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Oscillations of the orthogonal mechanism with a non-ideal source of energy in the presence of a load on the operating link

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ABSTRACT

This work studies the features of vibrational motion of an orthogonal mechanism with disturbances, such as restricted power in the presence of a fixed load on the horizontal link. Dynamic and mathematical models were prepared, and the operating conditions' fields of existence for the vibration mechanism in terms of the driving power were defined. With stable rotational operating conditions of the mechanism, it was shown that the value of the angular rate of the driving link varies about its average value according to the harmonic law. The frequency of the change in the value of the angular rate equals the average value of this rate, and the amplitude is inversely proportional to this value. Therefore, the average value of the angular rate depends on the features of the driving link and the sources of power. The rotational motions of the mechanism are demonstrated to be stable. The librational motions of the mechanism were examined. An amplitude-response curve was built, and the conditions that contribute to the amplitude of driving link's oscillations were defined. The law of variation of the amplitude of the librational motion was established. The frequency of the oscillations were shown to depend on the amplitude and the parameters of the power and mechanism source.
Because the mathematical model provided good practical results, the results of this research can be successfully used during the design of vibration equipment with orthogonal mechanisms.

1. Introduction

In recent years, the vibrating equipment in the mechanical engineering industry has begun to be constructed on the basis of leverage mechanisms. These mechanisms possess unique abilities to create oscillations of the executive element. The development of vibration mechanisms that are based on mathematical modeling results in acceptable and practical results.

Vibration machines and their technological processes are used almost all industrial fields. In one case, a specific technological processes may be constructed with only the use of vibration, yet in other processes, the application of vibration leads to a significant intensification of the processes and increases the quality rate.

The structural schemes of vibration machines, as a rule, are not complex; however, one needs to determine their parameters accurately for a successful application. These parameters can only be determined based on researching the dynamics of the vibrating machines and the technological processes performed by these machines.

The work in [1] presents a study of vibration transportation in a material part, and in summary, this research presents the vibration transportation through solid substances and the behavior of granular materials and continuous medium undergoing vibration.

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The article in [2] examines the horizontal motion of a part in two directions perpendicular to the excited plane while controlling the dry friction coefficient between the plane and the part. The dependences of the transition of the part from its initial position to the center of the stable motion path were defined. Additionally, the dependences of the directional angle of the motion path from the moment when the friction was reduced relative to the excitation signal and the duration of time of the decreased friction were defined. The work in [3] cites research that features the vibration transition of a body on a swinging plane, which is applicable to the field of automated part collection. Dynamic and mathematical models of vibration transition were constructed. The operating conditions of the body were defined as being dependent on the excitation frequency and the oscillation of the plane, the rolling angle of the plane and the factor of rigidity.

The authors of articles [4] and [5] examine the tasks of the optimal and dynamic synthesis of a swivel-lever guidance mechanism and counterbalancing, and the solution to these tasks helps determine the directional impact of the lever vibrator on a foundation. Numerical interpretation is used to determine the combined target function that contains all conditions that achieve complete dynamic balancing.

Balancing of the principal moment of inertia forces based on the mean-square approximation was used in the work in [6], where the counterweights were located on links associated with a rack.

The work in [7] presents a new method of determining the four links, which, in turn, allow for one to satisfy all kinematic demands and ensure dynamic balance. The predicted characteristics of the driving (working) link motion and the conditions of dynamic balance are ensured by means of prescribing the driving link speed change, the disk counterweights and the sizes of the links.

The effectiveness of all the above-mentioned methods is primarily determined by the choice of the model and the oscillating conditions for the working body of the corresponding machine because the most diverse and complicated types of oscillations, such as harmonic, polyharmonic, rectilinear, two-component and spatial oscillations, are used in practice. These modes may be implemented with the help of leverage mechanisms, which have a wide range of functional abilities.

One of the vibrating pieces of equipment, a shaking table with flat leverage mechanisms, can be successfully utilized in the construction industry to compact concrete mixtures, in the chemical, pharmaceutical and food industries to apply vibrating impact on pulps and suspensions, in the mining industry for screening fractions depending on the volume and weight, and for many other purposes. One of the problems with the mathematical modeling during the development of vibrating equipment based on leverage mechanisms is the variability of the vibrational characteristics. An apparatus of generalized functions is used in the works in [8] and [8] to determine the solution of equations describing the machine assembly dynamics.

K. Bissembayev and Zh. Iskakov [10] have studied the oscillation of the automatic press shaking table that uses flat leverage mechanisms. A mathematical model of the automatic press shaking table that uses an orthogonal mechanism was also developed.

The book in [11] reviews linear and non-linear systems, and it is hypothesized that these systems are influenced and excited by sources of energy that have a limited capacity.

Further development and the presentation of the characteristics of oscillating systems that interact with the energy source were obtained in the work in [12]. This work cites the dynamic analysis of a self-oscillating system interacting with the energy sources in the presence of non-linear elastic constraints as well as periodic parameter impacts and delays. Non-linear forced and parameter oscillations of the systems interacting with two energy sources are examined.

Article [13] examines stationary motions of a non-symmetrical spin (unbalanced rotor), which has a fixed point and is impacted by the moment of elasticity and the torque. The impact of the dissipation created by the engine with restricted power on the stability of the conservative system is studied.

The purpose of this work is to study the dynamics of the orthogonal mechanism of a shaking table with a non-ideal energy source in the presence of a fixed load (account of load) on the operating link.

2. Kinematic relations

The calculation model for the orthogonal mechanism is shown in Fig. 1. The start of the *OXY* coordinate system is placed at the crank rotation axis. Here, we designate the coordinates of the articulated link C (see Fig. 1) through *X* and *Y*, and the ranges of the

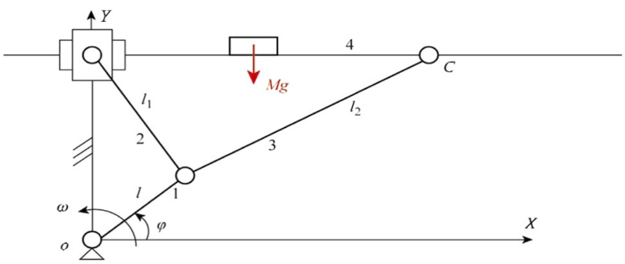

Fig. 1. A schematic diagram of the orthogonal mechanism of the shaking table.