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ДОСЛІДЖЕННЯ ДИНАМІЧНИХ НАВАНТАЖЕНЬ У МЕХАНІЗМІ ПІДЙОМУ ПОРТАЛЬНИХ КРАНІВ «СОКІЛ»

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Анотація. *У роботі досліджено динамічні навантаження у канатах приводу підйому портального крану «SOKIL» при перевантаженні колод лісу за схемою «склад-судно» у річковому порту. Для дослідження характеру зміни динамічних зусиль в елементах приводу використано електротензометричний метод.*

Аналіз показує, що динамічні навантаження в приводі підйому козлових грейферних кранів, які експлуатуються вже більше чотирьох десятиліть, вивчені недостатньо. Слід підкреслити, що кожен кран вимагає індивідуального підходу до досліджень, оскільки на динамічні параметри його механізмів суттєво впливають умови експлуатації, геометричні характеристики, а також фізико-механічні властивості.

Аналіз отриманих значень показав, що при перевантаженні вантажів вагою від 11 до 15 тонн коефіцієнти динамічного зусилля в тягових канатах коливалися в межах від 1,18 до 2,45, причому залежність від ваги вантажу нелінійна. Розрахункові значення коефіцієнтів динамічності свідчать про перевантаження приводу підйому. Результати дослідження можуть бути використані для уточнення існуючих та розробки нових моделей.

Ключові слова*: портальний кран, грейфер, механізм підйому, динамічні зусилля, коефіцієнт динамічності.*

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INVESTIGATION OF DYNAMIC LOADS IN THE LIFTING MECHANISM OF GANTRY CRANES «SOKIL»

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Abstract. *In this paper, we study the dynamic loads acting on the ropes of the SOKIL portal crane lifting drive during the overload of forest logs according to the «warehouse-ship» scheme in a river port. An electrotensometric method was used to analyze the nature of changes in dynamic forces in the drive elements.*

The analysis shows that the dynamic loads in the lifting drive of portal grab cranes, which have been in operation for more than four decades, are insufficiently studied. It should be emphasized that each crane requires an individual approach to research, since the dynamic parameters of its mechanisms are significantly affected by operating conditions, geometric characteristics, as well as physical and mechanical properties.

The results obtained indicate that when loading loads weighing from 11 to 15 tons, the dynamic force coefficients in traction ropes range from 1.18 to 2.45. the dependence of these coefficients on the weight of the load is nonlinear..

Keywords: *portal crane, grab, lifting mechanism, dynamicforces, dynamic coefficient.*

Introduction. Portal grab cranes are important equipment for handling various materials in sea and river ports [1-3]. The economic situation in the country over the past quarter of a century has led to the fact that at the moment more than 90 % of port cranes have exceeded their standard service life. Their continued use is due to limited supplies of new equipment to ports [1-4].

Since they are a key element of the technological process, their reliable and trouble-free operation directly affects the performance of Port lines. Practice shows that the main cause of Crane breakdowns is their intensive cyclic operation beyond the established period [1-9].

Data analysis shows that a significant part of mechanical failures and accidents occur due to the fact that lifting devices continue to be intensively operated cyclically, even after the end of their service life [11-18]. Taking this into account, the analysis and determination of the level of dynamic impact on the lifting mechanisms of portal cranes becomes particularly important both in the scientific field and in practical application.

Taking this into account, an urgent scientific and applied task is to determine the value of dynamic loads that occur in the lifting mechanisms of portal grab cranes.

The aim of the study is to study and analyze dynamic loads in the drive of Sokol grappling portal cranes, which have worked out regulatory terms, when overloading logs.

Data and methodology. Given the complexity of accurate modeling of forces in the ropes of lifting mechanisms due to the influence of many factors, their determination was carried out experimentally. The objects of the experiment were four identical Sokol cranes operated in Grab mode with loads weighing 11, 13 and 15 tons in sea and river ports with a boom reach of 22 meters.

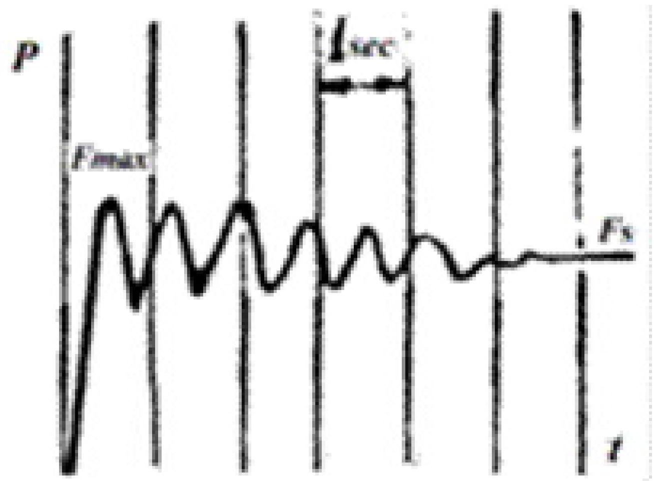
The lifting speed of the load during the research was constant.

