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CONTENT

CHEMICAL SCIENCES

PHYSICAL SCIENCES

TECHNICAL SCIENCES

6. Polyansky KK, Glagoleva KE, Ryahovsky YV Dietary fiber in dairy products. Dairy industry. 2001. № 6. pp. 41–45.

7. Sour cream KI Pharmaconutriciology as a scientifically sound direction of preventive use of biologically active additives. Pharmacy. magazine. 2006. № 6, pp. 34–37.

8. Bondar MM, Vlasenko VV, Solomon AM Semko TV Functional foods with fillers. All-Ukrainian scientific and technical journal "Technology, energy, transport of agro-industrial complex", Vinnytsia, 2016. Issue 3 (95). Pp. 106-109.

9. Bondar M., Solomon A., Dyakonova A. Substantiation of technology of fermented sour milk - desserts with bifidogenic properties. East - European Journal of Advanced Technology 1/11 (97) 2019. P. 6-16.

10. Bondar M. The use of probiotics and prebiotics in dairy drinks. Scientific thought. 2020 №42. Vol.1. Pp. 14-23.

EXPERIMENTAL STUDY OF VIBRATION ACCELERATIONS IN AXIAL DIRECTION ON MODERNIZED TRAVEL WHEELS

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Abstract

The article discusses experimental studies of axial vibration accelerations that occur in the axle of the traveling wheels when the cargo carriage of the overhead crane moves. To compare the results of experimental studies, double-ribbed running wheels with a cylindrical rim were selected. These wheels are used on almost all overhead cranes. Also, wheels of a new modernized design were manufactured for experimental research.

Keywords: traveling wheel, vibration acceleration, modernized wheel, overhead crane.

The most common hoisting machines in the manufacturing process are overhead cranes. Ensuring their reliable and trouble-free operation at the present time is a very urgent task [1, 2].

The durability of an overhead crane depends on the durability of its metal structure, which perceives significant variable loads [3, 4].

The operating cycles of an overhead crane cause rapidly changing load processes not only in time, but also in magnitude [5]. This requires a fairly accurate determination of all force factors that arise during the operation of an overhead crane, both static and dynamic [6].

The main loads arising in the metal structure of an overhead crane appear during the lifting and lowering of the load and the operation of the mechanisms for the movement of the freight carriage and the bridge [7, 8].

Many works have been devoted to assessing the influence of parameters of movement mechanisms on dynamic loads in metal structures [9, 10].

We proposed a new design of a traveling crane wheel with an elastic insert [11, 12], which made it possible to significantly reduce the dynamic loads during the operation of the movement mechanism [13].

The dynamic model of an overhead crane is considered in [14]. The authors determined the linear oscillations of the model. There is also a description of the vibration of the load and the trolley during the movement of the crane. The friction forces in the system are estimated. An assessment is given of the influence of the load shift during the action of the resistance forces when the crane is moving. But the work does not consider the dynamic loads in the metal structure of the crane during movement.

The possibility of modernizing the mechanism of movement of the cargo carriage of an overhead crane by replacing a three-stage vertical cylindrical gearbox with a two-stage and separately removed gear transmission is considered in [15]. In this case, the running wheel is mounted on the shaft of the bogie wheelset. The authors argue that such a block diagram will reduce energy losses and increase reliability. But at the same time, it was not investigated how much the dynamic loads decrease.

This gives grounds to assert that it is advisable to conduct a study to improve the operational reliability and durability of the running wheel through the use of elastic inserts.

The aim of the study is to substantiate the feasibility of modernizing the design of the running wheel on the basis of vibration signs arising in the running wheel.

To achieve the goal, the following tasks were set:

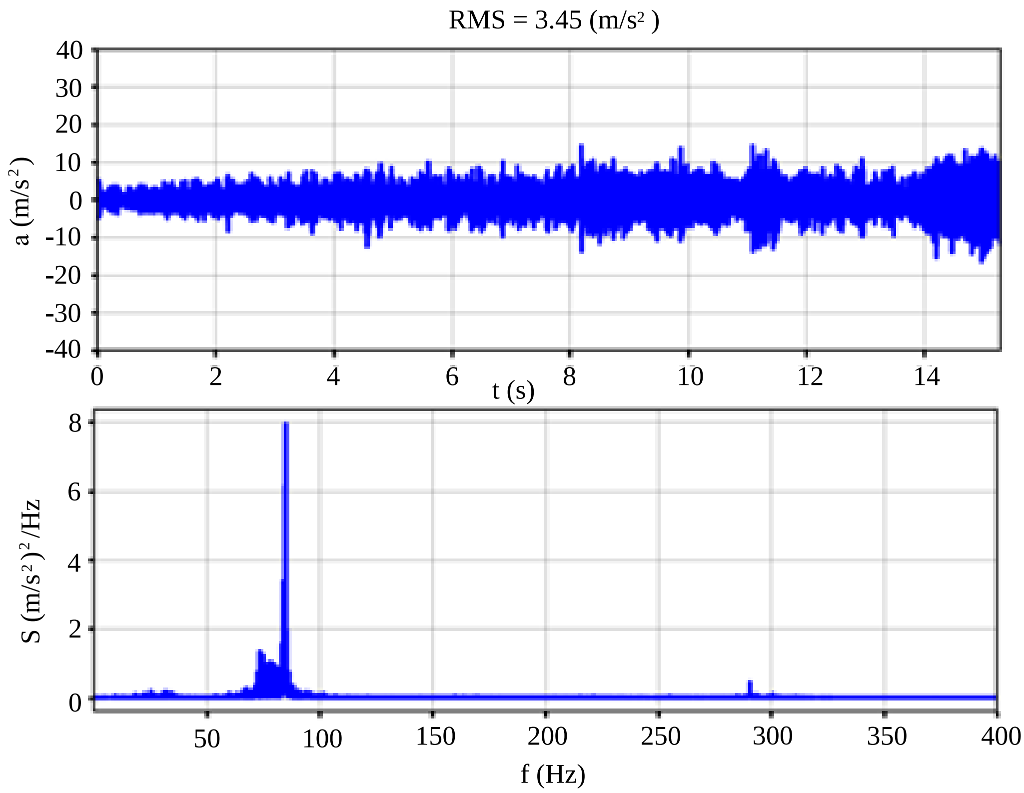
- conduct an experimental study of the formation of vibration accelerations in the axial direction in wheels of standard design;
- conduct an experimental study of the formation of vibration accelerations in the axial direction in the wheels of the modernized design.

