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STUDIES ARE DEFINED PERFORMANCE DRIVING MECHANISMS CHANGING SPEED AND LIFTING TOWER CRANE

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The results of experimental studies conducted on the physical system model jib tower crane. The portraits are characterized timing characteristics of motion elements mechanisms changing speed and lift-term of tower crane, confirming the adequacy of theoretical studies.

Key words: *tower crane, gear changing speed, lifting mechanism, experimental study*

It is known that during the change mechanism departure of cargo and postal lifting crane arise pendulum and its vertical oscillations prize-lead to significant dynamic loads, not only in metal structures, but also in power transmission mechanisms. Investigations of dynamic loads and their causes were engaged scholars such as M.S. Komarov [1], M.O. Lobov [2], S.T. Serhyeyev [6], A. O. Smekhov and N.I. Erofyeyev [7] and others. They have established a connection between the reduction of dynamic loads and improve the reliability of crane mechanisms. Most studies of the dynamics of the moving crane trolleys, were performed for the case of constant length flexible suspension, which contradicts the high performance of the crane. So were carried out theoretical studies and calculations of dynamic characteristics with simultaneous operation mechanisms changing speed and load lifting tower crane. The results of theoretical studies presented graphs changes the dynamic characteristics tick when paired work under consideration mechanisms supporting oscillations in the motion of individual elements of the crane [3].

To improve the reliability and efficiency of crane mechanisms by eliminating negative factors, which causes fluctuations in load mechanisms at work changing

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speed and lift was built optimal modes of motion of selected mechanisms [4].

Theoretical study of the dynamics of the coupled mechanisms for changing speed and load lifting tower crane and construction of optimal laws of motion investigated possible mechanisms to minimize vibrations load and individual items tap.

The purpose of the study is to confirm the adequacy of the previous theoretical results by conducting experimental studies and their comparison.

The main material. Conducting experimental studies on a real tower crane is not possible due to security, installation complexity and cost of managing and measuring equipment. Therefore, these research should be performed on the physical model. The physical model of the mechanisms of changing speed and load lifting tower crane was laboratory model jib crane system with appropriate mechanisms. Using a physical model for experimental studies possible through use of similarity theory [5].

The program of experimental studies carried out in such sequences:

- calculation of physical parameters (laboratory) models;
- building a physical model of a tower crane jib systems and mechanisms for changing speed and load lifting for experimental studies, researches in the laboratory;
- development control circuit drives mechanisms, equipment selection and assembly, electrical control panel;
- selection and connection of measuring and recording equipment for the registration of the main indicators of the parameters of the physical model;
- develop software to control the mechanisms of physical models;
- conducting experiments to determine the basic parameters of movement mechanisms on the natural and mechanical characteristics result in optimal control;
- selection methodology for processing the experimental data.

Building a physical model that would adequately reflect the nature of the processes inherent in a real system often becomes very complex task. Exact reproduction of the dynamics of complex spatio-temporal relationships between elements of the physical models that make up the mechanism and all multiplicity its

ties with the environment is practically impossible. In addition, in determining the parameters of the physical model must take into account that its size may be transportable and one that can be placed in research laboratory and will not create hazards to its operators. It should also be remembered that reducing the size of the physical model irreversibly reduced accuracy obtained by the experimental results. Based on the above-mentioned and applying Theorem similarity was the physical model of tower crane jib system (Fig. 1).

