_1 d_m}(x_1)$ is autocorrelation of the frame x_1 day d_1, $r_{d_m d_m}(x_1)$ is autocorrelation of the frame x_1 day d_m, $N \in [0...8191]$; $x_{1d1}(n)$ is a numeric value within a row of frame x_1, day d_1, serial number of a numeric value (n); $x_{1dm}(n)$ is a numeric value within a row of frame x_1, day d_m, serial number of a numeric value (n).

The formula for calculating the similarity of the state of the chain during the experiment at the beginning of the day x_1, at the end of the day x_k

$$S_{x_1}=\frac{r_{d_1 d_m}(x_1)}{\sqrt{r_{d_1 d_1}(x_1)\cdot r_{d_m d_m}(x_1)}}, \tag{2}$$

where S_{x_1} is similarity of the chain state for the first frame of each day of the experiment.

Fig. 5 shows the graphs of the similarity change for 114 days of the experiment, the similarity (S_{x_1}) for the first frame of each day of the experiment (Fig. 5, *a*) and the similarity (S_{x_k}) for the last frame of each day of the experiment (Fig. 5, *b*). It can be seen that the similarity of the motor torque decreases every day of the experiment, which indicates a decrease in the sliding speed of the chain joints, an increase in the friction in the chain.

The graphs show a decrease in the similarity of the motor torque value for the rotation of the chain for all days of the experiment. Reducing the similarity of the condition of the roller plate chain at the beginning of the day (S_{x_1}) for all days of the experiment was about two percent and at the end of the day (S_{x_k}) – about four percent for all days of the experiment.

Periodically, usually every 200 hours, the chain was removed from the test bench; an inspection was performed to detect signs of abnormal wear: the destruction of rollers and bushings, development of lugs. Intermediate visual inspections of the chain did not reveal any signs of abnormal wear due to correct operating conditions, low specific pressure on the chain joints.

Development, research on a method for evaluating friction in a roller plate chain at idle speed. The proposed method is used to assess the technical state of the friction of the chains rotated by the drive at idle and to plan the maintenance of the drive. The idea of the method for determining the friction of the chain is to assess the change in the ratio between the force spent on the rotation of the chain at idle speed and the gravity of the

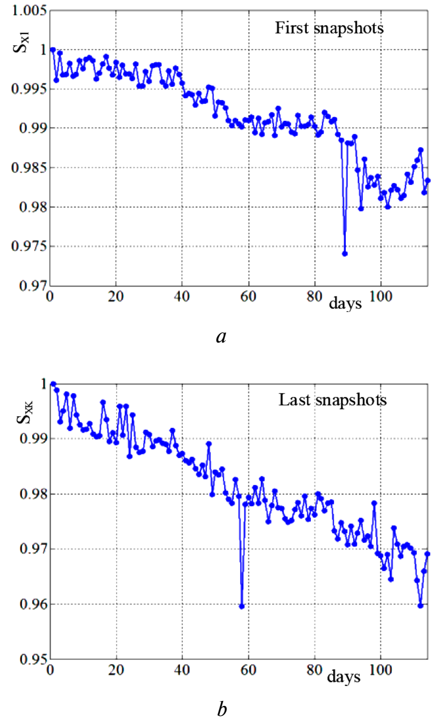


Fig. 5. The graphs of the similarity change for 114 days of the experiment:

a – the similarity S_{x_1} for the first frame of each day of the experiment; b – the similarity S_{x_k} for the last frame of each day of the experiment

chain itself. We proceed from the assumption that the force spent on the rotation of the chain at idle speed is conventionally divided into overcoming the force caused by the gravity of the chain itself (F_g) and forces to overcome semi-dry friction (F_f) in the chain (Fig. 6). A chain with a weight M is located vertically between the sprockets; the less the gravitational force of the weight M to rotate the chain is, the less frictional force (F_f) in the chain is. When using the method, we neglect the friction force in the drive supports when the sprockets rotate, the chain tension, and the mass of the sprockets.

The more the friction in the chain is, the more weight M is required to move the chain under the action of gravitational force. The force F_g, which can set the chain in motion, is proportional to the coefficient of friction in the chain (k) and the gravity of the chain (mg)

$$F_f \approx M\cdot g = k\cdot m\cdot g,$$

where k is the coefficient of friction.