To measure vibration accelerations arising during testing of the bridge crane trolley, the «Ultra-B-I» complex. The software included in the measuring complex allows real-time plotting of vibration accelerations versus time, as well as determining the spectral composition of the signal.

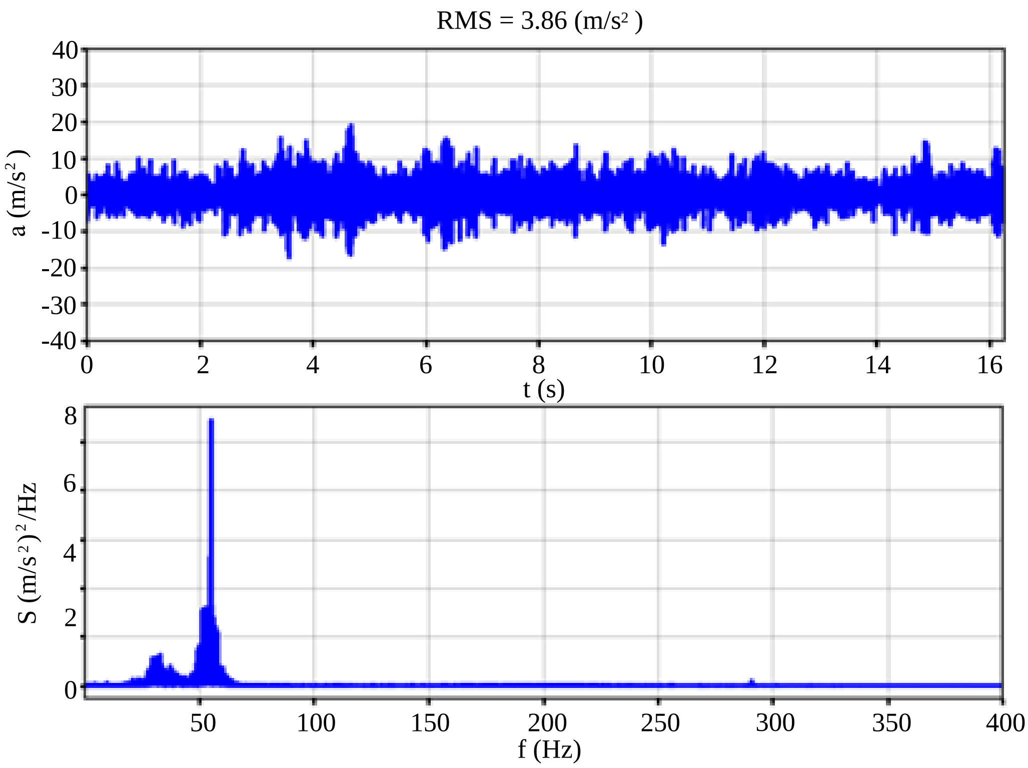
The research was carried out on an operating overhead crane. The vibration measuring complex was located directly on the bridge crane. The sensors were installed at the control points of the crane trolley. With the help of wires placed on the crane beam, they were connected to an analog-to-digital converter. This made it possible to exercise direct control over the operating modes of the crane.

The study of the vibration state was carried out on the axis of the standard running wheel and on the axis of the modernized running wheel of the cargo carriage of the overhead crane.

Based on the results of experimental studies, we will generalize the results of vibration accelerations in the axial direction on the modernized (with an elastic, rubber insert) and standard driven wheels (Fig. 1–3).



