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In this article conducted Motion Simulation bridge crane with optimal control. Manage crane movement smodelyrovano with pomoshchju frequency converter scalar type. Effect of research parameters settings for frequency converter Dynamic, эnerhetycheskye kynematycheskye indicators and movement of the crane.

Optymalnoe Management, Mostovoy crane chastotnыy converter, asynhronnыy Elektroprivod.

Modeling of bridge crane movement with optimal control has been carried out in the article. Bridge crane movement has been modeled by mean inverter scalar kind. Influence of inverter's setting parameters has been researched on dynamic, energetic and kinematical indexes of crane movement.

Optimal control, bridge crane, inverter, asynchronous drive.

UDC 534.1

IMPROVING METHODS AND ANALYSIS sub SUPERHARMONICHNYH VIBRATIONS VIBROUDARNYH nonlinear MECHANICAL SYSTEMS

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The following physico-mechanical model, which is used in the information and analytical support CAD vibroudarnyh mechanical systems. The improved method of analysis and sub superharmonichnyh fluctuations.

Physical and mechanical modeling, mathematical software, and superharmonichni subharmonic oscillation.

Problem. In the study of the dynamics of machinery, creating physical and mechanical models, mathematical and analytical support CAD vibroudarnyh (nonlinear) mechanical systems typically must deal with nonlinear vibrational systems. This is because without existing physical and geometrical nonlinearities is not always possible to determine the dynamic characteristics of the machine and properly assess its durability and reliability. No linear elastic characteristics found in many mechanisms. It is the cause of sub- and superharmoniynyh oscillations of large amplitude oscillations in nonlinear resonance zones in stationary and transient conditions, at a single frequency bahatorezhymnosti forced power vibroudarnyh modes, parasitic nonlinear spatial fluctuations. In this regard, important is the prediction of occurrence of these unwanted nonlinear regimes that are dangerous for machines and mechanisms especially due to the significant increase in their rates. On the other hand, the use of non-linear effects

above, to improve performance and vibration design brand new vibrating devices for the various processes of the construction industry. (Of course, the process of designing these devices must be accompanied by improvement of existing and creation of new mathematical framework similar to CAD systems). Nonlinear vibration are increasingly used in the field vibroperemischennya, vibrouschilnennya, vibroobrobky, vibrozborky etc.

Analysis of recent research. In terms of vibration technology for the production of building materials was also important for the solution of certain nonlinear vibration synthesis with pre-set parameters of motion and stability margin [1].

The main methods that are used in this paper, the study of local and global problems of formation of periodic regimes are accurate analytical and numerical methods of analysis and synthesis of nonlinear systems [1, 2]. These methods are not competing with well developed approximate analytical methods (method of small parameter, asymptotic methods, etc.), Allow to find precise laws of motion, which correspond to different batch mode and find out stock stability for systems with typical elastic characteristics.

Analysis of a large number of exact solutions in nonlinear non-autonomous oscillating systems led the author of this work to the conclusion that the main nonlinear effects in these systems is a manifestation of internal vibrational properties of the system, ie its free oscillations. (This point of view in different degrees and hold to the author of several works on nonlinear oscillations [1, 3-5], but many researchers do not consider the ties between free and forced resonant vibrations, which in some cases leads to inaccurate qualitative conclusions drawn Based on the results of the approximate analysis (for example, data dependent manner possible subharmonic modes of degree polynomial and elastic properties of the impossibility of even the existence of subharmonic modes in symmetric systems [6] or the smallness of oscillation amplitudes superharmoniynyh). This approach assumes that a decisive role in the systems for stock fluctuations play an elastic restoring force. Therefore, it is possible based on the analysis of free oscillations of the system parameters and involuntary force allow for certain nonlinear effects without the usual mathematical calculations.

References listed in the article or in any way exhaustive. A more complete list of references on various aspects of the nonlinear theory can be found in [7-9].

The purpose of research. Improve the existing methods of analysis and sub superharmoniynyh nonlinear vibrations of mechanical systems, considering the conditions of formation of periodic regimes in mathematical models of such systems, namely deterministic nonlinear oscillatory systems with one degree of freedom of movement. The implementation of the said objectives will also significantly improve and enhance existing software of CAD mechanical systems under consideration, which is widely used in construction, building technologies and production of modern building materials.

