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IMITATION MODELING FOR THE INVESTIGATION OF THE LOADED LOCK OF MOBILE VERSTA - WORK

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Summary. *In this article the issues of dynamic analysis of the executive branch of the machine system are considered. The analysis of the design scheme consisting of the spatial system, suspended in space on the flexible elements, was carried out. The mathematical description of the harmonic oscillator, which is the executive link of the mobile machine, is obtained. A simulation model was created in the Simulink computer environment to study the dynamics of the loaded executive of the mobile machine. The reaction of the model to forced harmonic oscillations, which has quasi-random character, with sinusoidal influence, is obtained. The obtained result suggests that in the operating unit of the mobile machine there are oscillations with a wide frequency and amplitude spectrum, which can cause resonance of elements of the technological system in a wide frequency range.*
Key words: *dynamic analysis, intellectual machines - works, parallel kinematics*

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Statement of the problem. When designing machines and mechanisms, a decisive role in choosing the parameters of a future product has a reasonable prediction of its performance, based on strength and strength calculations. At the same time, the indicators of the expected accuracy of the executive motions of the product are determined based on the chosen calculation schemes, which are based on a number of assumptions that allow them to be reduced to solvable mathematical constructions - the equation of statics and dynamics. However, in some cases, such assumptions allow finding common solutions that relate to the established modes of product operation, but overlook certain cases of practical interest and are not trivial. This applies, first of all, to the dynamic processes that can accompany the projected product [1, 2].

Analysis of the available investigations. The development of mechanical assembly production is also based on the use of promising constructions of the main technological equipment. Therefore, high-speed, multi-operation metal-cutting machine tools with numerical control systems, technological equipment of flexible machine-tool modules and robotized production are used. A special place in this process begins to occupy equipment based on mechanisms with parallel kinematics. Their advantages are manifested in their low metal capacity, energy intensity, dynamism, and also in the kinematic possibilities. This makes this equipment attractive for the creation of flexible automated productions with smaller, compared with traditional manufacturing solutions, primary costs, as well as the costs of continuously updating core production assets to maintain the competitiveness of products produced by reducing its cost [3 – 6].

The Objective of the work. The purpose of the work is to develop a method of experimental research of the loaded part of a mobile machine tool. This goal is due to the fact that in the prediction of the performance characteristics of mobile robot machines based on mechanisms with parallel kinematics, the dynamic analysis of the executive part of the machine tool system is an important task, the solution of which it is expedient to perform on the basis of attracting funds simulation behavior of the spatial structures of the spatial structure.

Statement of the task. Conduct an analysis of the executive part of the machine system based on the attraction of the simulation behavior of spatial structures.

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Experimental model. The mechanisms of the "tripod" and "tetrapod" type, which, in conjunction with the delta mechanism and the control device, based on the neural network, have been used as the source link in the problem laboratory of mobile intelligent technological machines of the Donbas State Machine Building Academy for the construction of a mobile machine tool-robot, reference model of the mechanism in the working space (Fig. 1).