a



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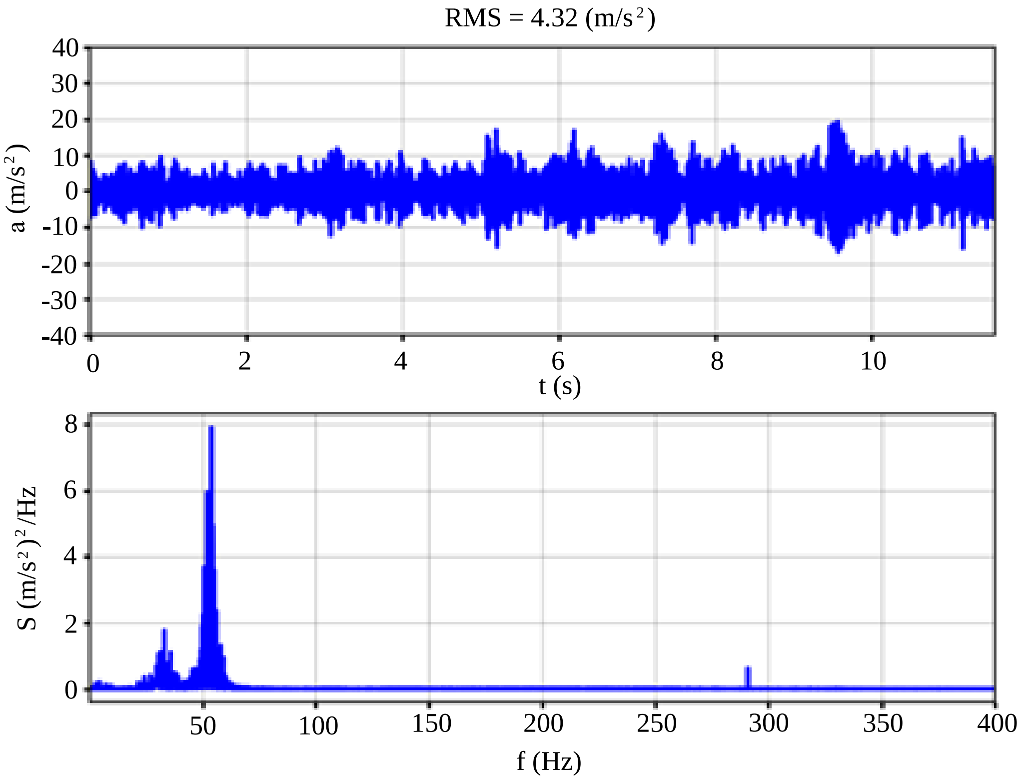

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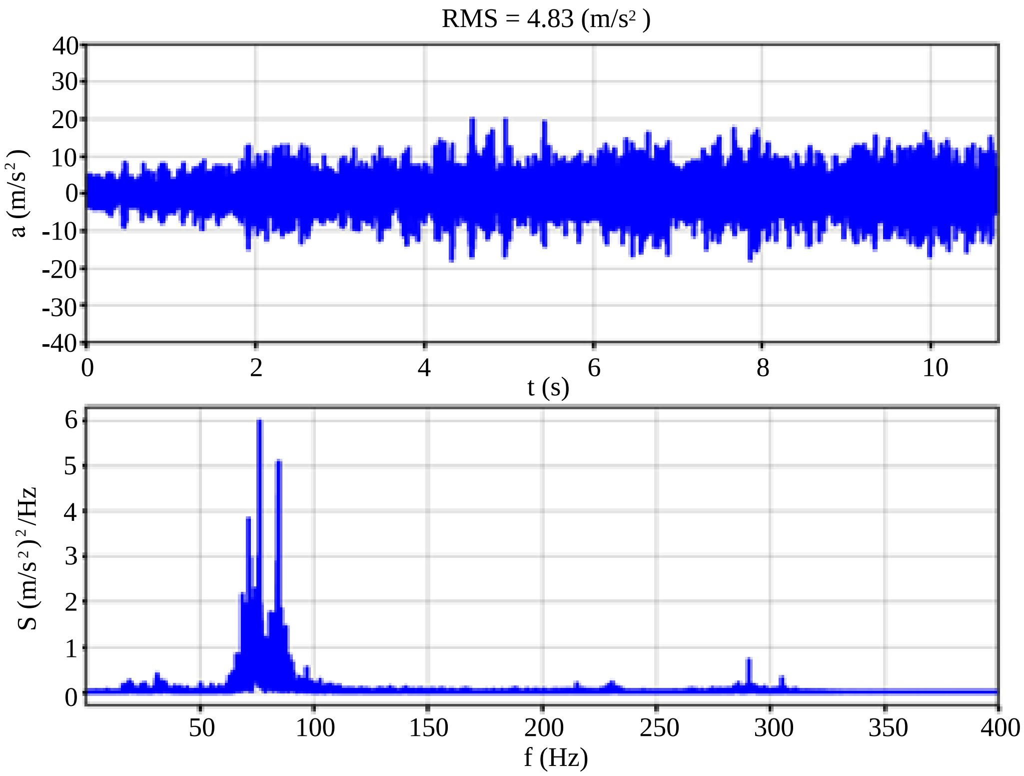