The parameter is measured the moment of an induction motor rotating a driven sprocket through a plate chain. The motor torque (MT), when the chain rotates, is proportional to

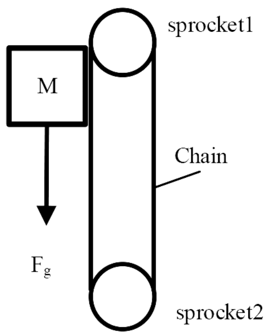


Fig. 6. Conversion of the chain friction force through the gravitational force of load with weight M

the load on the motor axles, including the chain friction. The motor torque (3) is equal to the multiplying of the force (F) and the radius of the driving sprocket (h)

$$MT \approx F_f = F \cdot h = M \cdot g \cdot h = k \cdot m \cdot g \cdot h. \quad (3)$$

The calculation of the chain friction coefficient (4) is based on three parameters: motor torque (MT) proportional to the load on the motor axle, chain weight (m), drive sprocket radius (h)

$$k = \frac{MT}{m \cdot g \cdot h}. \quad (4)$$

The numerical value of the coefficient of friction (k) is the basis of the criterion for evaluating the friction (C_f) in the chain at idle

$$C_f \leq k,$$

where $k \in (0-n]$, for planning the timing of scheduled maintenance of transport equipment.

Research on the change in the coefficient of friction during the time for a roller chain was carried out experimentally. The duration of the experiment is 114 days, which is up to 912 hours. Fig. 7 shows a graph of the change in the coefficient of friction.

For a chain rotating idle between two sprockets for 912 hours of the experiment, the increase in the coefficient of friction was more than 20 percent from the minimum value.

Discussion of the research results of the roller plate chain. Changes in the friction of the plate chain during rotation at idle speed for about 900 hours were investigated under laboratory conditions. The distribution of random variables and their numerical characteristics is performed based on the experimental data of the motor torque parameter. Research on the idle chain has shown an increase in the force required to rotate the chain. In the process of interaction between the chain and the teeth of the sprockets, the oil is redistributed and displaced from the contact zones in the chain joints. The oil flows into the free space between the pin, sleeve, and roller. Some of the oil is forced out of the chain joint. Loss of lubricant in the chain joint reduces the sliding speed of the roller relative to the sleeve of the chain joint. This increases the coefficient of friction, which causes the roller chain to heat up. Probabilistic-statistical analysis of data using the calculation of the mathematical expectation, dispersion, standard deviation made it possible to determine the relationship between the values of the motor torque and the time of the experiment for the studied roller chain.

The research revealed the following relationships:

- during each day the chain is idling, the motor torque values fall from the beginning to the end of the working day;
- in the first hours of operation (up to 180 hours), the values of the motor torque decreased at the beginning and at the end of the day, i.e., the friction in the chain decreased;
- after 180–200 hours of operation of the chain, the motor torque values only increased at the beginning and the end of the day, that is, the friction in the chain increased;
- the two graphs of the average motor torque values at the beginning of the day and the end of the day of operation are closer to each other, which means an increase in friction in the chain;
- the dispersion and standard deviation of the mean values of the motor torque for 912 hours of operation are continuously increasing. The standard deviation from the minimum value has doubled from 0.036 to 0.071 Nm;
- the similarity of the consumed current of the motor torque for the rotation of the circuit has decreased for all days of the experiment. The decrease in the similarity of the state of the roller plate chain at the beginning of the day (S_{x_1}) for all days of the experiment was about two percent, and at the end of the day (S_{x_k}) – about four percent for all days of the experiment.

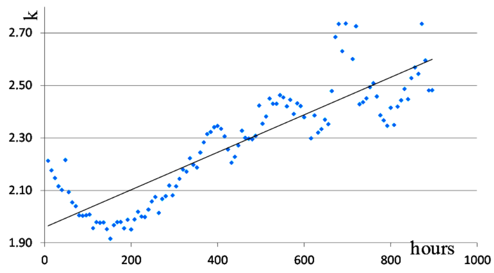


Fig. 7. Chain friction coefficient change in 912 hours

A method has been developed for determining the friction force in the chain by calculating the friction coefficient, which takes into account the motor torque, chain weight, and the radius of the driving sprocket. The results of the numerical calculation of the friction force of the chain under research indicate a decrease in the sliding speed of the chain joints, an increase in the friction force in the chain during the experiment, while the increase in the friction coefficient for 912 hours was more than 20 percent from the minimum value.