Results. Selection and method of research for the following reasons. Modern systems and vibration protection vibrotehniky usually is nonlinear, that is, in which the nonlinearity of reconstructive-regenerative force is not small. With accurate research methods can be more reasonably predict conditions for the existence of desirable or, on the contrary, parasitic (harmful) fluctuations than the approximate methods. Therefore, the authors of this work and pursue the following objectives: 1) to investigate the forced vibrations of mechanical systems with nonlinear elastic restoring forces using accurate analytical methods for the analysis of nonlinear systems; 2) comprehensively and scientifically grounded describe the main characteristics of these systems, using approximate methods (such as harmonic balance method [2]).

We strive to include in this work only the results of studies of nonlinear systems which can be regarded as accurate. This, of course, narrowed the range considered problem. (As for stability analysis of various modes and sub superharmoniynyh fluctuations, their conditions of (threshold amplitudes), then generally used approximate methods of analysis). However, since the mechanical oscillating system is often rude systems (so-called robust system), availability of exact standard solutions and construct maps of areas that draw periodically with a variety of typical non-linear characteristics, can quite confidently predict the behavior of other relatives nonlinearities, exact solutions for which are unknown.

Due to the wide spread of approximate methods for the study of nonlinear oscillatory systems and methods of mathematical modeling on computers and AOM also a problem of availability of appropriate standard solutions. Perhaps obtained in this paper by analyzing accurate analytical solutions major, sub and superharmoniynyh modes for nonlinear systems with smooth and piecewise linear elastic characteristics can be used as a reference such decisions.

*1. Analysis of the basic properties of nonlinear oscillation systems.*In the study of oscillatory processes occurring in machines and mechanisms of the construction industry are generally unable to identify three groups of forces that determine the behavior of dynamic systems: 1) Recover elastic; 2) dissipative; 3) forced labor. In this approach, the equations of motion oscillatory system with one degree of freedom of motion can be written as [1]:

$$m\ddot{x} + f(x) + R(x, \dot{x}) = H(t), \qquad (1)$$

where $x-$ generalized coordinate; $m-$ weight; $f(x)-$ Healing elastic force (elastic characteristic; $R(x,\dot{x})-$ power dissipation (dissipative characteristics); $H(t)-$ periodic external excitation system (forced power) period T.

It should be noted that under external excitation $H(t)$ In this paper understand deterministic forces or impulses that act on the part of the underlying dynamic system of the unaccounted mathematical model in another part of the more general dynamic system. Clearly, the adequacy of the mathematical model (1) of the object under study can be ensured only if the reverse effect processes dynamics model (1) the formation of "external" influences can be neglected, as is assumed in this paper. Otherwise, it is necessary for better integration of energy properties [7, 10-14].

In cases where the system (1) is linear, ie $f(x) = p^2 x$ and $R(x,\dot{x}) = 2n\dot{x},$ it established periodic oscillations with a period of forced power $H(t)$. And given system parameters regardless of the initial conditions uniquely determine the settings for the unique periodic regime. This uniqueness usually occurs in the system (1) with linear elastic characteristic and low nonlinear dissipative force is a force which set parameters for other forces does not lead to fluctuations in the finite time stops the system.

Much more complex situation occurs in the system of nonlinear elastic restoring force characteristic. In this case, depending on the initial conditions at the same parameters of the system (1) there is more than stable periodic regimes as different from the period of involuntary force, and with multiple periods. This is the main feature of bahatorezhymnist nonlinear systems. She, like other forms of nonlinearity is determined primarily type elastic properties $f(x)$. In this paper, moreover, considered system essentially nonlinear in the sense that the nonlinear elastic restoring force characteristics can be any piecewise continuous function of the variable x.

In nonlinear systems, compared with linear, along with the increase in the number of periodic modes are possible and increasing number of resonant frequency bands in which developing significant variations with frequency of involuntary forces as well as other higher or lower frequencies.

Among the factors that affect the formation of periodic regimes of nonlinear systems under consideration should be allocated, according to the author of the following: 1) internal oscillating properties; 2) forced external force; 3) strength inelastic resistance (dissipative forces); 4) the initial conditions. Let us examine them in detail.