To ensure the accuracy and reliability of measurements during lifting, it is extremely important to control a wide range of parameters.

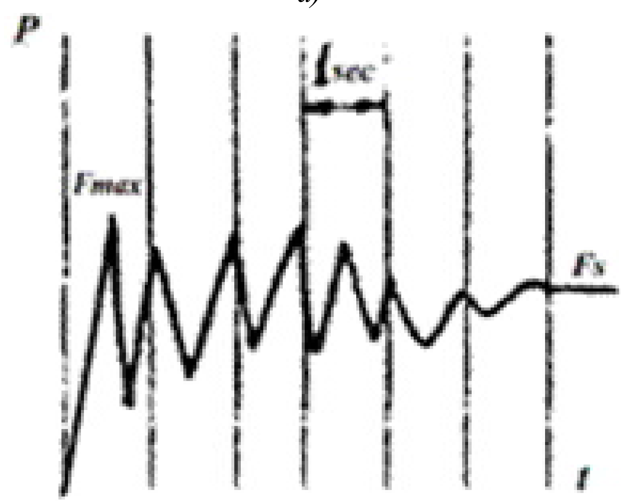
The method of electrotensometry is used to measure dynamic forces in the lifting mechanism. The process of lifting the load began after the measurement system was activated. Load cells were installed on the supporting and closing ropes, signals from which were transmitted to a data acquisition device (ADC) connected to a portable computer. The received data was processed and displayed on the monitor. The load cells were pre-calibrated by the manufacturer.

In parallel with the measurement of forces, the lifting speed was recorded using tachometers that were installed on the shafts of electric motors. After lowering the grab, the measuring devices were started.

Figure 1 shows the graph of change of dynamic forces in the closing and carrying ropes of the grapple with time when lifting a load of 15 tons.



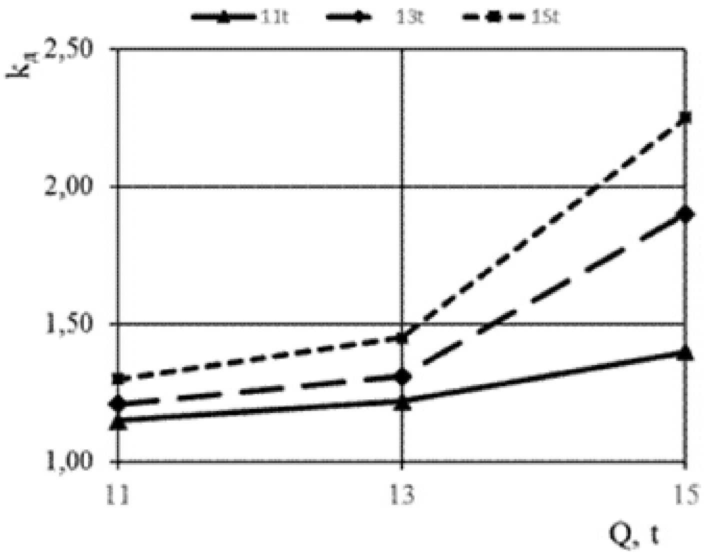
a)



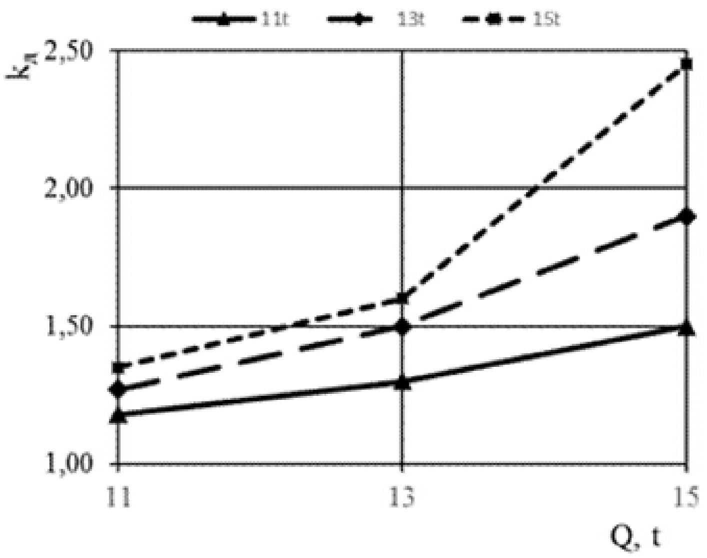
b)

Fig. 1. Graph of change of dynamic forces in the closing (a) and supporting (b) ropes of the grapple with time when lifting a load weighing 15 t

Examination of the received data (see Fig. 2) revealed the wave-like nature of the force change in the rope branch, due to the weight of the load and the lifting mode used.



a)



b)

Fig. 2. The dependence of the dynamic coefficient in the closing ropes of the grapple on the weight of the lifted load at a boom outreach of 14 (a) and 22 (b) meters

The oscillation amplitude increases during lifting, which may be due to an increase in the mass of the load being moved, an increase in the deformation of the support column and boom, as well as an increase in the load moment (the influence of the weight of the load on the boom of the crane).