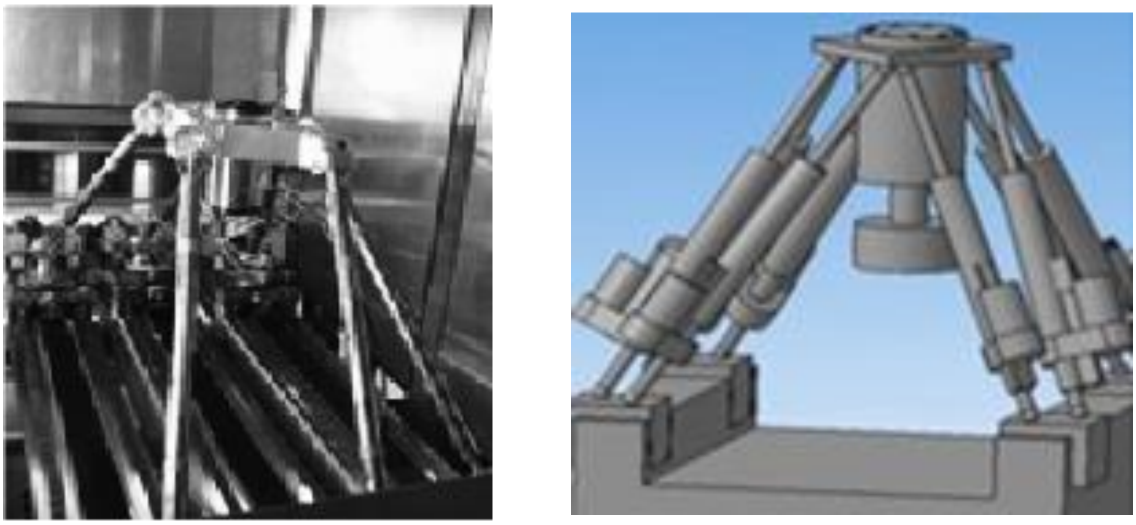

Figure 1. Design and scheme of a mobile robot

An estimation scheme that allows an analysis of the dynamics of the design features can be represented by the spatial mass system *m* suspended in space on flexible elements with rigidity parameters c_x, c_y, c_z and damping h_x, h_y, h_z (Fig. 2).

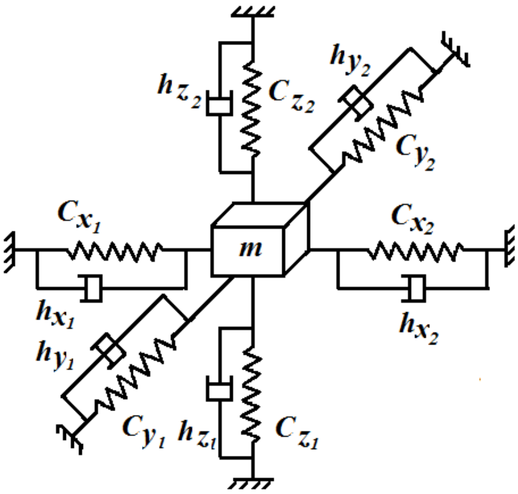

Figure 2. Scheme of a mechanism with parallel kinematics for simulation modeling

For this system, within the limits of small amplitudes, it will be fair to assert that the frequency of fluctuations f_0 of mass *m* can be calculated by the formulas (1):

$$f_{ox} = \sqrt{\frac{c_{1x} + c_{2x}}{m}}; \qquad f_{oy} = \sqrt{\frac{c_{1y} + c_{2y}}{m}}; \qquad f_{oz} = \sqrt{\frac{c_{1z} + c_{2z}}{m}} \qquad (1)$$

where, f_0 – frequency of oscillations, Hz; m – weight, kg;
c_{1x}, c_{2x}, c_{1y}, c_{2y}, c_{1z}, c_{2z} – hardness H / m.

Since the resonance frequency is the same for any direction of the axes, and the mass of the material point remains the same for any measurement of space, then we can accept equality (2):

$$c_{1x}+c_{2x}=c_{1x}+c_{2x}=c_{1x}+c_{2x} \tag{2}$$

Based on this expression, we can restrict ourselves to studying the features of the dynamics of a system consisting of a body of mass m, suspended on two springs with rigidity c_1 and c_2.