Internal oscillating properties. Nonlinear effects in oscillatory systems in terms of content is a manifestation of internal vibrational properties of the system. Depending on the parameters of the influence and power dissipation internal oscillating properties due to elastic restoring forces can appear stronger or weaker, but the main features of oscillatory processes in nonlinear system (1) defines its main part, is an autonomous system nedysypatyvnoyu:

$$\ddot{x} + f(x) = 0 \qquad (1)$$

at its free oscillations. It is free oscillations characterize the internal oscillating properties of nonlinear systems for which time and spectral composition of free oscillations depend on the initial conditions. Available nonlinear oscillations are inharmonious, and the contribution of individual harmonics in the expansion of free oscillations of Fourier series for different elastic properties $f(x)$ may be different. If now the primary system (2) attach a small periodic emergency power $H(t)$ and low power dissipation $R(x,\dot{x})$, then such a system may be seen one or more stable periodic regimes. However, all these regimes tend to be close to the corresponding free oscillations of the main system.

Elastic properties $f(x)$ at the appropriate scale reflecting the relationship between power and reproducing variable x. The main characteristic is its free oscillation amplitude and frequency dependence, graphical representation of which is called "skeletal curve."

External forced labor. In calculating machines and mechanisms fluctuations often have to consider periodic forces or impulses. Depending on the law changes forced power all kinds of external periodic excitation divided into five groups [1].

The main role of external forces in shaping forced periodic modes in nonlinear systems is to maintain a system of free oscillations with a period equal to, or fractional multiples relative to the period of forced effort.

The qualitative behavior of nonlinear dynamical systems have the same basic component (2) and are influenced by various pulsed or continuous external forces $H(t)$, The same, if different types of external influences have the same symmetry properties, that belong to one of the classification groups. (In the qualitative behavior is to understand the number and type of possible periodically). In some cases there is a coincidence of quantitative research results by selecting appropriate parameters of external forces, such as the study of substrates and superharmoniynyh modes. Therefore, in such cases, to determine the number and type of periodic regimes, assess their sustainability replacement of one type of external influence others in order to simplify the mathematical side of vibrational dynamics research.

The above invariance under consideration qualitative behavior of oscillatory systems with generalized symmetry properties internally forces on the specific form of the force shows the crucial role of internal factors.

Force inelastic resistance (dissipative forces). The role of dissipative forces in the formation of periodic oscillations in nonlinear systems generally is that they are to some extent reduce the expression of internal vibrational properties of the system.

Stop at the influence of dissipative forces in sub- and superharmoniyni modes. It is believed that a small dissipation causes the death of subharmonic modes. But this is true only when Subharmonic modes have small drawing area and therefore a small margin of stability. Many subharmonic modes with large areas that attract Chance for sufficiently large dissipation and samozbudzhuvani Subharmonic modes can exist at sufficiently large dissipative forces.

In nonlinear systems dissipative forces on superharmoniyni modes affect probably weaker than Subharmonic. As a rule, and at considerable dissipation superharmoniynyy nature's laws of motion in the corresponding resonance zones stored for a system with one, so also with several degrees of freedom of movement.

The initial conditions. Internal and external oscillating properties characterizing the opportunity to influence the manifestation of nonlinear systems of various periodic regimes. Which of these modes will be implemented in reality depends on the initial state of the system. For non-autonomous systems with one degree of freedom of movement initial condition is characterized by three numbers $(x_0, \dot{x}_0$ and $t_0)$, who are called initial values. The initial state can be given as initial conditions $x(t_0) = x_0$ and $\dot{x}(t_0) = \dot{x}_0$.

It should be noted that only the initial values of phase coordinates and velocities can not uniquely determine the initial state of the system, that is, the same values x_0 and $\dot{x}_0$ and different values of time t_0 possible to implement different regimes. Initial phase coordinates t_0 describes the initial phase of foreign influence, and therefore should set the initial value t_0. This fact is significant (important).

Bahatorezhymnist. And sub superharmoniyni fluctuations. The role of initial conditions in nonlinear systems with linear versus nonlinear systems bahatorezhymnistyu explained, that the existence depending on the initial conditions of several different periodic modes for the same external influence.

For nonlinear systems of type (1) bahatorezhymnist manifests itself primarily in the area of skeletal curve (the main area or the main resonance) by forced oscillations with a frequency of forced labor (major fluctuations).