The changing rigidity of an elastic element during deformation presents complex issues. This makes it difficult to handle dynamic load problems in crane systems.

Occasionally, the grab detaches from its support, leading to greater fluctuations in rope tension. Examination has revealed that early rope breakdown, due to wear or internal cracks, is the reason for this. These imperfections can arise from prolonged contact with the environment, not following crane operating guidelines, fatigue over time, or flaws in manufacturing. These elements increase the chance of the rope failing suddenly under dynamic stress [14-18].

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According to the obtained dynamic forces in the ropes, the dynamic coefficients were calculated, according to the formula (Fig. 2):

$$k_{Д} = \frac{F_{k\,\max}}{Q}, \tag{1}$$

where F_{kmax} – maximum dynamic force in the rope;

Q – is the weight of the load.

Accurate modeling of these coefficients is crucial for predicting the behavior of the cable under various load conditions and ensuring safe operation of the crane, especially at maximum reach, when the stresses in the cable are amplified by an increased torque arm.

It should be noted that with an increase in the departure and weight of the lifted load, the amplitude of the boom oscillations increased, the dependencies were nonlinear.

The load was lifted three times at each departure and weight, and the values obtained were averaged.averaged

The correct reproduction of these parameters is critically important for predicting the reaction of the cable under various influences and ensuring reliable operation of the crane. This is especially true at the highest boom reach, where the stresses in the cable increase significantly due to the elongated torque lever.

Evaluation of the obtained data showed that when lifting loads with a mass in the range from 11 to 15 tons, the dynamism coefficient ranges from 1,18 to 2,45, and this dependence on the mass of the load is nonlinear. The loads in the closing rope were higher than in the supporting rope. The highest recorded load indicators in individual rope branches were observed at the time of lifting the Grab with the load from the surface.

The change in load over time is characterized by fluctuations, which corresponds to the results of previous studies [1-10]. The decrease in the amplitude of vibrations over time can be explained by the action of internal friction forces in metal structural elements and ropes, the damping properties of joints, and energy losses during rope bending [1-13].

The calculated values of the dynamism coefficients exceed the established standards [4-13], which indicates a possible overload of the lifting drive and the risk of failure of its components.

The analysis of graphs of dynamic forces in ropes over time (Fig. 2) demonstrates that intensive cyclic operation of cranes leads to a decrease in the dissipative characteristics of the system.

As can be seen from Fig. 2, an increase in the boom departure and the weight of the lifted load leads to an increase in loads in the ropes, and as a result, the coefficient of dynamism. The dependencies are nonlinear. It is important to take into account that the values of the inertial forces that occur during movement directly depend on the deformation changes in the column.

These deformations increase when lifting an object, especially when the moment of loading increases (the product of the mass of the lifted load by the distance of departure of the crane). In addition, they are affected by the rate at which the force in the ropes increases, which is proportional to the rate at which the load is captured.

Accordingly, the loads acting on the boom of the crane during lifting increase as the boom extends and the weight of the object being lifted increases. These factors together have a significant impact on the overall stability and safety of the crane.

It should be emphasized that the calculated values of dynamic coefficients turned out to be higher than the standard values established for portal cranes [1-4]. Prolonged operation of the crane in this mode can provoke premature failure of the lifting mechanism [2-4].

These dependencies are of great importance for ensuring safe and reliable operation of the equipment.

The revealed patterns allow us to estimate the amplitude of fluctuations in the load acting on the structure, and can be used to create dynamic models. This, in turn, will improve and simplify the analysis process, as well as the determination of physical parameters for specific loading conditions.

Conclusion. This research focuses on analyzing the forces exerted on the ropes of a «Sokol» grappling portal cranes, which have worked out regulatory terms, when overloading logs.

After analyzing the data obtained during the study of dynamic loads in the lifting mechanism of the «Sokol» portal crane when moving logs, it was found that the maximum values of the dynamic load in the cable sections were fixed at the moment the grab was detached from the load at the lowest point.

An analysis of the results showed that when lifting loads, the weight of which varies between 11-15 tons, the dynamic coefficient takes values from 1,18 to 2,45. At the same time, it was found that the dependence of the dynamicity coefficient on the mass of the lifted load is nonlinear.

An increase in the boom departure and the mass of the understood load lead to an increase in the dynamism coefficients and forces in the ropes of the lifting mechanism.

The pattern of changes in these loads over time showed fluctuations, which corresponds to the results of previous studies. The gradual decrease in the amplitude of vibrations over time is explained by the influence of internal friction in the metal structure and cables, as well as damping in the joints and losses associated with bending the cable.

These patterns allow us to estimate the change in the load acting on the structure, and can be used to create dynamic models.

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