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EXPERIMENTAL STUDY DYNAMICS OF HINGE-JOINTED JIB CRANE SYSTEM

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In the works of local and foreign scientists widely studied oscillation of the load suspended from a rope as it moves [1, 3, 4, 6]. Considerable attention is given to the negative impact of oscillation of the load on the overall reduction efficiency of different types of cranes during lifting and handling operations. In particular, describes the effect of rocking on the prolongation of the working cycle of the crane, reducing its maneuverability, worsening working conditions crane operator and maintenance personnel, as well as a significant increase in dynamic loads on the links, machinery and cranes in general [4, 5, 6]. Increased dynamic loads affects links and kinematic pairs of cranes with a lifting boom, particularly with hinged-rigid jib system [2, 9, 10].

The aim of the study was to analyze the impact of oscillation of the load to increase the dynamic loads on the links jib systems and, in particular, the mechanism for changing departure.

The main material. Studies conducted on the physical model, which reflects a certain scale dynamic processes movement of gantry crane jib MARC-40 [8]. To see pictures of the negative impact of oscillation of the load on the links jib systems and, in particular, the mechanism of changing speed, the following parameters were studied: boom angles to the horizon and cargo rope deviation from vertical, internal longitudinal forces in outhaul and dentate rail, rotor speed of the motor.

Research conducted under manual control mechanism motor changing speed in the horizontal movement of cargo weighing 16 kg, which corresponds to an average 19,2 tons lifting capacity for the crane MARC-40 [8].

Measuring these parameters performed by measuring complex, which consists of: potentiometric sensor angle arrows, inductive sensor deflection cargo rope DSD-523, measure delay of the sensor, the sensor measure rack and sensor rotor speed motor DCHV-1, analog-to-digital converter (ADC) Spider-8 and a personal computer with the program Catman Express 4.5 [7]. Analog performance of the sensors are transmitted to the ADC, which converts them into digital data packets and sends to your computer for further processing.

The angle α is the angular coordinate arrows, and shows its inclination to the horizon. Research the angle needed for fixing the position boom and jib all parts of the system at a time. In Fig. 1 shows a graph of the angle to the horizontal arrows α with respect to real time, with a change of departure from minimum to maximum.

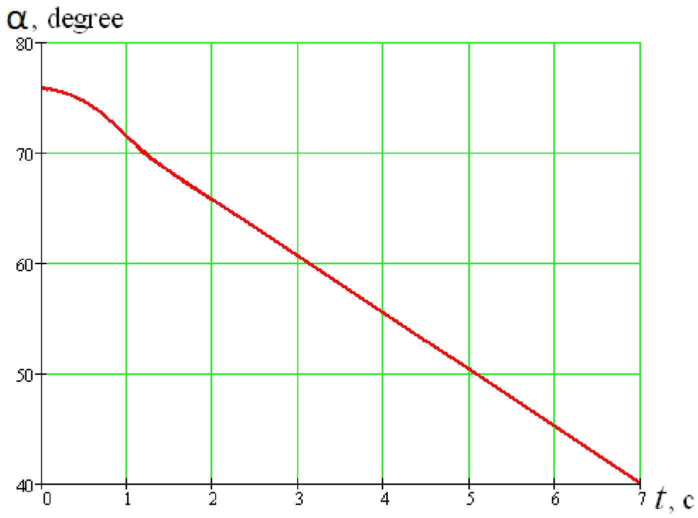

Fig. 1. Schedule changes angular coordinate arrows

We construct a graph of deflection from the vertical rope cargo ψ. But because the experiment was determined angle rope from the trunk γ (Fig. 2), the angle from the vertical rope cargo ψ determined analytically, considering geometric characteristics of jib system [6].

Trunk angle to the horizon is defined by the expression:

$$\pi - \varphi_2 = \arcsin\left(\frac{L\sin\alpha - H}{l}\right), \tag{1}$$

where L – boom length, m; l – length of the trunk, m; H – length of the suspension load of, c.

With regard to dependence (1) the expression for determining the angle of deviation from the vertical load of the rope becomes:

$$\psi = \gamma - (\pi - \varphi_2) - 90° = \gamma - \arcsin\left(\frac{L\sin\alpha - H}{l}\right) - 90° . \qquad (2)$$

Based on expression (2) and collected data array angle γ plotting temporal variation of the angle ψ (Fig. 3).