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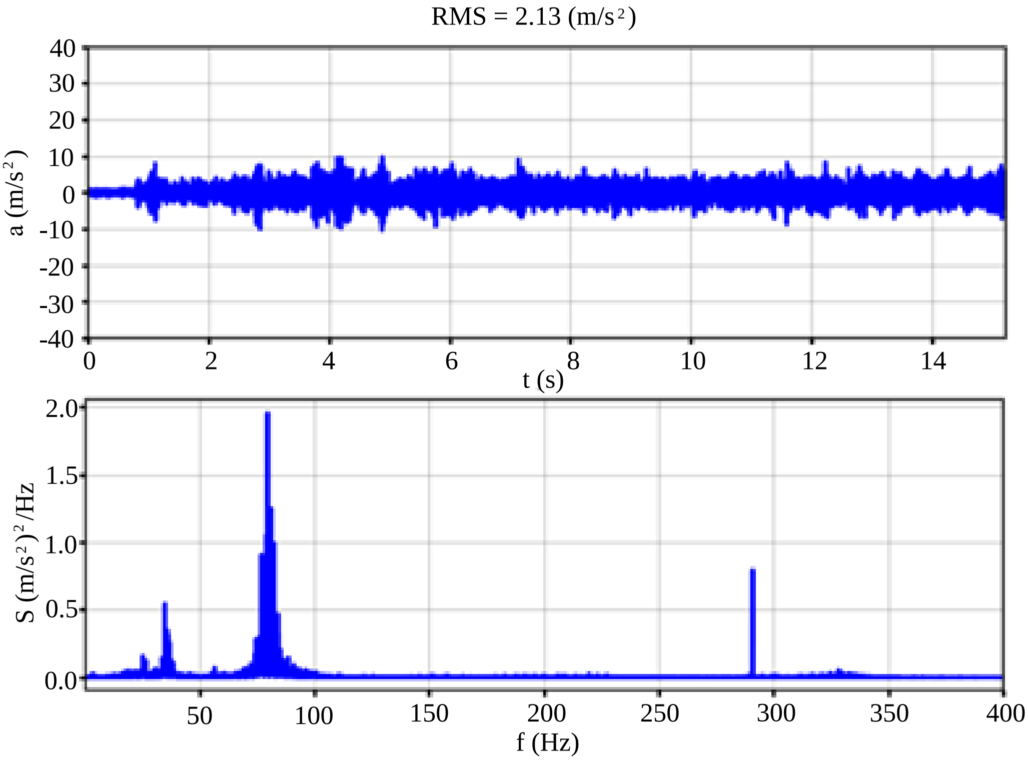
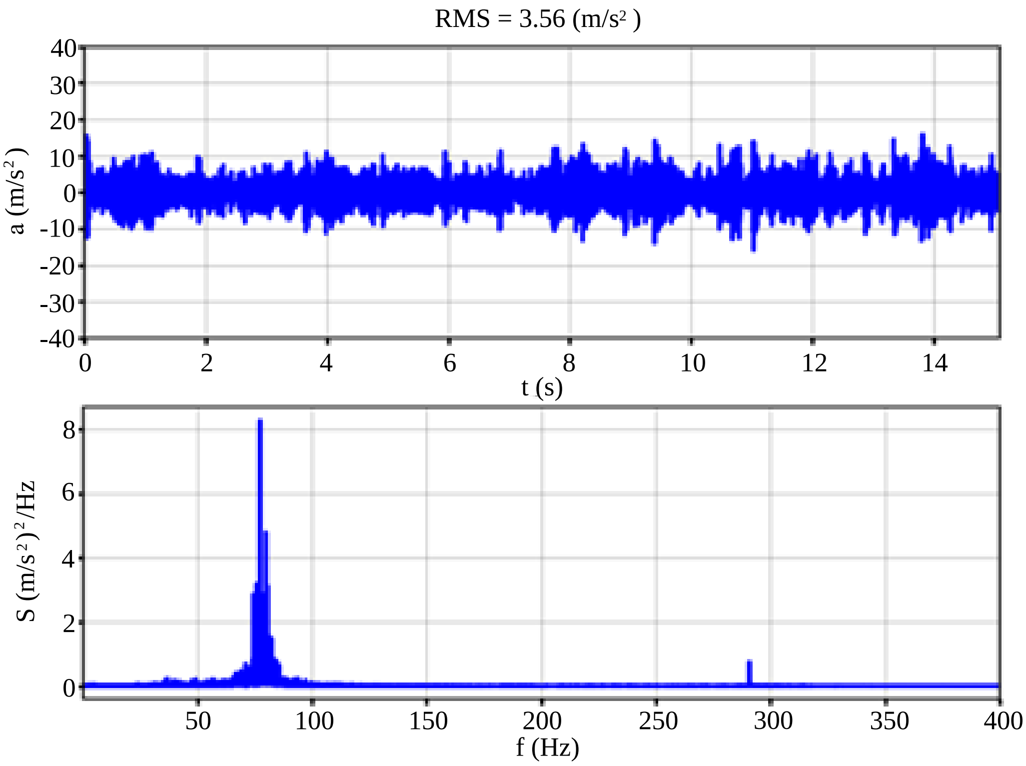
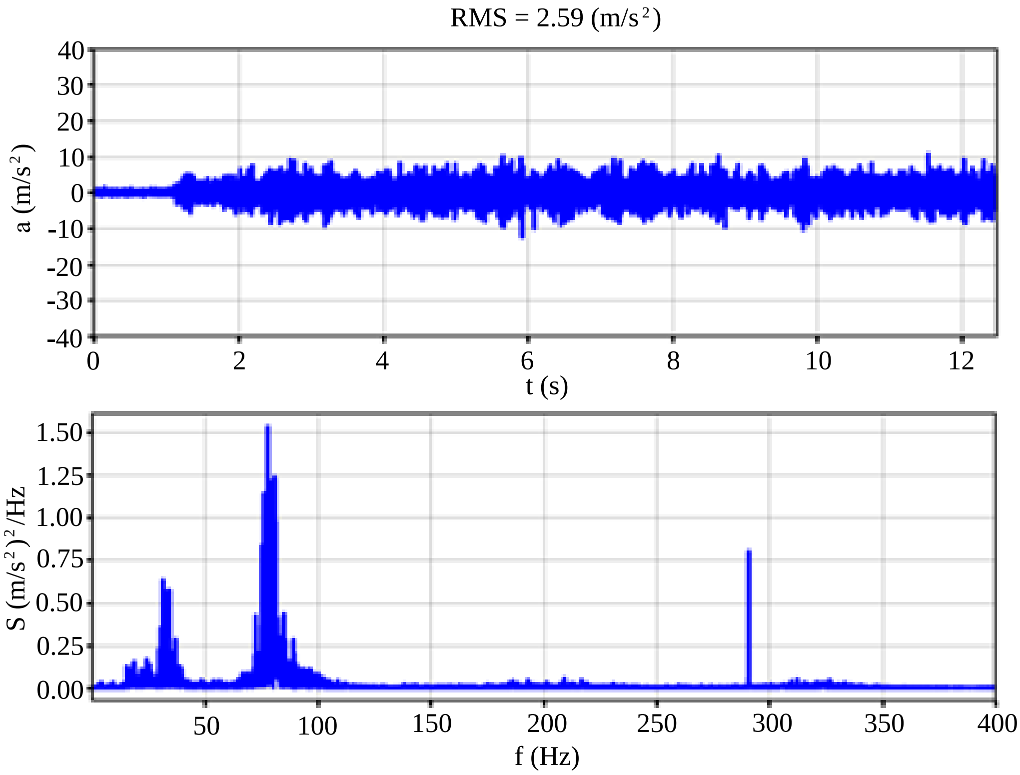
Fig. 1. Vibration acceleration in the axial direction on wheels during idling of the bogie at the first a, b and second c, d travel speeds; a, c - modernized wheel; b, d - standard wheel