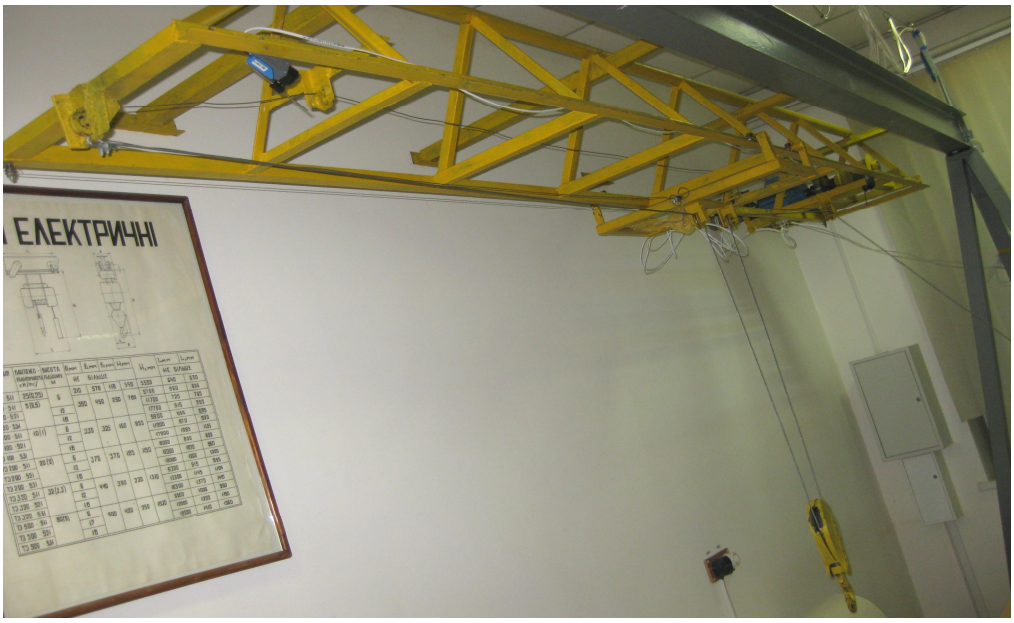
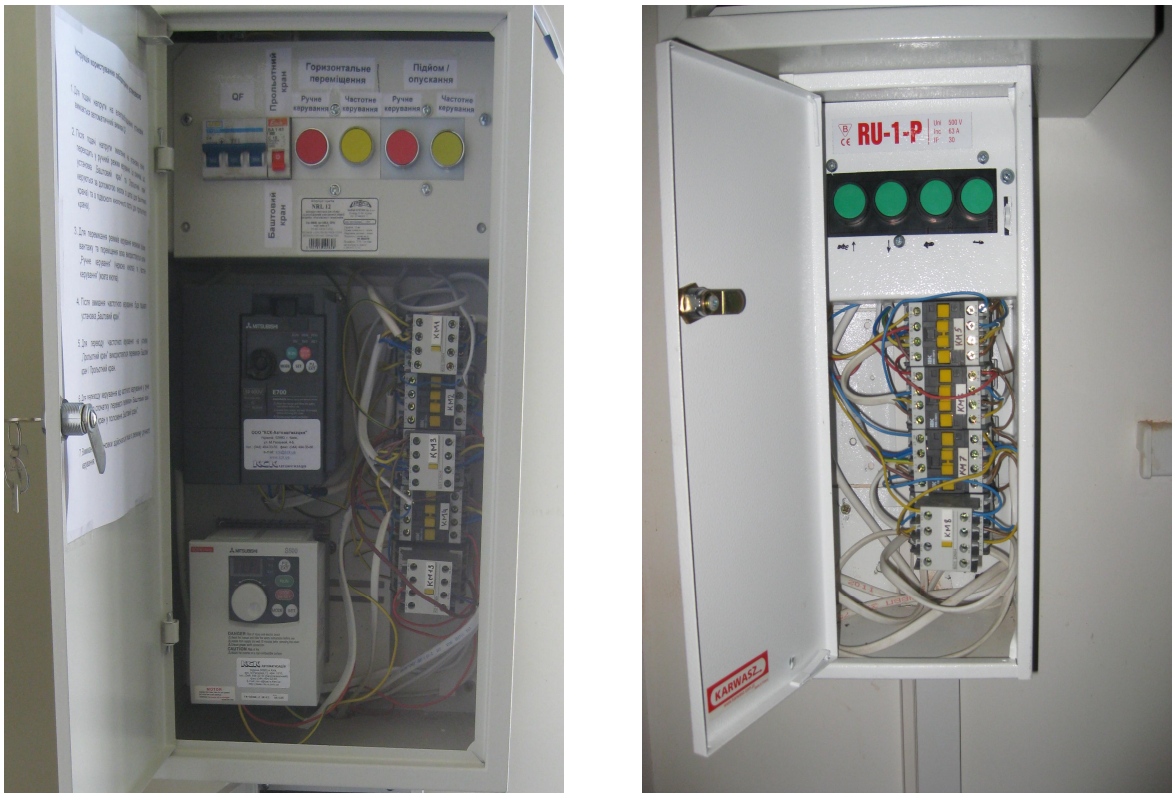


Fig. 1. General view of the laboratory model

Physical model of jib tower crane is welded farm triangle cross section of the metal exactly 32x32x3 and 25x25x3 GOST 8509-93 and pipes 52x4 GOST 3262-75. Jibs tightly closed Plaines to the wall with angles 40x40x4 GOST 8509-93.