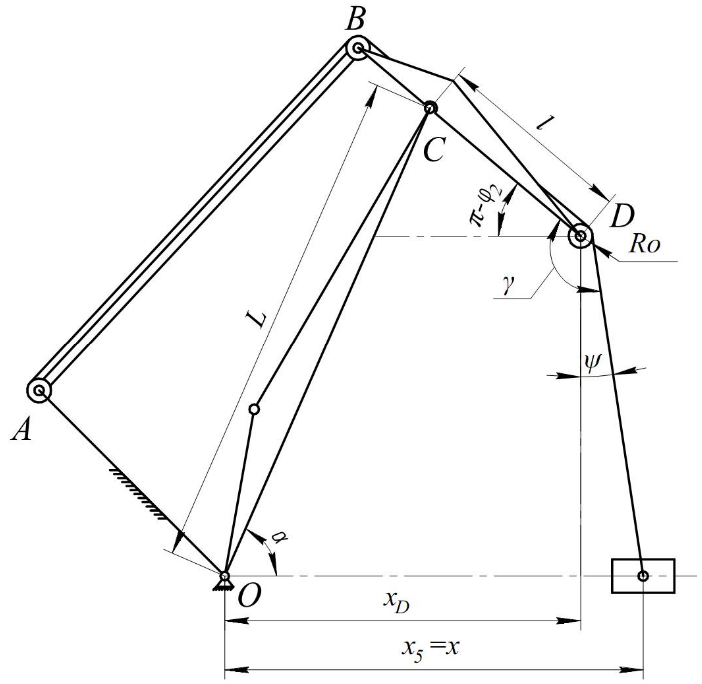

Fig. 2. Scheme to determine the angle of deviation from the vertical rope cargo

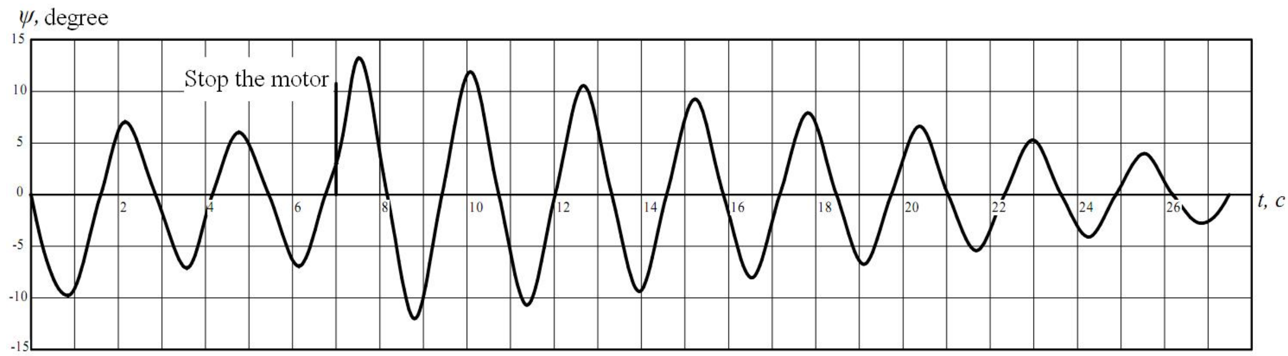

Fig. 3. Schedule changes deflection cargo rope

Analysis of the resulting graph showed that the largest angle of 12,6 degree cargo rope occurs after stopping the motor, and therefore the jib system, while the load continues to move by inertia. In addition, the process of extinction fluctuations after stopping the motor three times while driving jib system from minimum to maximum and departure is 21 sec.

To investigate the horizontal coordinates of the cargo offered an expression that combines angular coordinate radius and angle from the vertical rope cargo using kinematic relations links jib crane system (Fig. 2):

$$x_5 = L\cos\alpha - l\cos\varphi_2 + H\sin\psi + R_0, \tag{3}$$

where φ_2 – angular coordinate trunk, R_0=0,5m – radius end bypass block ka trunk (Fig. 2).

Based on the reduced dependence graph constructed horizontal coordinates x_5 load time for manual control mechanism for changing speed electric jib system (Fig. 4).