For this scheme a mathematical description of a harmonic oscillator is obtained, which is an executive link of a mobile machine, if we take into account the perturbing influence that submits to dependence (3):

$$\mathrm{x}+\frac{1}{\tau}\mathrm{x}+\omega_0^2\mathrm{x}=\alpha_0\cos\omega\mathrm{t} \tag{3}$$

An outrageous force is presented in the form of an expression (4):

$$\alpha_0 e^{i\omega t}\equiv\alpha_0\left(\cos\omega\mathrm{t}+\mathrm{i}\ \sin\omega\mathrm{t}\right) \tag{4}$$

You can make a decision for the real part X, if α_0 y the expression $\alpha_0 cos\omega t$ is a real value, then the solution is found (5):

$$x=X_0 e^{i\omega t} \tag{5}$$

Then:

$$\left(-\omega^2+\frac{i\omega}{\tau}+\omega_0^2\right)X_0 e^{i\omega t}=\alpha_0 e^{i\omega t} \tag{6}$$

From here:

$$\mathrm{X}_0=\frac{\alpha_0}{\omega_0^2-\omega^2+\mathrm{i}\left(\omega/\tau\right)}\cdot\frac{\omega_0^2-\omega^2-\mathrm{i}\left(\omega/\tau\right)}{\omega_0^2-\omega^2-\mathrm{i}\left(\omega/\tau\right)}=\alpha_0\frac{\omega_0^2-\omega^2-\mathrm{i}\left(\omega/\tau\right)}{\left(\omega_0^2-\omega^2\right)^2+\left(\omega/\tau\right)^2} \tag{7}$$

And the real and imaginary parts are like:

$$Re\left(X_0\right)=\frac{\left(\omega_0^2-\omega^2\right)\alpha_0}{\left(\omega_0^2-\omega^2\right)^2+\left(\omega/\tau\right)^2} \tag{8}$$

$$Im\left(X_0\right)=\frac{-\left(\omega/\tau\right)\alpha_0}{\left(\omega_0^2-\omega^2\right)^2+\left(\omega/\tau\right)^2} \tag{9}$$

At large values of τ, the attenuation weakens and the imaginary part of the displacement increases at resonance.

You can record the bias amplitude (10):

$$\rho=\left(X_0X_0^*\right)^{1/2}=\frac{\alpha_0}{\left[\left(\omega_0^2-\omega^2\right)^2+\left(\omega/\tau\right)^2\right]^{1/2}} \quad (10)$$

Then, the force acting in the executive link can be determined by the formula (11):

$$P=-\frac{1}{2}M\alpha_0\omega I_m\left(x_0\right)=\frac{1}{2}M\alpha_0^2\frac{\omega^2/\tau}{\left(\omega_0^2-\omega^2\right)^2+\left(\frac{\omega}{\tau}\right)^2} \quad (11)$$

The resulting expression is fully consistent with the conclusions presented in the works [7 – 12].

To study the peculiarities of the dynamics of the loaded executive branch of the mobile machine, an imitation model was created in the computer environment Simulink (Fig. 3).