RMS = 2.13 (m/s²)
a (m/s²)
t (s)
S (m/s²)²/Hz
f (Hz)

a


RMS = 3.56 (m/s²)
a (m/s²)
t (s)
S (m/s²)²/Hz
f (Hz)

b



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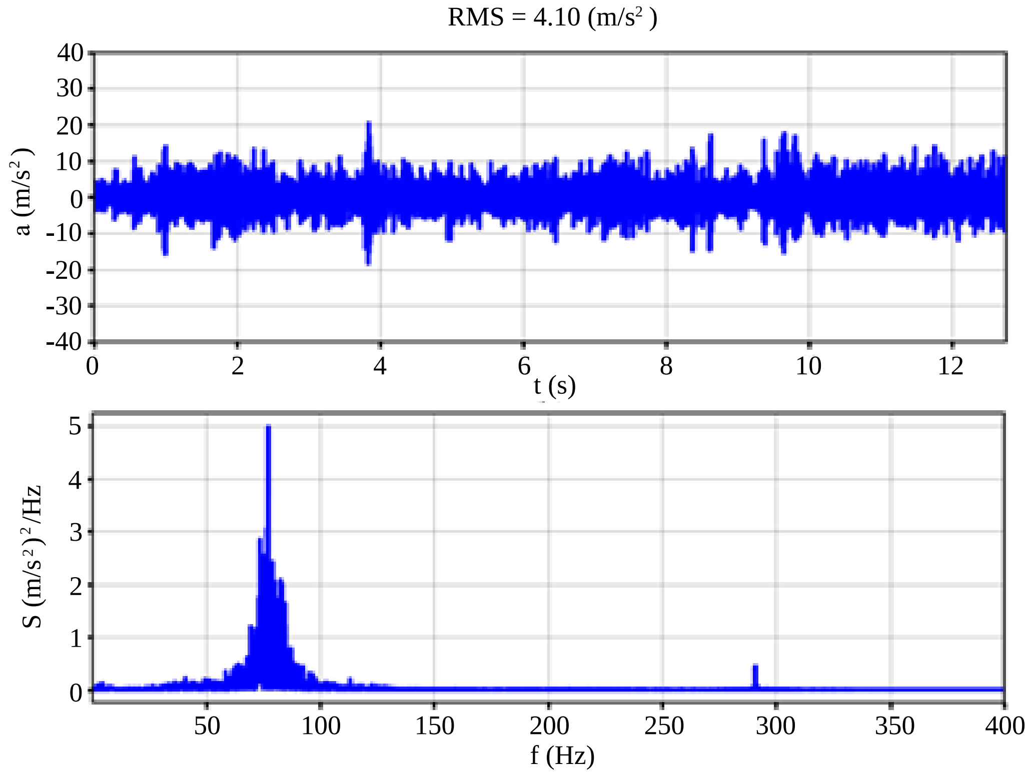