In longitudinal angles rectangular moving truck, also made with angles. Winch mechanism for changing speed cargo consists of asynchronous electric short-4AA56 V4U3 (GOST 12139-74), two-stage cylindrical gear and a cylindrical drum. Winch lift mechanism consists of ASYNCHRONOUS motor 4A71A4UZ (GOST 12139-74), worm gear and cylindrical drum. Working body is hook suspension. Control mechanisms for changing speed and load lifting property with separate frequencies, these converters or manually.

All stationary electrical equipment (frequency converters, magnetic starters, push buttons) to control model drives mounted in the shield (Fig. 2).



a b

Fig. 2. Poster for motion control model: a - shield with frequency converters; b - flap with buttons for manual control

This design allows the physical model experiment of the study of the basic characteristics of the movement elements mechanisms for changing speed and load lifting tower crane.

To measure the parameters of individual model elements used electron-Ronnie-measuring equipment (incremental encoder module and ADA-1406). The location and general appearance of electronic measuring equipment to gather data shown in Fig. 3.

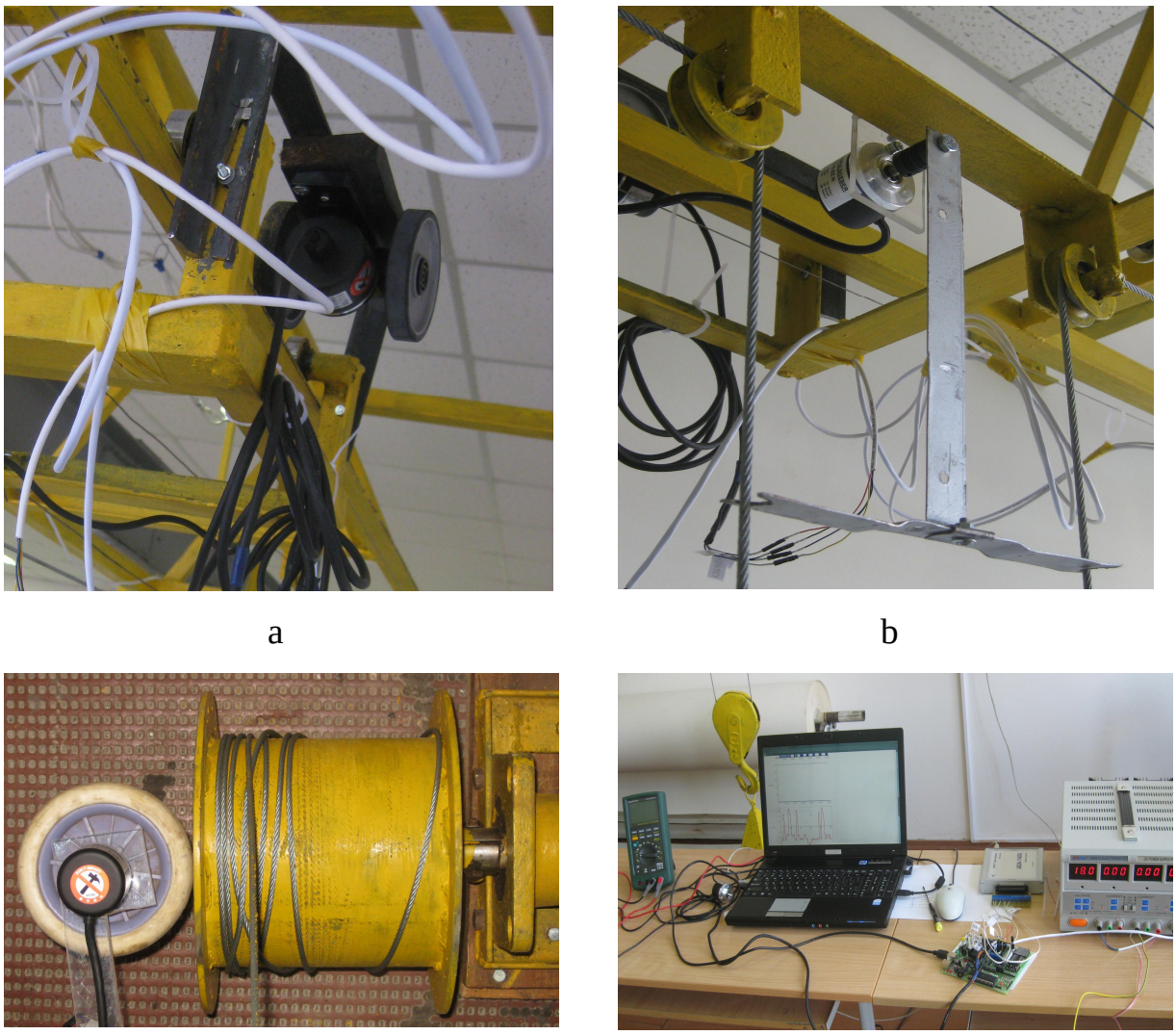


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Fig. 3. Location encoder and the module ADA-1406 with electronic raids connection to data collection: a - carriage position sensor; b - angle sensor deviation rope; c - angle sensor mechanism drum lift; d - exterior module ADA-1406 with electronic equipment for data collection

To control the electric motors must somehow coordinated wool interaction between frequency converter and a personal computer. This was carried out using the developed program "tower crane" which work both frequency converters connected to the actuators laboratory model crane. Exterior window "tower crane" is shown in fig. 4.