Normal construction amplitude-frequency curves forced oscillations ($|a| = f(\omega)$) Provides no phase of forced labor. For further information, which can be used to build areas that attract periodic modes give the amplitude-frequency curves constructed taking into account the sign "amplitude" ($a = \tilde{f}(\omega)$). In this case, stable branches correspond to areas that have a positive slope, namely: $\partial a / \partial \omega > 0$; fragile - plot amplitude-frequency curves with negative slope, ie: $\partial a / \partial \omega < 0$.

Amplitude-frequency curves give qualitatively correct information on the number of sets and their "amplitude" vibrations only their proximity to skeletal curves, ie the free oscillations. In cases where the law of motion is superharmoniynyy, ie schedule $x(t)$ there are substantially higher harmonic components, the period in which the integer times less than the period of forced force amplitude-frequency curves do not give correct information about the maximum values of coordinates. (Later superharmoniynymy fluctuations will call these fluctuations, the law of motion which has more than two extremes for the period).

In nonlinear systems bahatorezhymnist also manifests itself in the form of subharmonic oscillations in the relevant frequency bands. The number of modes for symmetric systems ($f(x) = f(-x)$) Depends on the placement of skeletal curve and parameters of forced labor.

And sub superharmoniyni fluctuations are formed on the basis of free oscillations of the system that supports forced external force.

Necessary conditions for the existence of these oscillations in symmetric systems found in [15, 16]. They can be reduced to the following:

1. If n periods of low power forced the period T_ω approximately coincide with m periods of free oscillations, ie if about the relation:

$$n \cdot T_\omega = m \cdot T, \ \ (m,n) \in N, \tag{3}$$

or:

$$\frac{\omega}{n} = \frac{p}{m}, \tag{4}$$

where $\omega = \frac{2\pi}{T_\omega}, p = \frac{2\pi}{T}$ and thus the strength and frequency of forced oscillations own system, then the nonlinear oscillation system may be different sub- or superharmoniyni fluctuations or oscillations order m/n (Because, based on (4) $p = \frac{\omega \cdot m}{n}$), or emerging modes of procedure m/n. At $m = 1$ – This Subharmonic oscillations order $1/n$, at $n = 1$, $m \geq 2$ – superharmoniyni.

2. Necessary conditions for the existence of oscillations order m/n in symmetric systems are defined skeletal curve. If the frequency of free oscillations lies in the range (ω_0, ω_1) Then a necessary condition for the existence of the order mode m/n is the condition:

$$\frac{n}{m} \cdot \omega_0 \leq \omega \leq \frac{n}{m} \cdot \omega_1, \ \ (n,m) \in N. \tag{5}$$

It should be noted that at one frequency forced power ω can immediately coexist several different periodic regimes.

The method of calculating periodic motions (and sub superharmoniynyh fluctuations) in nonlinear oscillatory systems. Consider the equation of nonlinear non-conservative system, describing it forced oscillations in the presence of an arbitrary time $\tilde{F}(t)$ involuntary force, viscous and piecewise linear elastic properties $\tilde{f}(x)$:

$$m\ddot{x} + \tilde{\alpha}\dot{x} + \tilde{f}(x) = \tilde{F}(t). \tag{6}$$

Equation (6) can be represented as:

$$\ddot{x} + \alpha\dot{x} + f(x) = F(t), \ \ \alpha = \frac{\tilde{\alpha}}{m}, \ \ f(x) = \frac{\tilde{f}(x)}{m}, \ \ F(t) = \frac{\tilde{F}(t)}{m}. \qquad (7)$$

Using the approach [1, 2], we can find the equation of the curve skeletal system, ie dependence $\omega_* = \omega_*(A)$, where $\omega_* -$ natural frequency of oscillation of a nonlinear system, which depends on the amplitude A (Oscillations). If you use the method [2], for certain types of piecewise linear dependence of the elastic properties $\omega_*(A)$ can be set precisely. (In particular, this statement is acceptable for bilinear and trohlantsyuhovoyi piecewise linear elastic properties (symmetric and asymmetric)).