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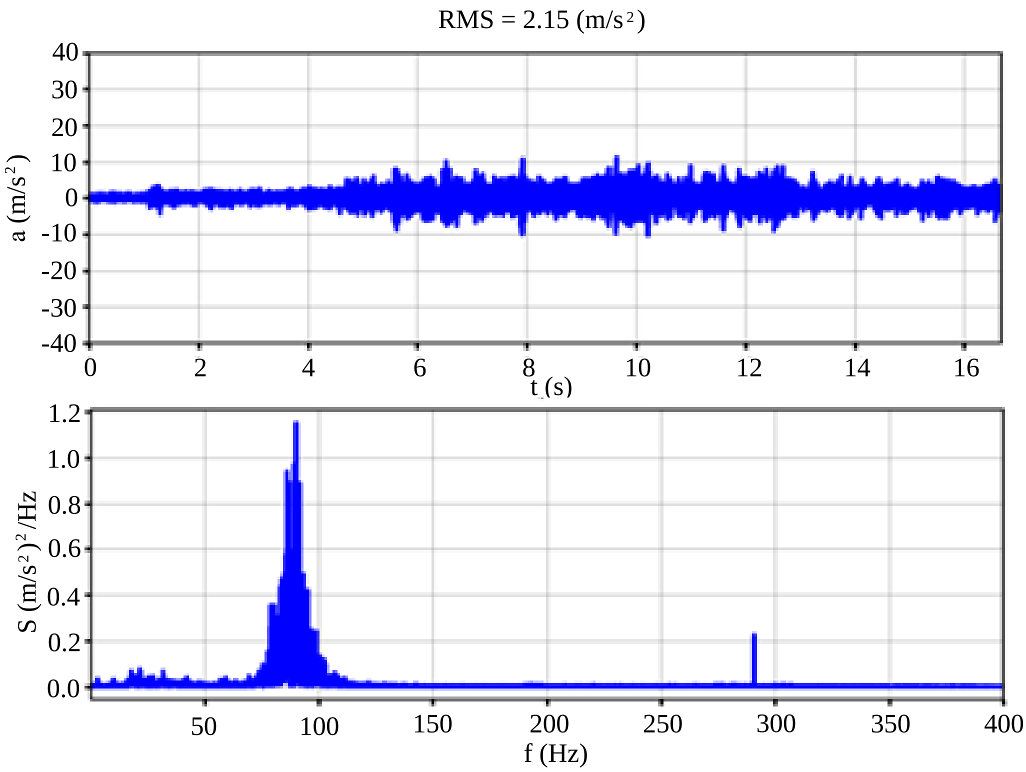
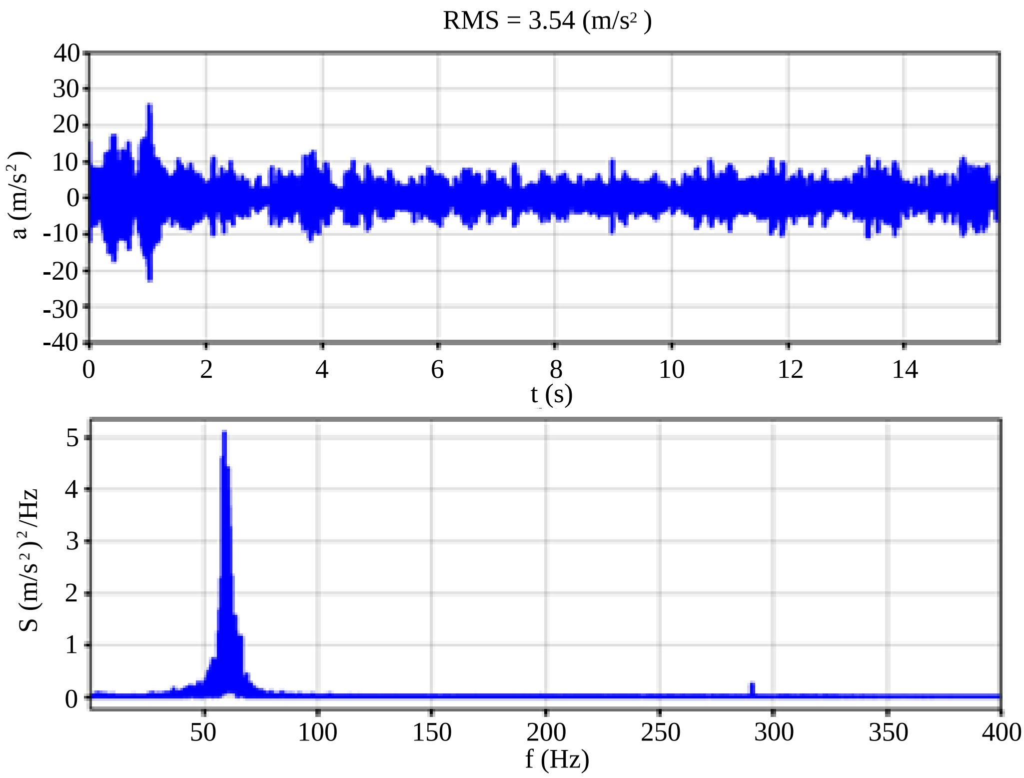
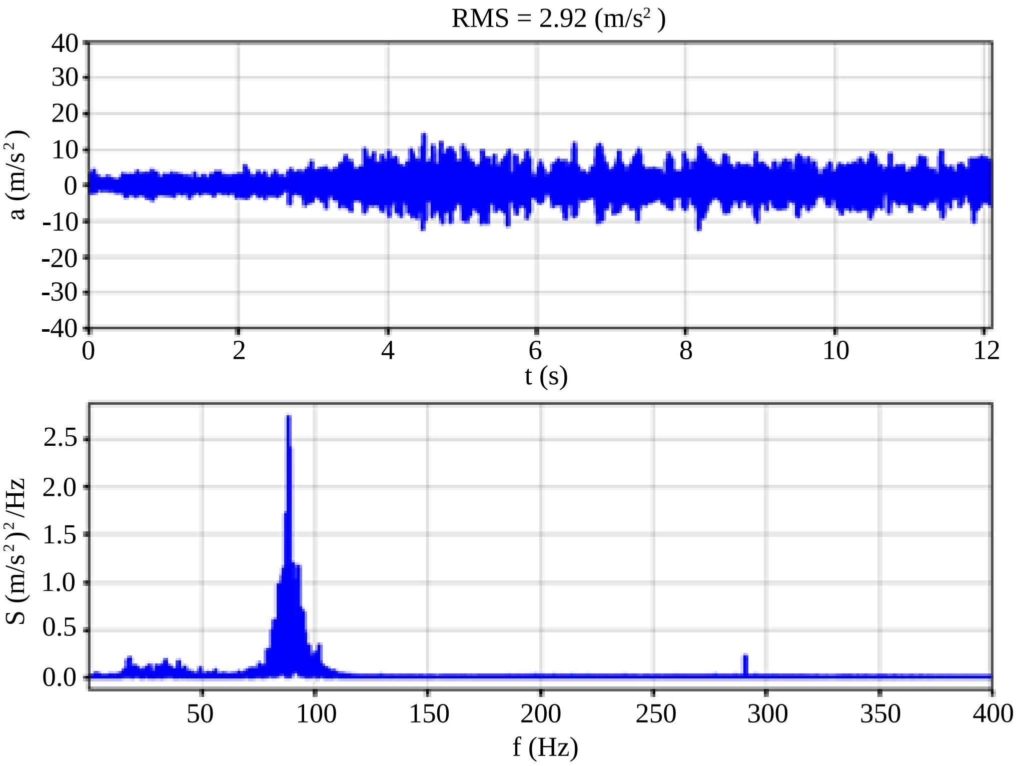
Fig. 2. Vibration acceleration in axial direction on wheels when transporting a cargo of 0.5 tons at the first a, b and second c, d speeds; a, c - modernized wheel; b, d - standard wheel