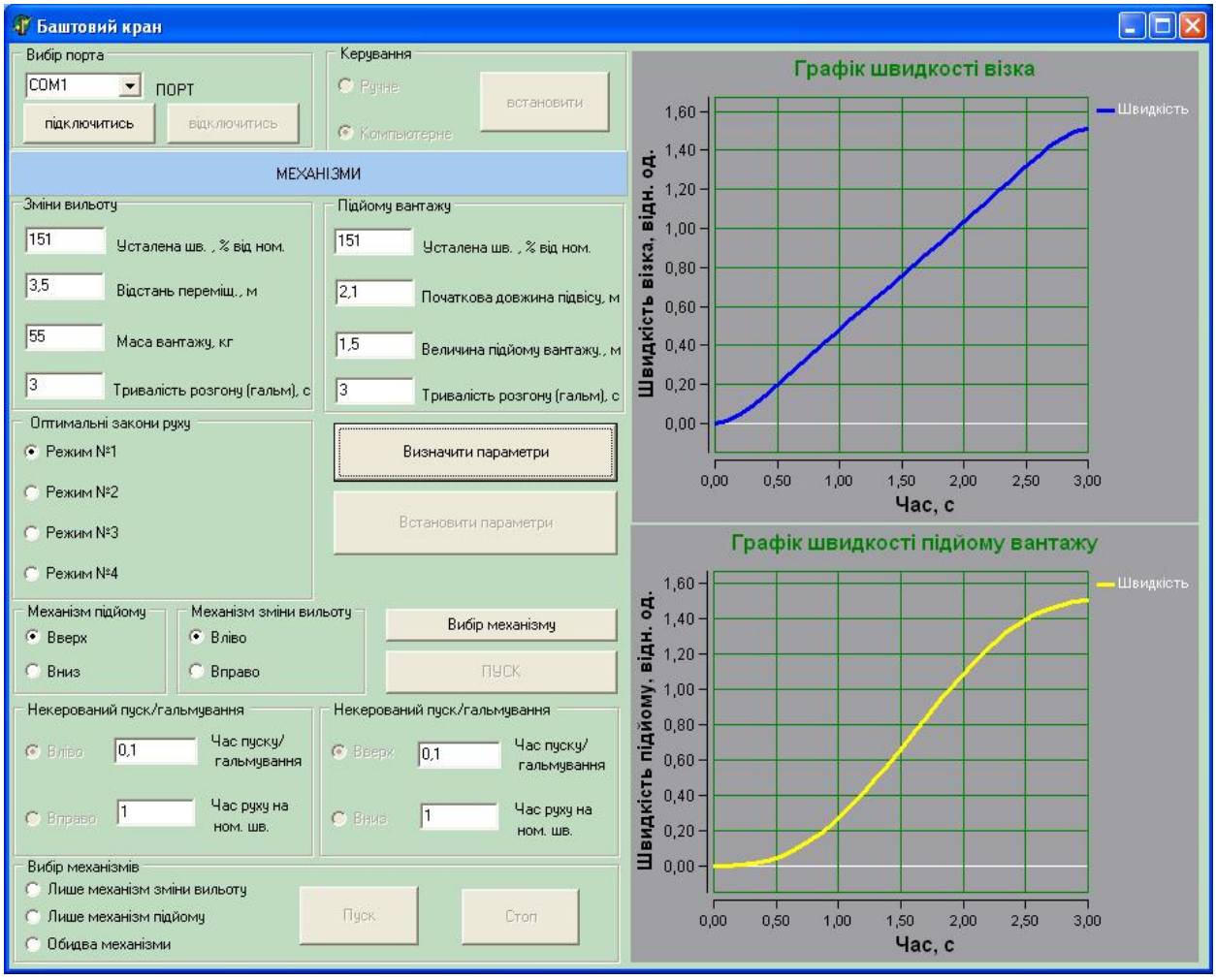


Fig. 4. Exterior window "tower crane"

To compare the adequacy of theoretical and experimental studies to evaluate compliance with such kinematic characteristics: displacement, velocity and acceleration of the trolley and the load (in horizontal direction), angular displacement, velocity and acceleration mechanisms drums changing speed and load lifting. The vertical position of load, speed and acceleration with its booming obtain simple mathematical transformations.

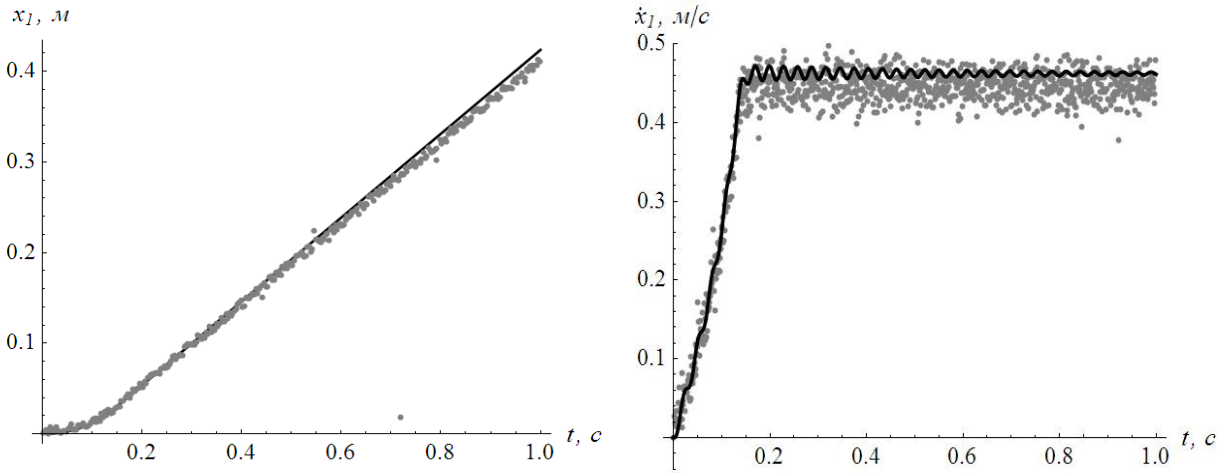
To conduct all investigations they should be divided into two series. The first is to determine the characteristics of movement elements jib crane system for natural mechanical characteristics of its drives, the second in determining the characteristics of the movement of these same elements, but for optimum control. Variables is the length of the flexible suspension (1 and 2.1 m) and weight of cargo (20 and 100 kg).

Thus, the planned series of two studies: 4 experiments you for the first and 16 for the second series.

The collected experimental data presented in the form of a multidimensional array, individual elements which reflect the change in measured physical parameters of the model tower crane. Multivariate experimental data recorded in a special text file that connects (imported) for aqueous product Mathematica for statistical analysis.

After processing the experimental data, graphics kinematic features built mechanism for lifting and changing speed load, and the respective schedules of theoretical calculations.

In Fig. 5 shows graphs for movement mechanism changes the departure from the natural mechanical characteristics for the transfer case and lowering weighing 20 kg with a height of 1m. Black line shows the theoretical data and gray points - experimental.



