Some problems of control of dynamical conditions of technological vibrating machines

N K Kuznetsov[1], V L Lapshin[1], A V Eliseev[2]

[1] Irkutsk National Research Technical University, 83, Lermontov St., Irkutsk, 664074, Russia
[2] Irkutsk State Transport University, 15, Chernyshevsky St., Irkutsk, 664074, Russia

E-mail: eavsh@ya.ru

Abstract. The possibility of control of dynamical condition of the shakers that are designed for vibration treatment of parts interacting with granular media is discussed. The aim of this article is to develop the methodological basis of technology of creation of mathematical models of shake tables and the development of principles of formation of vibrational fields, estimation of their parameters and control of the structure vibration fields. Approaches to build mathematical models that take into account unilateral constraints, the relationships between elements, with the vibrating surface are developed. Methods intended to construct mathematical model of linear mechanical oscillation systems are used. Small oscillations about the position of static equilibrium are performed. The original method of correction of vibration fields by introduction of the oscillating system additional ties to the structure are proposed. Additional ties are implemented in the form of a mass-inertial device for changing the inertial parameters of the working body of the vibration table by moving the mass-inertial elements. The concept of monitoring the dynamic state of the vibration table based on the original measuring devices is proposed. Estimation for possible changes in dynamic properties is produced. The article is of interest for specialists in the field of creation of vibration technology machines and equipment.

1. Introduction

The dynamic process of vibration processes in which the working environment interacts with the surface of a workpiece, is determined by the requirements in relation to the movement of the working body parameters such as homogeneity, single-dimensionality, etc. Similar problems are considered in references [1-3].

Technical facilities for realization of vibration technology processes are quite complex, and the assessment of their dynamic properties requires the use of rather difficult analytical approaches [4-7].

The dynamic aspects of the interaction between elements of technological systems and the possibility of creating conditions for the maintenance of the parameters of vibrational field are studied to a lesser extent.

In this article an approach to creation of control systems, the field vibratory technological machine are developed. The purpose of the proposed research is to develop principles, selection and implementation of configuration tools and control field vibration technology machine.

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2. Principles of work, models and dynamic properties

In the approach to the control of the vibrational field by introduction of a device to transform the motion of the mathematical model vibration stand (vibration hardening) is proposed. The model is reduced to the linear model (figure 1) of small oscillations of a rigid body with two degrees of freedom placed on elastic elements [8,9].

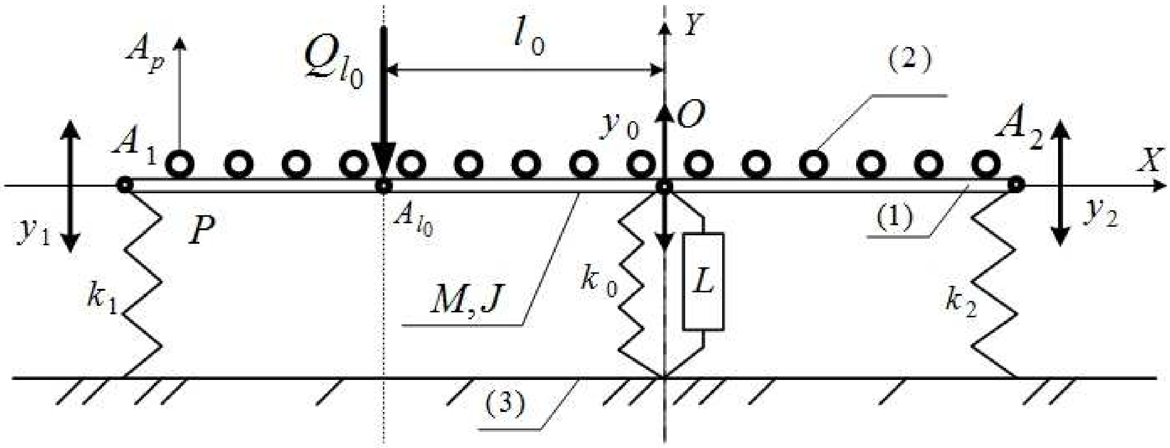

Figure 1. Design model of vibration technology machines: 1-solid vibrating surface, 2 – element of the granular media, 3-fixed support.

The peculiar properties of interaction between the working environment with surface (figure1) engaged in vertical vibrations by harmonic law with amplitude A_v and frequency ω_v are reflected in the mathematical model.

Configuring the vibration of the stand (figure 1) is reduced to the fact that the variable parameters of the shake table (weight of vibrator, stiffness of elastic elements, etc.) are selected so that the amplitude and frequency of oscillation of the working body correspond to the technological requirements. In the conditions of the model problem process requirements to the vibrational field of the working body are the homogeneity and one-dimensionality. Frequency, ensuring uniformity of vibration fields, depending on the system parameters, has the form [8]:

$$\omega_0^2 = \frac{1}{M+L}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right). \tag{1}$$

The oscillations of the characteristic points A_1, A_2 of working surface with the same amplitude are provided by frequency ω_0. The inclusion in the circuit of the vibration table “configuration item” L creates the preconditions for the extension of the frequency range of vibrations in which the vibration table of the considered structure keeps a homogeneous field of the working surface.