RMS = 2.15 (m/s²)
a (m/s²)
t (s)
S (m/s²)²/Hz
f (Hz)

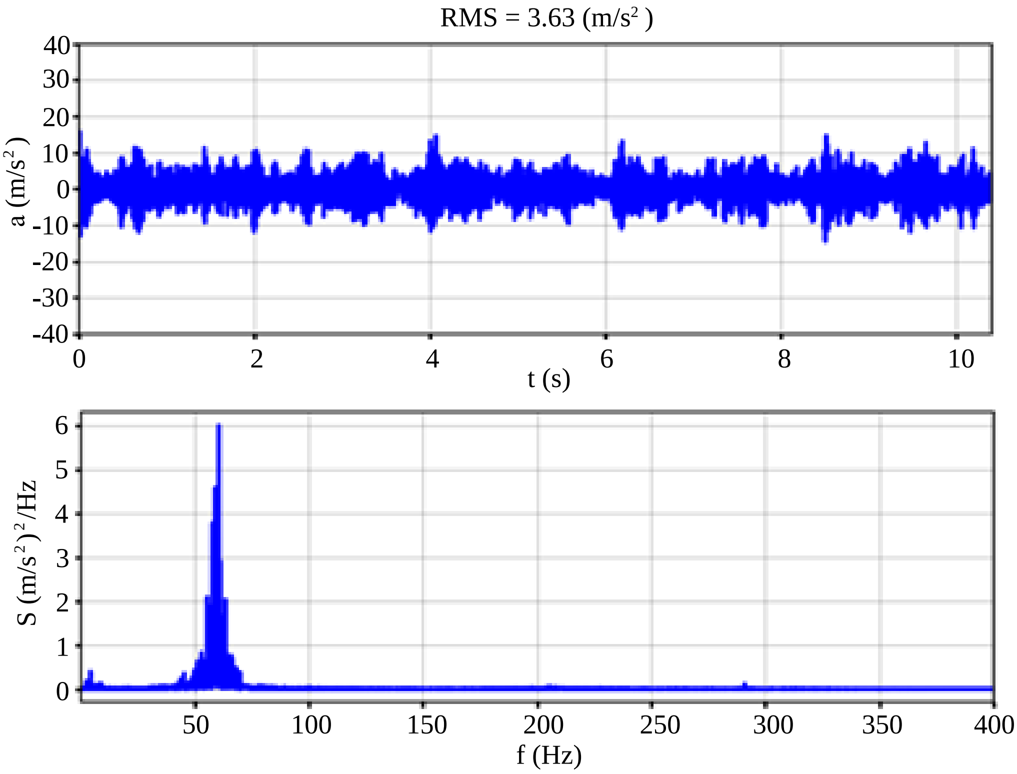
a


RMS = 3.54 (m/s²)
a (m/s²)
t (s)
S (m/s²)²/Hz
f (Hz)

b



c



d

Fig. 3. Vibration acceleration in axial direction on wheels when transporting a cargo 2 tons for the first a, b and second c, d speeds; a, c - modernized wheel; b, d - standard wheel

According to the data obtained from experimental studies, we will make histograms of vibration acceleration in the axial direction on the modernized (with an elastic rubber insert) and standard driven wheels of the overhead crane truck trolley at the first speed (Fig. 4).