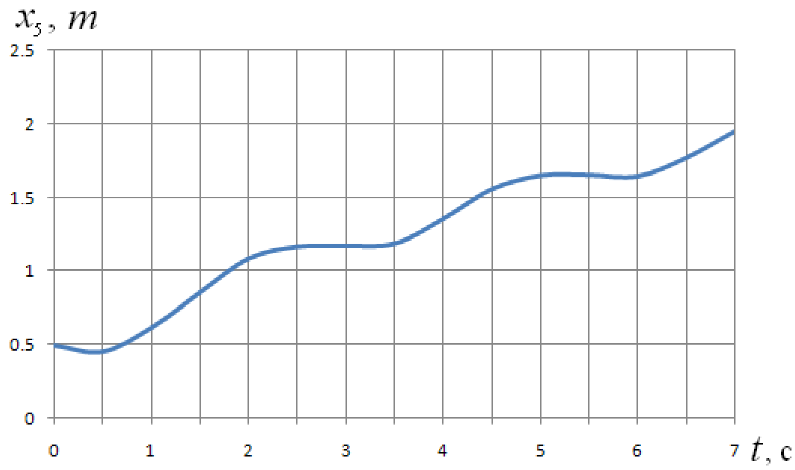

Fig. 4. Schedule changes horizontal coordinates cargo

To establish the influence of oscillation of the load on the drive mechanism for changing speed and, in particular, motor, built a graph of the speed of the rotor motor n in the process of changing departure jib system. This uses an array of data generated by sensor speed DCHV-1, and dependence, which allows to determine the rotational speed of the rotor of the electric motor at a time, taking into account characteristics of the sensor and the ADC:

$$n = \frac{60\nu}{Kz}, \tag{4}$$

where ν – frequency rotor sprocket teeth passing by the sensor, c^{-1} (values taken from the data array sensor DCHV-1); z = 28 – number of teeth sprocket rotor; K=50 c^{-1} – frequency surveys sensor.

Based on the dependence (4), plotting the frequency of rotation of the rotor motor mechanism changing speed when driving jib system from minimum to maximum flight (Fig. 5). When analyzing the chart revealed that the dispersal t_P equals 3,37 c, and braking $t_Г$ is 0,37 c.

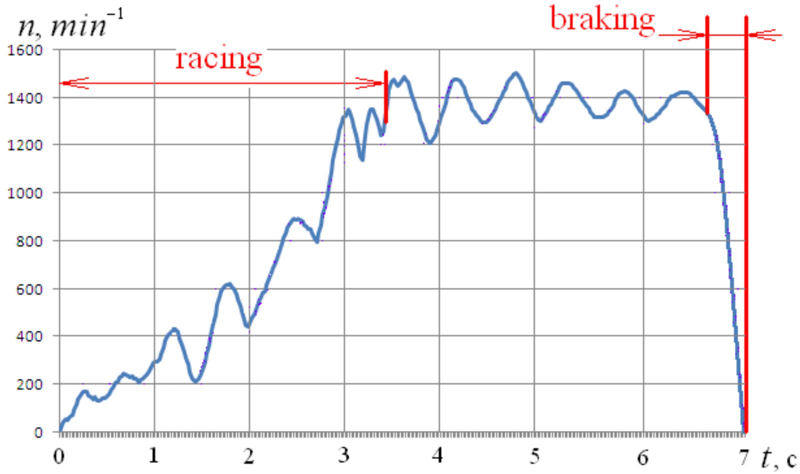

Fig. 5. Schedule change in frequency of rotation of the rotor of the electric motor

To analyze the impact of oscillation of the load on the links jib system constructed graphs of internal loads in vidtyazhtsi and dentate rail. The choice of these links for the study of internal efforts due to the fact that these units or their components often breaking down [3, 4, 9].

To plot changes internal efforts in dentate rail uses an array of data obtained by strain gauges rack. Since strain changing the voltage in the electrical circuit of the measuring channel ADC, then converting the indicators value efforts using calibration data [7]. When processing the array data should take into account that calibration was conducted in the «tension – weight».

Therefore, the study of internal efforts to move from mass to force, using the concept of force:

$$G = mg\,, \tag{5}$$

where m – mass calibration weights with calibration chart, kg [7]; g=9,81$м/c^2$ – acceleration of free fall.

Based on the data obtained constructed graphs efforts dentate rail when changing speed jib system from minimum to maximum values during the whole time of the mechanism (Fig. 6). These schedules set extreme values effort at the beginning and end of the mechanism. Emergence extremum 1 attack due to gear teeth of the rack and hit the rails on an arrow in the hinge. These attacks occur at the beginning of the movement mechanism, namely the shear rail from the place. The emergence of two extremum due to its instantaneous tension that occurs at the end of flight time changes as the motor and all gear stopped and jib system with the load continues to move by inertia. In addition, tensile rails at this point helps start swinging load in the direction of jib system (Fig. 3).