The presented dependence (1), frequencies of a homogeneous mode and mass-inertial factor define restrictions on a range of frequencies of a homogeneous vibrating field:

$$\omega^2 \le \frac{1}{M}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right). \tag{2}$$

The homogeneity of the vibration field is provided in a designated frequency band (2) for a fixed frequency external disturbance when there is the following equality:

$$L = \frac{1}{\omega^2}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right) - M \tag{3}$$

The maximum frequency ω_{max} of the range corresponds to the parameter $L = 0$, and one is equal to:

$$\omega_{max}^2 = \frac{1}{M}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right). \qquad (4)$$

Limit frequency range ω_{min} in the presented abstract model when $L_{max} \to \infty$ is equal to zero:

$$\omega_{min}^2 = \lim_{L\to\infty} \frac{1}{M+L}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right) = 0. \qquad (5)$$

Under the assumption that the variation of the mass-inertial coefficient is limited $L \le L_{max}$, minimum frequency is determined by the expression:

$$\omega_{min}^2 = \frac{1}{M+L_{max}}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right). \qquad (6)$$

The range $(\omega_{min}, \omega_{max})$ determines the limits of frequencies for which the vibrating stand of considered design provides homogeneous vibration field, with an appropriate choice of parameter L.

For each frequency of external excitation, the vibrating stand effectuates uniform oscillations with amplitude, provided that the mass-inertial coefficient keeps the value:

$$L = \frac{1}{\omega^2}\left(k_0 + k_1 + k_2 + \frac{l_2 k_2 - l_1 k_1}{l_0}\right) - M. \qquad (7)$$

The peculiarities of the setting method of the vibrating stand are determined by expressions for the boundary frequencies (4÷6) together with the formula for coefficient L (7).

Changing mass-inertia ratio without a corresponding change in the frequency of the external exposure leads to changes in the characteristics of homogeneity of vibration field. Changing the frequency according to analytical dependence (7) with the simultaneous control of uniformity by means of the measuring means is necessary to provide the homogeneous mode of vibration of the field.

The sensor define the boundary parameters of the interaction of bodies in a vibrating system (figure 2) is developed to control the state of vibration field at a fixed point [9].

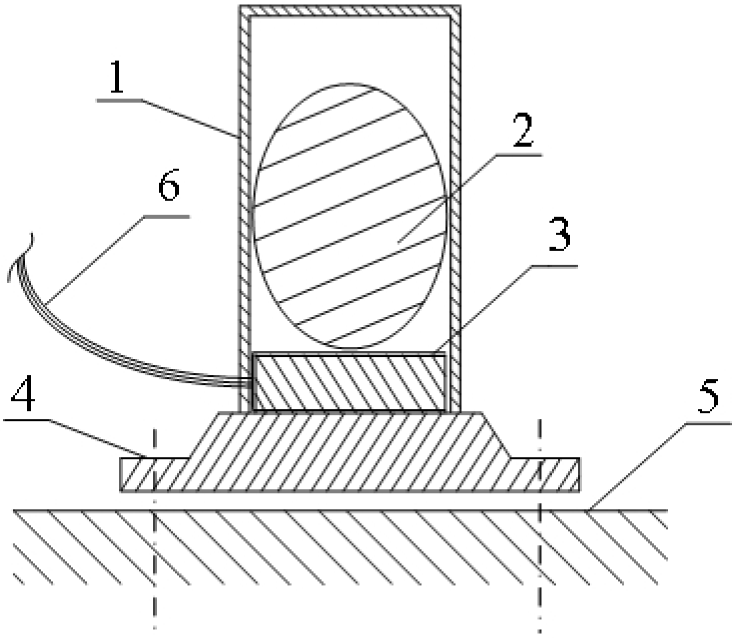

Figure 2. The detector of definition of boundary parameters of interaction of bodies in vibrating systems: 1 - the case, 2 - an inertial element, 3 - a piezoelement, 4 - fixture, 5 - support surface

Control of a vibrating field through the change of mass inertial characteristics of working body is patented as the invention [10]. Its essence consists in the fact that the working body of vibrating machine 4 detectors is established simultaneously in such a manner that the scheme of an arrangement of detectors considers features of oscillation of working body as the body performing at harmonious excitation a complex oscillative motion. The estimation of structure of a vibrating field is focused on measurement of vertical a component of speeds, motions and accelerations simultaneously with record on a corresponding data carrier that allows one to fix distribution of amplitudes of motions, speeds and accelerations. The circuit diagram of the vibrating machine in the form of the solid body making vertical fluctuations is shown in figure 3.

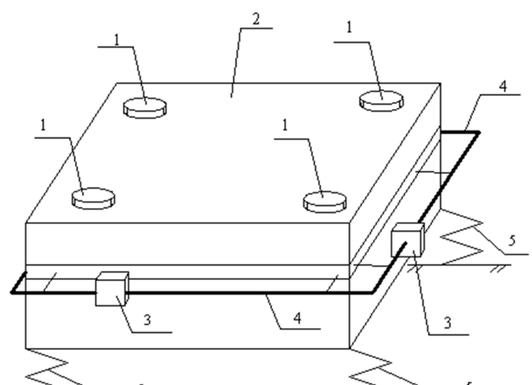

Figure 3. The circuit diagram of the vibrating table in the form of the solid body making vertical fluctuations: 1 - detectors, 2 - a vibrating surface, 3 - inertial elements, 4 - directing line, 5 - elastic elements

3. Conclusion

Principles of construction of the technological machines providing a variation of parametres of a vibrating field, change of characteristics of devices are developed for transformation of the movement imposing additional ties, forming dynamic properties of the working body by redistribution of inertial elements, moving along directing line (figure 3). The approach to control the system construction by a vibrating field of technological machines with the large-sized working body for realisation of vibrating technological processes is offered.

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