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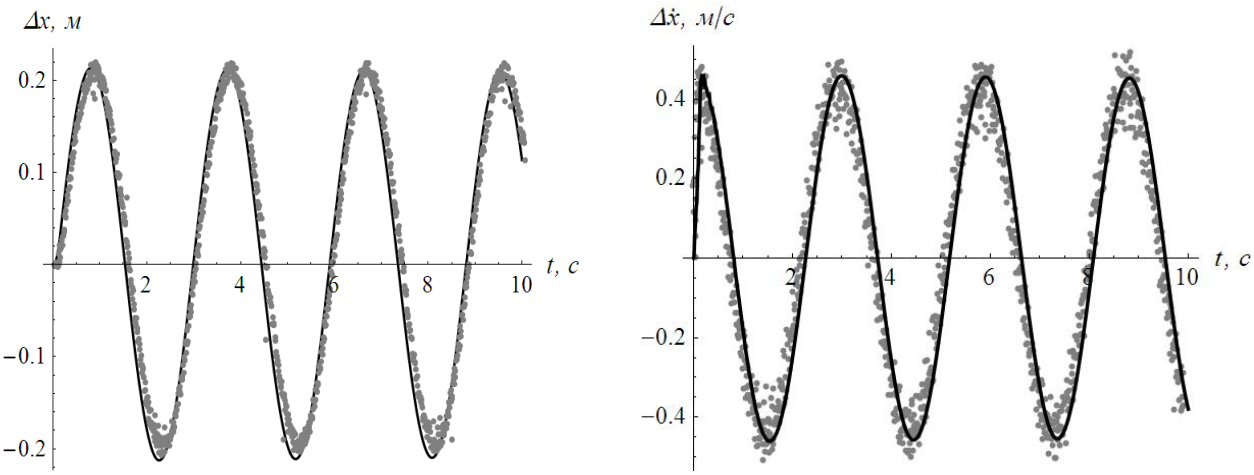

c d

Fig. 5. Charts changing kinematic characteristics of motion change mechanism departure for the first experiment: a - moving carriage; b - rate carriages; c - angle rope with a weight from the vertical; d - rate of change of the angle of deflection of the rope from the vertical load

Charts for other experiments similar to those presented in fig. 5, so they do not show.

Here are the charts that describe the mechanism for lifting goods (Fig. 6), based on data obtained during the first experiment.