The practical significance of the research performed is the use of the developed method for assessing the friction in the chain at idle for planning the timing of scheduled maintenance of transport equipment. An increase in the value of the motor torque that rotates the chain at idle is associated with a decrease in the sliding speed of the chain joints, an increase in the friction coefficient, which is a criterion for assessing the state of the drive chain. The results of changing the friction coefficient of the developed method showed similarity with the results of the correlation method for assessing the state of the chain, which confirms the practical value of the developed method.

Further research can be carried out at the enterprise to control the change in friction in the drive chains of the conveyor, examining the relationship of the force spent on the rotation of the chain conveyor at idle speed with the parameters of chain wear.

Conclusions.

1. The research revealed a model of increased friction in the roller plate chain, which is explained, among other things, by a decrease in the sliding speed of the roller relative to the sleeve of the chain joint. The values of dispersion, standard deviation, average values of the motor torque for 912 hours of operation are continuously increasing, in particular, the standard deviation from the minimum value has doubled from 0.036 to 0.071 Nm.

2. Research during the experiment based on cross-correlation revealed a decrease in the similarity of the magnitude of the motor torque when the chain rotates. The decrease in the similarity of the motor torque during rotation of the roller plate chain at the beginning of the day (S_{x_1}) for all days of the experiment was about two percent, and at the end of the day (S_{x_k}) – about four percent for all days of the experiment.

3. A method has been developed for determining the friction coefficient of the researched roller plate chain at idle based on three parameters: the motor torque proportional to the load on the motor axle, the chain weight, and the radius of the driving sprocket. During the experiment, the increase in the coefficient of friction was more than 20 percent of the minimum value.

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Розкриття невизначеності стану роликового ланцюга на основі взаємної кореляції

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Мета. Зменшення простою транспортного обладнання внаслідок технічної несправності цепної передачі шляхом розкриття невизначеності зміни тертя пластинчатого роликового ланцюга через оцінку коефіцієнту тертя ланцюга на холостому ходу.

Методика. Для досягнення мети було встановлено наступні задачі: виконати дослідження зміни тертя на холостому ходу; розробити метод оцінки тертя роликового пластинчатого ланцюга на холостому ходу. Дослідження стану роликового пластинчатого ланцюга в лабораторних умовах виконуються на стенді, вимірюючи момент двигуна при обертанні ланцюга. Обробка даних випадкового процесу зміни стану роликового ланцюга зумовлює використання методів математичної статистики й кореляційного аналізу.

Результати. Виконане дослідження контролю стану роликового пластинчатого ланцюга дозволило визначити статистичну залежність зміни тертя за день і кореляційну залежність зміни тертя за всі дні експерименту. Для оцінки зміни стану ланцюгів транспортера розроблено метод визначення коефіцієнту тертя пластинчатого ланцюга через момент двигуна, що обертає ланцюг. За час експерименту підвищення коефіцієнта тертя склало більше 20 відсотків.

Наукова новизна. Виявлена залежність зміни параметра «момент двигуна, обертаючого ланцюг на холостому ходу» від часу експерименту внаслідок зміни тертя ланцюга або швидкості ковзання у шарнірах ланцюга.

Практична значимість. Складається у використанні розробленого методу оцінки тертя в ланцюгу на холостому ходу для планування термінів технічного обслуговування транспортного обладнання. Підвищення величини моменту двигуна, обертаючого ланцюг на холостому ходу, пов'язано зі зменшенням швидкості ковзання шарнірів ланцюга, підвищенням коефіцієнту тертя, що є критерієм оцінки стану приводного ланцюга. Результати зміни коефіцієнту тертя розробленого методу показали подобу з результатами кореляційного методу оцінки стану ланцюга.

Ключові слова: *роликовий пластинчатий ланцюг, швидкість ковзання, тертя відкритого ланцюга, знос, кореляційний аналіз*

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