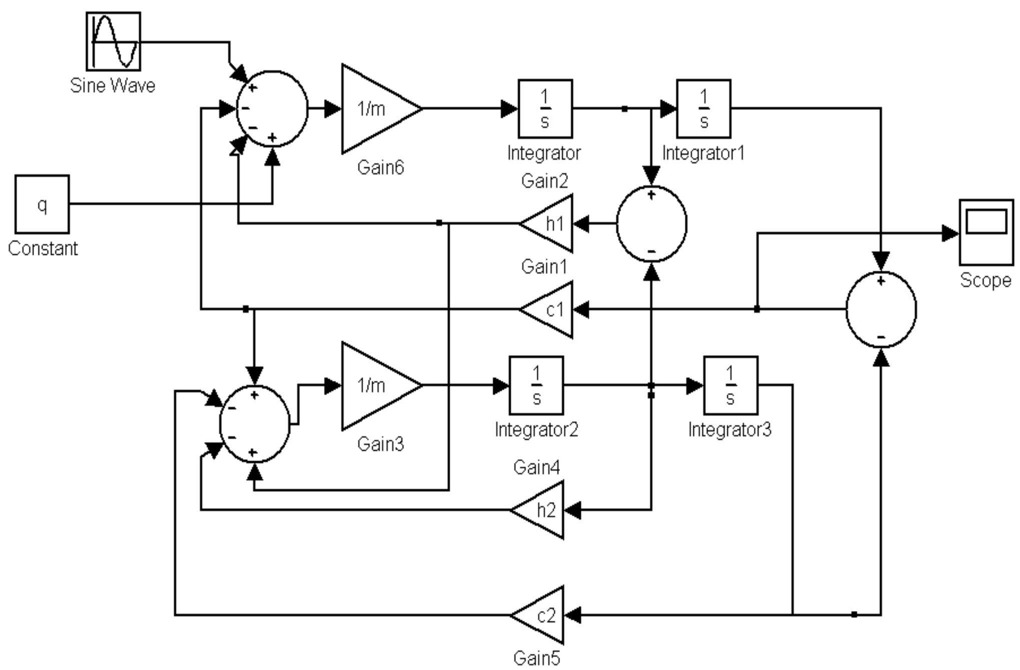

Figure 3. Simulation model of the executive branch of the mobile machine in Simulink

For given values m = 20; c_1 = 20; h_1 = 0.02; c_2 = 30; h_2 = 0.03; q = 10; the amplitudes of forced harmonic oscillations of 0.2 μm, the reaction of the model to forced harmonic oscillations is obtained in the form presented in Fig. 4.

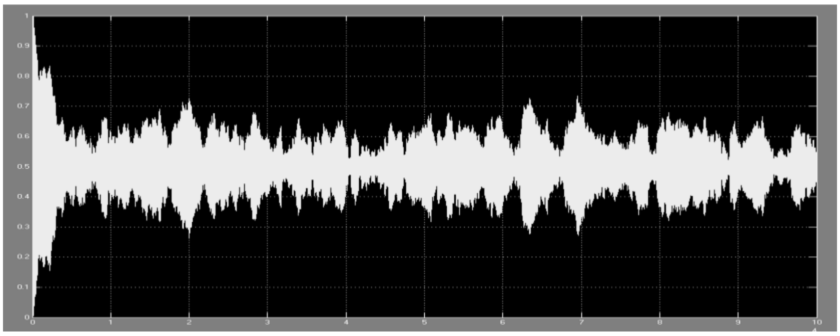

Figure 4. Temporal diagram of the oscillation of the executive link of the mobile machine when forced harmonic oscillations

The magnitude of the amplitudes in such a model does not exceed 2 μm, however, deserves attention to the quasi-random nature of oscillations, although the equilibrium effect has a sinusoidal form.

Conclusions and suggestions. The obtained result suggests that oscillations with a wide frequency and amplitude spectrum arise in the executive link of the mobile machine, which can cause resonance of the elements of the technological system over a wide range of frequencies. Such a mode of operation of mobile machines with mechanisms of parallel kinematics should be taken into account in the design of technological processes and in the technological preparation of production in order to ensure the productivity and accuracy of equipment throughout its lifetime.

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ІМІТАЦІЙНЕ МОДЕЛЮВАННЯ ДЛЯ ДОСЛІДЖЕННЯ НАВАНТАЖЕНОЇ ЛАНКИ МОБІЛЬНОГО ВЕРСТАТА-РОБОТА

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Резюме. *Розглянуто питання динамічного аналізу виконавчої ланки верстатної системи. Проаналізовано розрахункову схему, що складається з просторової системи, підвішеної в просторі на гнучких елементах. Отримано математичний опис гармонічного осцилятора, яким є виконавча ланка мобільного верстата. Створено імітаційну модель в комп'ютерному середовищі Simulink для дослідження особливостей динаміки навантаженої виконавчої ланки мобільного верстата. Отримано реакцію моделі на вимушені гармонійні коливання, що має квазівипадковий характер при синусоїдальному впливі. Отриманий результат дозволяє припустити, що у виконавчій ланці мобільного верстата виникають коливання з широким частотним і амплітудним спектром, здатні викликати резонанс елементів технологічної системи в широкому діапазоні частот.*

Ключові слова: *динамічний аналіз, інтелектуальні верстати-роботи, паралельна кінематика.*

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