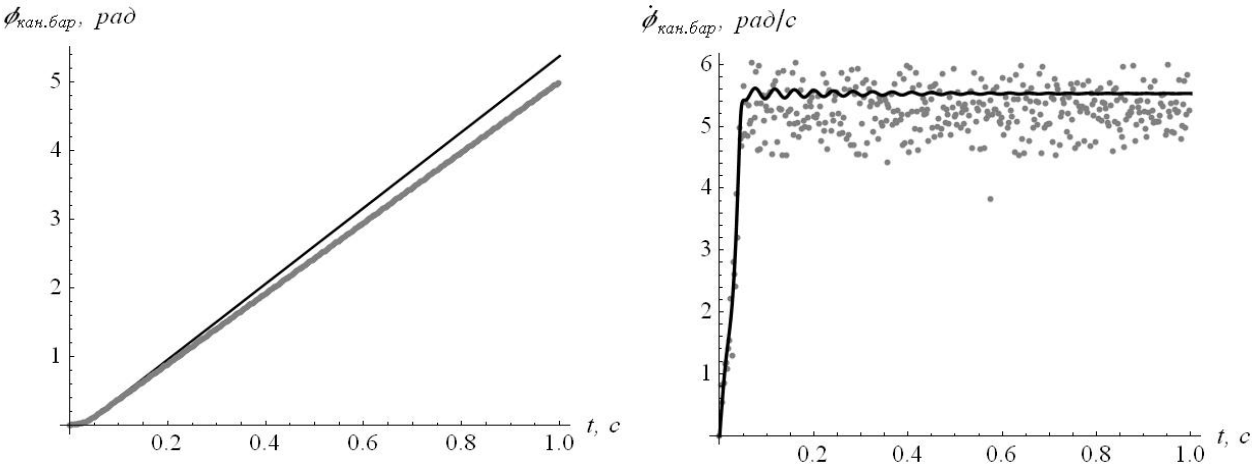

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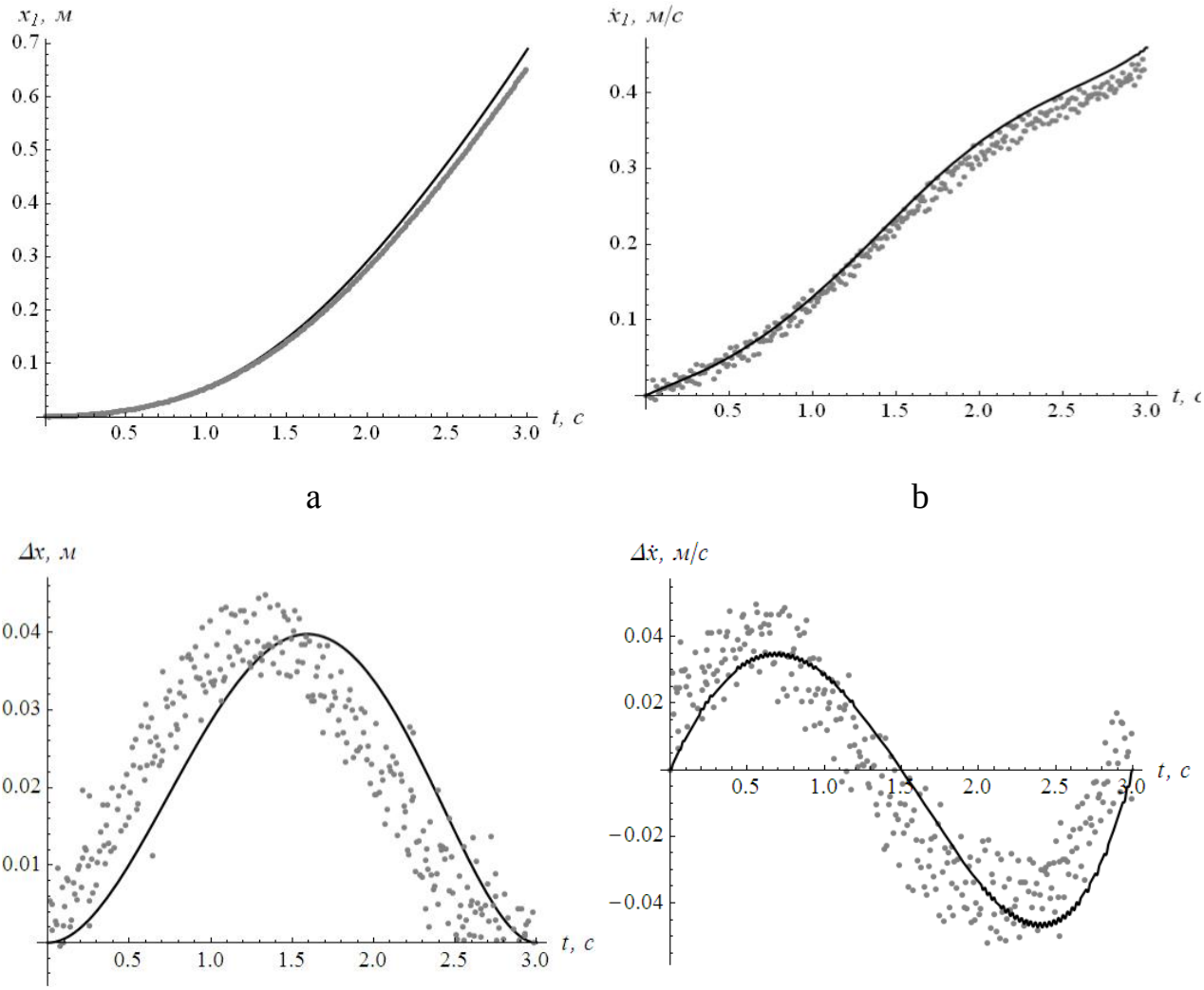
Fig. 6. Charts changing kinematic characteristics of motion mechanism for lifting goods during acceleration for the first experiment: a - angular coordinate kaness at room drum; b - angular speed cable drum

Schedules of kinematic parameters of the movement mechanism of change flight model tower crane for optimum control.