We seek the solution of (7) as:

$$x(t) = \sum_{k=0}^{\infty} A_k \cdot \cos\{k\omega_* t\} + \sum_{k=1}^{\infty} B_k \cdot \sin\{k\omega_* t\}. \qquad (8)$$

From (8) it is easy to find $\dot{x}(t)$ and $\ddot{x}(t)$. Substitute $x(t), \dot{x}(t)$ and $\ddot{x}(t)$ in (7). Then $(2k+1)-$equations to determine A_0, A_k, B_k You can find pomnozhayuchy (7) to $\cos(k'\omega_* t)$ (Or $\sin(\tilde{k}'\omega_* t)$), And integrating the right and left of the time specified by equation t within a period of free oscillations of nonlinear systems, ie $2\pi/\omega_*$. (The $k' = 0,1,2,...;$ $\tilde{k}' = 1,2,3,....$). Then we get the following equation:

$$\int_0^{2\pi/\omega_*} f(x)dt = \int_0^{2\pi/\omega_*} F(t)dt, \qquad (9)$$

$$\left\{-(k\omega_*)^2 A_k + \alpha(k\omega_*)B_k\right\} \cdot \frac{\pi}{\omega_*} + \int_0^{2\pi/\omega_*} f(x)\cos(k\omega_* t)dt = \int_0^{2\pi/\omega_*} F(t)\cdot\cos(k\omega_* t)dt, \qquad (10)$$

$$\left\{-(k\omega_*)^2 B_k - \alpha(k\omega_*)A_k\right\} \cdot \frac{\pi}{\omega_*} + \int_0^{2\pi/\omega_*} f(x)\sin(k\omega_* t)dt = \int_0^{2\pi/\omega_*} F(t)\cdot\sin(k\omega_* t)dt. \qquad (11)$$

By [2] defines A_0, A_k, B_k method of harmonic balance of approximately. Considering the effect of viscous negligible compared to the other components of equation (7) can be defined (A_0, A_k, B_k) - Amplitude in [2] substitute in the exact equations (9) - (11). Then get the approximate equation to determine (A_k, B_k), $k \in N$. (The exact equation (9), however, remains unchanged). Last takes the following form:

$$\begin{cases} \alpha k\pi B_k = \int_0^{2\pi/\omega_*} F(t)\cos(k\omega_* t)dt, \\ -\alpha k\pi A_k = \int_0^{2\pi/\omega_*} F(t)\sin(k\omega_* t)dt, \ \ k \in N. \end{cases} \qquad (12)$$

We seek solutions of equations (12), giving $F(t)$ in the form of:

$$F(t) = \sum_{j=0}^{\infty} F_{cj}\cos(j\omega t) + \sum_{j=1}^{\infty} F_{sj}\sin(j\omega t), \ \ \omega = \frac{2\pi}{T}, \qquad (13)$$

where $T-$ period of forced power $F(t)$, that is, $F(t+T)=F(t)$. Using (12), (13), we obtain for the mode $\omega_* = \omega \cdot \frac{m}{k}, j \equiv m$:

$$\begin{cases} \alpha k \pi B_k \approx \int\limits_0^{2\pi/\omega_*} F_{cj}\cos(j\omega t)\cdot\cos(k\omega_* t) = F_{cm}\cdot\frac{1}{2}\cdot\frac{2\pi}{\omega_*} = F_{cm}\cdot\frac{\pi}{\omega_*}; \\ -\alpha k \pi A_k \approx \int\limits_0^{2\pi/\omega_*} F_{sj}\sin(j\omega t)\cdot\sin(k\omega_* t) = F_{sm}\cdot\frac{1}{2}\cdot\frac{2\pi}{\omega_*} = F_{sm}\cdot\frac{\pi}{\omega_*}. \end{cases} \quad (14)$$

Or:

$$B_k \approx \frac{F_{cm}}{\alpha k \omega_*};\ \ A_k \approx -\frac{F_{sm}}{\alpha k \omega_*}. \quad (15)$$

Assuming that (15) for approximate values $|B_k|: \omega_* \approx \omega_*(|B_k|)$, and for $|A_k|$: $\omega_* \approx \omega_*(|A_k|)$, ie depending $\omega_*(A)$ take into account the basic amplitude $(k-$a) mode $\frac{m}{k}$, which characterizes the contribution to the specified mode of oscillation of the actual nonlinear system can be obtained sufficient conditions and the presence of sub superharmoniynyh fluctuations in the underlying system (ie thresholds that must be overcome to there respective types of oscillations of the system):

$$\begin{cases} \omega_*(|B_k|)\cdot|B_k| \ge \frac{|F_{cm}|}{\alpha k}; \\ \omega_*(|A_k|)\cdot|A_k| \ge \frac{|F_{sm}|}{\alpha k}. \end{cases} \quad (16)$$