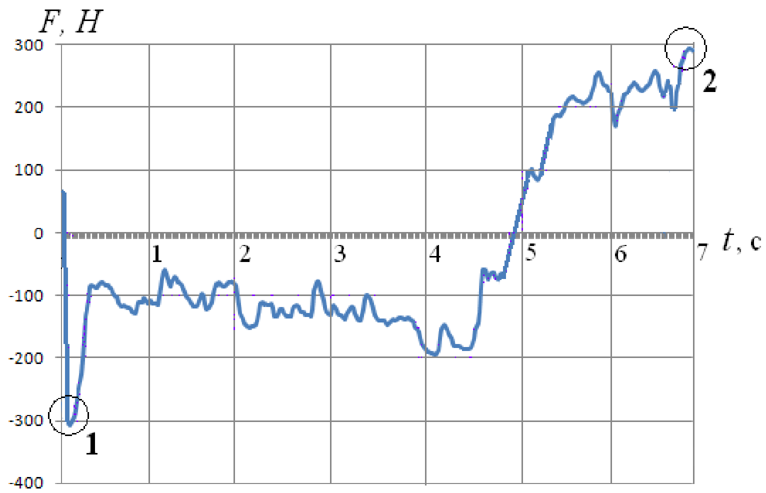

Fig. 6. Schedule changes of internal forces in dentate rail

To plot the changes in internal efforts vidtyazhtsi used data set derived from strain gauges mounted on it. To convert an array of data from the ADC value in efforts using taruvalni data [7]. The transition from mass to force, as in the case of rack, by the formula (5).

Based on the data obtained, constructed graph of longitudinal efforts outhaul, changing flight jib system from minimum to maximum during the whole time of the mechanism (Fig. 7).

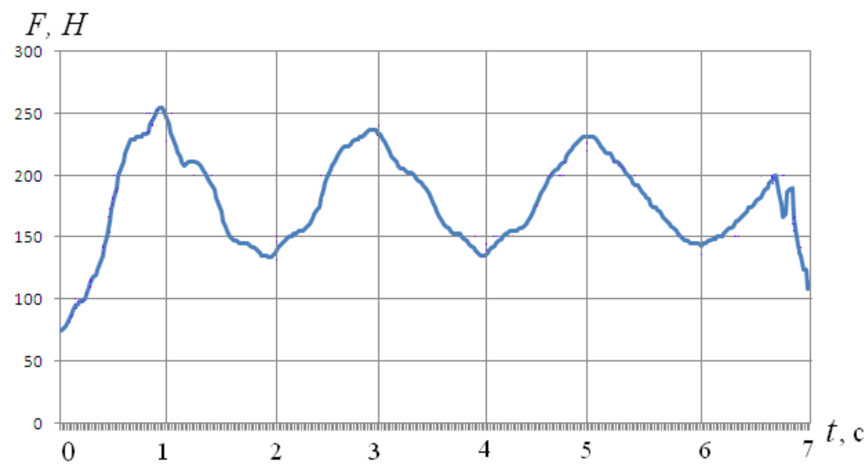

Fig. 7. Schedule changes internal efforts outhaul

Conclusions

Dependencies based on the results of experimental studies, clearly confirm the increase in dynamic loads on the links jib system as a result of fluctuations in load. Analysis efforts in dentate rail showed that it changes from -303,34*N* – early movement to 291,82*N* – in the end, far exceeding the average value efforts. In addition, there is a significant increase in alternating loads outhaul and dentate rail, which result in unequal operating conditions. This leads to a considerable length of acceleration of the engine to the rated speed.

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ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ ДИНАМІКИ РУХУ ШАРНІРНО-ЗЧЛЕНОВАНОЇ СТРІЛОВОЇ СИСТЕМИ КРАНА

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Наведено результати експериментального дослідження динаміки руху шарнірно-зчленованої врівноваженої стрілової системи крана при ручному керуванні електродвигуном механізму зміни вильоту. Під час досліджень, проведених на фізичній моделі визначено такі параметри: кути відхилення вантажного канату від вертикалі та нахилу стріли до горизонту, поздовжні зусилля у відтяжці та зубчастій рейці, частота обертання ротора електродвигуна.

Ключові слова: *стрілова система, фізична модель, відтяжка, зубчаста рейка, зусилля, датчик*

Экспериментальное исследование динамики движения шарнирно-сочлененной стреловой системы крана

В.С. Ловейкин, Д.А. Паламарчук

Представлены результаты экспериментального исследования динамики движения шарнирно-сочлененной уравновешенной стреловой системы крана при ручном управлении электродвигателем механизма изменения вылета. Во время исследований, которые проводились на физической модели, были определены следующие параметры: угол отклонения грузового каната от вертикали, угол наклона стрелы к горизонту, продольное усилие в оттяжке и зубчатой рейке, частота вращения ротора электродвигателя.

Ключевые слова: *стреловая система, физическая модель, оттяжка, зубчатая рейка, усилия, датчик.*