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THE USE OF ROCKING SPRINGS AS A MECHANICAL MODEL OF MODERN TECHNOLOGICAL PROCESSES AS DYNAMIC SYSTEMS

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The paper considers the approach to solving a class of problems, when within a certain dynamic system its nonlinearly connected oscillatory components can exchange energy with each other. Many examples of such problems are given in [1, 2]. At the same time, the dependence of the energy exchange action on the system control parameters is investigated. The problem is to determine the total energy of the system and correctly estimate the energy values over time, as well as their relationship for each of the components.

To illustrate this approach, a two-dimensional spring pendulum is used as a mechanical model for the study of several nonlinearly coupled systems. The two-dimensional spring pendulum in idealized form consists of a "point" load of mass m attached to the end of a weightless spring with a stiffness k and a length h in the unloaded state. The other end of the spring is fixed. The oscillating system formed in this way should move only in the vertical plane, while keeping the spring axis rectilinear. Point load simultaneously participates in two types of oscillations: spring-like - when moving along the rectilinear axis of the spring, and pendulum-like - when it oscillates in conjunction with its axis. This type of oscillating system in the literature is called a swinging spring. With the help of a rocking spring, the exchange of energies between transverse (pendulum) and longitudinal (spring) oscillations is clearly illustrated. The influence of the initial conditions of oscillation initiation must also be taken into account. Of particular importance is the study of the condition of the resonance state of the oscillating spring. That is, when the frequency of longitudinal oscillations will differ a multiple of the frequency of transverse oscillations. In addition to the common "classical" case (2: 1 resonance), it is advisable to solve problems with other values of the frequency ratio. For example, there is a need [3] to build trajectories of cargo for cases of such resonances: 2: 1, 7: 3, 9: 4, 11: 2 and others. The found geometrical forms of a trajectory of movement of cargo of a rocking spring [4] with the set parameters will help to define characteristics of a decision of the chosen problem.

In [1, 5] a large number of possible implementations based on the application of the idea of oscillating spring oscillations are given. A significant part of this list is directly related to the violation of the stability and controllability of aircraft or high-speed ships in the process of their movement. When calculating the displacement of a dynamic system in space (ship or aircraft) it is necessary to take into account the energy exchange between transverse and path (longitudinal) oscillations as components of the system. In most cases, the frequencies of these oscillations are taken as a ratio of 2: 1. But for more thorough research, it is advisable to consider other frequency ratios. This is especially true of studies of the dynamics of oscillations of aircraft type "Dutch roll" (Dutch roll) [6]. Such oscillations occur in the case of high lateral stability of the aircraft in comparison with low ground stability. Then the lateral movement of the aircraft will be characterized by interdependent oscillations of roll and slip. Moreover, the oscillations of the slip lag behind the phase of the oscillations of the roll, which is associated with weak track and excessive lateral stability. The roll of the aircraft is the cause of the slippage of the aircraft, the elimination of which is delayed due to poor road stability. The slip that occurs provokes the need for an emergency roll of the aircraft in the opposite direction due to increased lateral stability, and the process is repeated. To dampen oscillations on aircraft, damping dampers are used, the calculation of which should be performed with the involvement of the concept of pumping the energies of the rocking spring in the resonance state.

The modified model of a rocking spring - the model of a flexible thread - plays an important role in building mechanics. After all, a flexible thread is a kind of spring that acts only on tension. In a typical two-dimensional model, the flexible thread can simultaneously perform transverse oscillations in its plane (analogous to the angular oscillations of the oscillating spring with the load) and pendulum oscillations that combine the support fasteners (analogous to vertical oscillations). An example is the wires of high-voltage lines, the condition of which is affected by wind gusts. At a frequency ratio of 1: 2 of these oscillations there is a loss of dynamic stability, and then there are transverse oscillations of the thread, the amplitude of which can reach quite large values. The possibility of such phenomena must be taken into account when calculating various structures of structural mechanics (suspension bridges, cable-beam systems, cable cars, power lines, various antennas of cable systems for holding objects, flexible hoses, etc.).

The idea of using rocking springs as a mechanical model should be developed for the analysis of modern technological processes as dynamic systems. These systems may consist of nonlinearly coupled oscillatory components that exchange energy with each other. The oscillations of the rocking spring should be considered in conjunction with the geometric component - the trajectory of its load. As a result, it is possible to characterize the resonance of oscillations of the oscillating spring using periodic trajectories selected from possible movements during oscillations of the load of the oscillating spring. Moreover, for the synthesis of the trajectory it is necessary to use not only the main parameters of the oscillating spring, but also the parameters of the initial conditions of initiation of oscillations. After all, in this case, the most effective is the angular oscillation of the rocking spring due to the energy of this spring. The development of random transverse perturbation will proceed to a fixed amplitude value, because the energy reserves of the spring are exhaustible. After reaching this amplitude during the oscillations of the rocking spring is again stretching (or compression) of the spring. In [7], a phenomenological method of constructing the contour of the vertical section of the liquid surface in a tank, which oscillates due to the movement of this tank, is presented. These contours are called Faraday waves. The method is based on a mechanical "pendulum" analogy of the process of fluid oscillation. Namely, Faraday waves are interpreted as the trajectories of a mathematical pendulum (not a spring) suspended from a moving cart. The issues of formulas that would approximate the parameters of the liquid with the parameters of the pendulum under the cart are discussed. Based on the idea of this example, consider the following. As a hypothesis, we formulate the premise of using the model of a rocking spring. To find the solution of the considered class of the problem it is necessary to define in its statement two (as an example) nonlinearly connected oscillatory components which exchange energy among themselves. Next, you need to determine the main parameters of the system (which significantly affect the solution), and put them in accordance with the parameters of the rocking spring - its stiffness, unloaded length and weight of the load. And also the parameters that determine the initial conditions of oscillations of the rocking spring - the initial angle of deviation of the spring and the speed of its displacement. Then the desired solution of the problem can be associated with the periodic trajectory of the load of the oscillating spring. And among the many periodic trajectories of motion it is necessary to look for a trajectory of the shortest length. It is possible to compare features of resonant trajectories on condition of density of pixels which make the image of a certain trajectory. According to the general principle of "minimum energy", it is logical to assume that the case with the shortest periodic trajectory (or rather, with one of its periods) will be interesting in the implementation of a particular implementation. The obtained periodic trajectory of the cargo can always be represented digitally as a sequence of coordinates of the points that make it up. From these positions it will be interesting to investigate nonlinear connected systems with interacting subsystems on the examples of technical problems. Difficulties in the development of research in this direction will arise when trying to determine the resonant state in the case of the study of oscillations of the spatial oscillating spring.

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