With the system of inequalities (16) that the thresholds subharmonic oscillation amplitudes (about $\frac{1}{k}$) At $m=1, k \ge 2$ defined as follows:

$$\begin{cases} \left[\omega_*(|B_k|)\cdot|B_k|\right]_{\text{ïîðîã}} \ge \frac{|F_{c1}|}{\alpha k} \approx \frac{\omega}{2\alpha^2 k^3}; \\ \left[\omega_*(|A_k|)\cdot|A_k|\right]_{\text{ïîðîã}} \ge \frac{|F_{s1}|}{\alpha k} \approx \frac{\omega}{2\alpha^2 k^3}, \end{cases} \quad (17)$$

which accounted Dynamic system (available viscous).

For superharmoniynyh fluctuations ($m-$th order) at $m \ge 2, k=1$ we have:

$$\begin{cases} \left[\omega_*(|B_k|)\cdot|B_k|\right]_{\text{ïîðîã}} \ge \frac{|F_{cm}|}{\alpha} \approx \frac{m\omega}{2\alpha^2}; \\ \left[\omega_*(|A_k|)\cdot|A_k|\right]_{\text{ïîðîã}} \ge \frac{|F_{sm}|}{\alpha} \approx \frac{m\omega}{2\alpha^2}. \end{cases} \quad (18)$$

(Again, use considerations of Dynamic Systems, as in (17)).

In the general case for regime $\frac{m}{k}$ $(\omega_* = \omega\cdot\frac{m}{k})$ have:

$$\left\{\begin{matrix}\omega_*(|B_k|)\cdot|B_k| \\ \omega_*(|A_k|)\cdot|A_k|\end{matrix}\right\}_{\text{îðîã}} \geq \left\{\begin{matrix}\dfrac{|F_{cm}|}{\alpha k} \\ \dfrac{|F_{sm}|}{\alpha k}\end{matrix}\right\} \approx \frac{m\omega}{2\alpha^2 k^3}. \tag{19}$$

Consequently, as follows from (17) - (19):

1) with increasing m superharmoniynyh oscillation threshold increases (their vazhkishe excite the system, the threshold of oscillation $\sim m^1$)

2) with increasing k subharmonic oscillation threshold decreases (easier to excite the system, the threshold of oscillation $\sim \frac{1}{k^3}$)

3) decreasing the coefficient of viscous friction α as sub-threshold and superharmoniynyh fluctuations increases $\sim \frac{1}{\alpha^2}$. The physical reason for this growth is that vazhkishe excite any fluctuations in nonlinear systems because there is no (or very little / not) centers absorb the energy coming into the system from outside of involuntary force, enabling use in complex oscillation process its own system of free oscillations. After all, the main nonlinear effects (including modes of oscillation $\frac{m}{k}-$order) in nonlinear systems is proposed type is a manifestation of internal vibrational properties of the system, ie its free oscillations [1].

Conclusions

1. Performed a detailed analysis of the basic properties of nonlinear oscillatory systems to establish the basic parameters and sub superharmoniynyh oscillations (modes $\frac{m}{k}-$order) necessary and sufficient conditions of excitation (restrictions on the frequency range of excitation thresholds and amplitude fluctuations).

2. Installed accurate and approximate equations that allow to determine the amplitude of oscillations of nonlinear systems with a given skeletal curve.

3. The said approach, the dependence can be used to improve and clarify the existing engineering methods for analyzing nonlinear vibroudarnyh systems used in modern technologies of construction materials and sealing compounds for various needs of the construction industry.

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The following physical and mehanycheskaya model kotoraja yspolzovana as is information and Analytical Provision vybroudarnыh mechanical CAD systems. Predlozhennыy usovershenstvovannыy method of analysis and sub superharmonychnyh oscillations.

Physical and mehanycheskoe Modeling, Mathematical Provision, subharmonychny and superharmonychny fluctuations.

Physical and mechanical model for the informational and analytic supply of SAPR of vibro-impact (substantially nonlinear) mechanical systems is proposed. The improved method for the analysis of sub- and super-harmonic oscillations is offered as well.

Physical and mechanical modeling, mathematical supply, sub- and super harmonic oscillations.

UDC 665.3

ANALYSIS TECHNOLOGY production of vegetable oils