In fig. 7-8 shows graphs for the movement mechanism of change departure and Lift weighing 20 kg with a height of 1m, the optimal control law for the case of its movement and subsidence. Black line corresponds to the best laws and the terms of gray represent the experimental data (Fig. 7-8).



a b

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Fig. 7. Charts changing kinematic characteristics of motion change mechanism departure for the experiment conducted by optimal control: a - move the trolley; b - speed trolley; c - angle of the rope with the load from the vertical; d - rate of change of the angle of deflection of the rope with a weight from a vertical

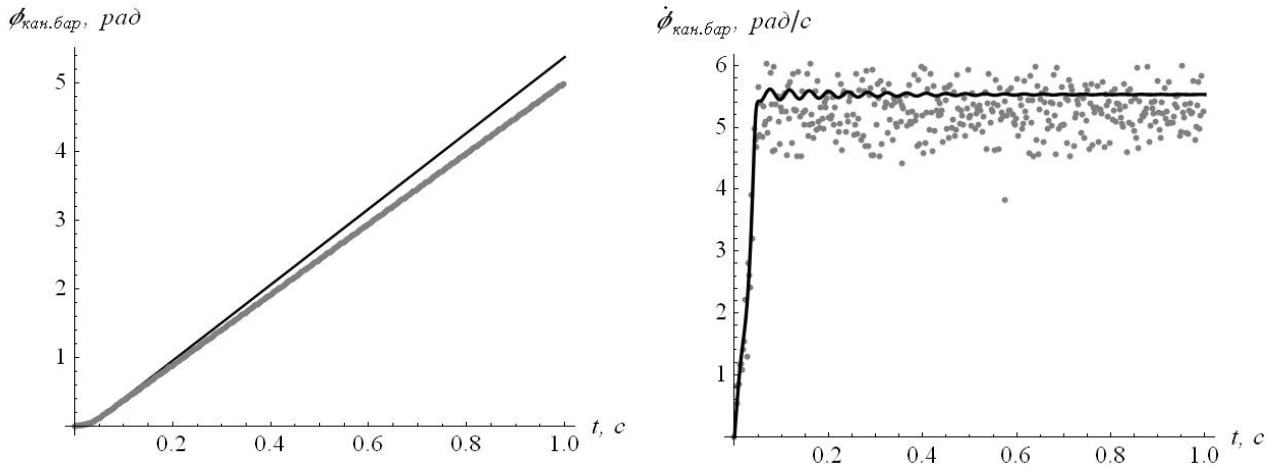

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Fig. 8. Charts changing kinematic characteristics of motion change mechanism departure for the experiment conducted by optimal control: a - angular coordinate rope drum; b - the angular velocity of the rope drum

Analysis of experimental data carried out using statistical indicators, shows quite a good work out optimal laws of motion. Maximum values obtained coefficients of variation of experimental data: to move the cart - 5.3%, trolley speed - 12.6%, deflection angle rope with a weight from the vertical - 16.7%, the rate of change of the angle deviation rope with a weight from the vertical - 12 6%.

Implementation of the optimal mode of motion mechanism for lifting goods shows a much larger difference in the theoretical and experimental data than for the mechanism of changing speed. The maximum value of the coefficient of variation of the angular coordinates rope drum mechanism for lifting goods does not exceed 30%.

Based on the analysis of statistics that match the experimental data obtained by driving mechanisms changing speed and load lifting on natural mechanical characteristics of the engines and their optimal control set adequacy performed theoretical calculations indicated functions these mechanisms.

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ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ З ВИЗНАЧЕНЯ ХАРАКТЕРИСТИК РУХУ МЕХАНІЗМІВ ЗМІНИ ВИЛЬОТУ ТА ПІДЙОМУ ВАНТАЖУ БАШТОВОГО КРАНА

В.С. Ловейкін, Г.В. Шумілов

Наведено результати експериментальних досліджень, проведених на фізичній моделі стрілової системи баштового крана. Отримано графіки характеристик руху елементів механізмів зміни вильоту та підйому вантажу баштового крана, що підтверджують адекватність теоретичних досліджень.

Ключові слова: *баштовий кран, механізм зміни вильоту, механізм підйому, експериментальні дослідження*

Экспериментальные исследования по определению характеристик движения механизмов изменения вылета и подъема груза башенного крана

В.С.Ловейкин, Г.В. Шумилов

Представлены результаты экспериментальных исследований, проведенных на физической модели стреловой системы башенного крана. Получены графики характеристик движения элементов механизмов изменения вылета и подъема груза башенного крана, подтверждающие адекватность теоретических исследований.

Ключевые слова: *башенный кран, механизм изменения вылета, механизм подъема, экспериментальные исследования*