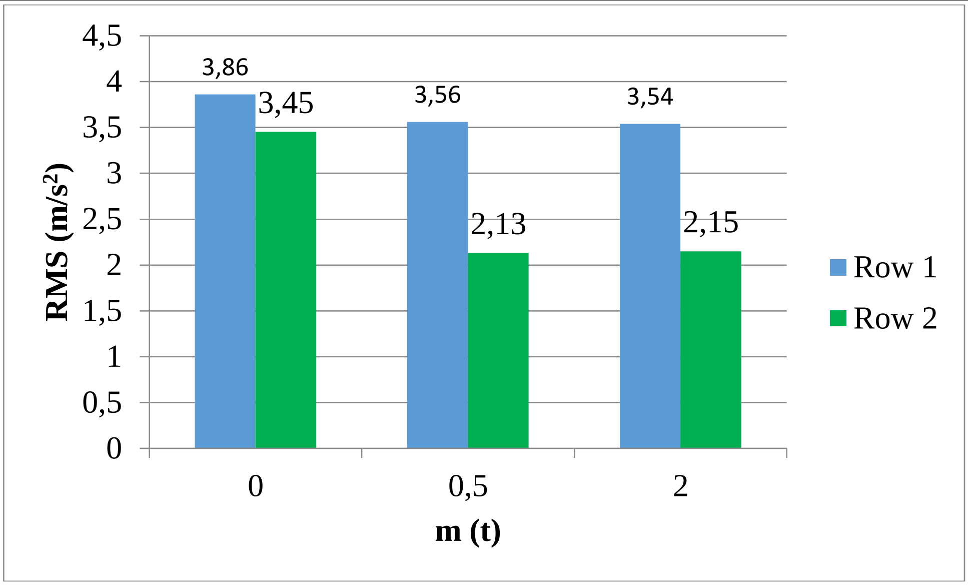


Fig. 4. Histogram of vibration accelerations in the axial direction on the driven wheels of an overhead crane truck at the first speed, Row 1 – standard wheel, Row 2 – modernized wheel

Based on the results of vibration accelerations in the axial direction on the modernized (with elastic, rubber insert) and standard driven wheels, we will calculate the percentage of axial vibrations from the modernization of the wheels at the first speed of the overhead crane truck, table 1.

Table 1 - Axial vibration percentages from upgrading wheels at first speed

Options	**Value**		
Mass (tons)	0,0	0,5	2,0
RMS standard wheel (m/s^2)	3,86	3,56	3,54
RMS modernized wheel (m/s^2)	3,45	2,13	2,15
Ratio (%)	**10,62**	**40,17**	**39,27**

According to the data obtained from experimental studies, we will make a histogram of vibration accelerations in the axial direction on the modernized (with an elastic, rubber insert) and standard driven wheels of the cargo trolley of an overhead crane at a second speed (Fig. 5).

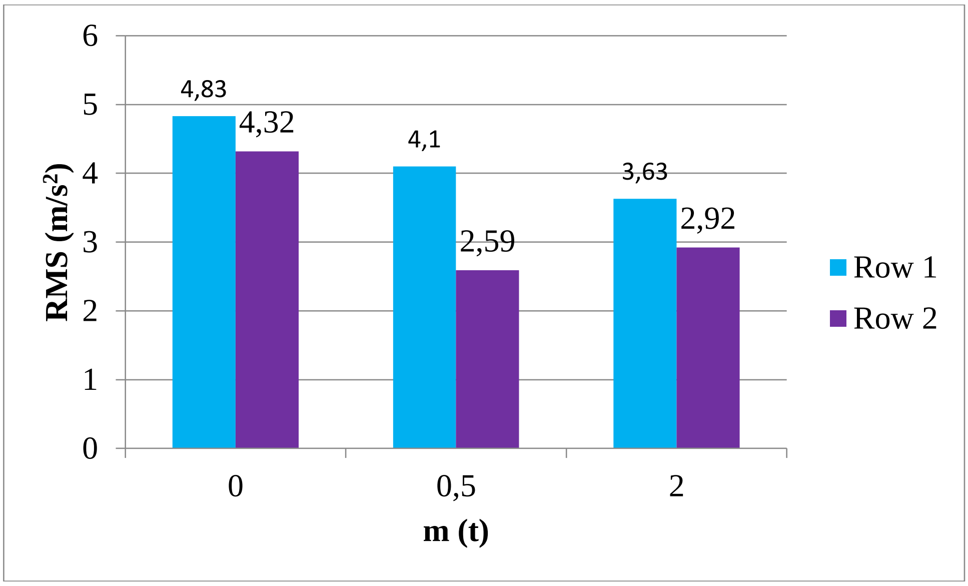


Fig. 5. Histogram of vibration accelerations in the axial direction on the driven wheels of an overhead crane truck at the second speed, Row 1 – standard wheel, Row 2 – modernized wheel

Based on the results of vibration accelerations in the axial direction on the modernized (with an elastic, rubber insert) and standard driven wheels, we will calculate the percentage of axial vibrations from the modernization of the wheels at the second speed of the cargo carriage of the overhead crane, table 2.

Table 2 - Axial vibration percentages from modernizing wheels at second speed

Options	**Value**		
Mass (tons)	0,0	0,5	2,0
RMS standard wheel (m/s^2)	4,83	4,10	3,63
RMS modernized wheel (m/s^2)	4,32	2,59	2,92
Ratio (%)	**10,56**	**36,83**	**19,56**

Conclusions. The ratio of axial vibrations from the modernization of the wheels during the movement of the freight carriage at the first speed of movement is: at idle speed of the freight carriage - 10.62 %; when transporting a cargo of 0.5 tons - 40.17 %; when shipping 2.0 tons - 39.27 %.

The ratio of vertical vibrations from the modernization of the wheels during the movement of the freight carriage at the second speed of movement is: at idle speed of the freight carriage - 10.56%; when transporting 0.5 tons of cargo - 36.83%; when shipping 2.0 tons - 19.56%.

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