ПРИКЛАДНІ ПРОБЛЕМИ ДИНАМІКИ, МІЦНОСТІ ТА ОПТИМІЗАЦІЯ ПРОМИСЛОВОГО УСТАТКУВАННЯ

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OPTIMIZATION OF DYNAMIC SCHEMES AND STRUCTURAL PARAMETERS OF VIBRATION BUNKER FEEDERS

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Розглянуто комплекс елементів, що впливають на продуктивність та ефективність роботи вібраційних бункерних живильників з електромагнітними приводами, що виконані за двомасовою коливальною системою. Запропоновано нові конструкції та параметри цих елементів.

The set of elements that affect the performance and efficiency of the vibration bunker feeders with electromagnetic actuators, are made on the basis of the oscillatory system with two masses. New structure and parameters of these elements, have been proposed.

The entry. The vibratory hopper feeders are widely used in the automated technological equipment and are intended, mainly, for the piece of issue of the products or billets to the exciting bodies manipulators in robotic systems, servicing machines, as well as the exciting bodies of other automated technological equipment.

Statement of the problem. The modern design of the vibration bunker feeders, which are made according to a classical dynamic scheme and have oscillatory system with two masses, do not fully utilize the energy of vibration exciter to perform useful work. In addition, through the presence of a severe reaction mass they have quite a lot of weight. To improve the efficiency of actions, and also to reduce the weight of such vibration bunker feeders need to change some elements of the device, as well as to contribute to the design of new elements.

The analysis of last researches and publications. The existing design, which are made according to a classical dynamic scheme, have oscillatory system with two masses [1]. They consist of a work item (Cup) and reactive plates, which are connected among themselves aimed elastic system, electromagnetic vibration exciter, fixed basis and a system of shock absorbers. Then you power on the occasion of the bowl and the rocket stove feeder perform the antiphase oscillations in the relative total amplitude of oscillations, consisting of the vibration amplitudes of the Cup and of the rocket stove. Total relative amplitude of oscillations of vibration bunker feeder is constant and depends on the power of vibration exciter, mass and moments of inertia of the Cup and of reactive plates and the detuning of the elastic system on the frequency of forced oscillations vibration bunker feeder. Thus, when working, energy of vibration exciter is spent in istanbul as the bowls that performs useful work, and reactive plates, performing single hesitation. If we consider that the optimal ratio of the mass and moments of inertia of reactive plates and bowls in vibration feeders is in the range of 2 to 3 up to one, and the ratio of the amplitudes of the

oscillations of reactive plates and bowls inversely proportional to their mass and moments of inertia, it is obvious that the amplitude of oscillations of the Cup will be in 2...3 times larger than the amplitude of the fluctuations of reactive plate [1]. Thus, part of the energy vibration exciter (and it is about 25–30 %) cannot be used to perform useful work, and spent idling.

In order increase the amplitude of oscillations of the Cup in respect of the real basics while retaining the relative total amplitude of fluctuations can be increase the ratio between the jet and the working masses for the account of the increase of reactive element (the case of reduction of weight of a bowl is not considered, because it when designing vibration of the bunker feeder select the minimum possible and the reduction is not the subject). However, if to consider, that reactive element of the bunker feeder is the most heavy object in the construction, the increase of its mass leads to a significant increase in the mass of all bunker feeder, which, in turn, will lead to increasing of the vibration exciter power necessary to ensure the desired relative total amplitude of fluctuations, as well as to an unjustified increase of consumption of metal.

The wording of the objectives of the study. To improve the efficiency of the device, increase of its productivity and to reduce its weight and metal consumption necessary to change the design of the bunker feeder and some of its elements that affect the redistribution of the amplitudes of vibrations of working (Cup) and reactive mass of the bunker.

Summary of the basic material of research. The proposed construction of the bunker feeder with a modernized dynamic scheme has a high performance by increasing the absolute amplitude of oscillations of the Cup in the same size of feeder and power consumption of the bunker feeder and the reduction of mass of reactive plates and with the weight of the whole unit. All construction elements remain unchanged, and the modernized only reactive plate, to which the additional weights, which are connected with the plate with the help of springs are added. Thus, the dynamic scheme of a vibrating system of the bunker feeder turns from the sistem with two masses on the system with three masses. Elastic system of additional weights is selected in such a way that the natural frequencies of oscillation of the cargo on the springs less than 2...6 % for the frequency of forced oscillations of the bunker feeder.

Two variants of the constructive scheme of the proposed device is shown in Fig. 1 and Fig. 2 [4]. Vibratory feeder consists of a working body – Cup 1 and reactive plate 2, connected between the main elastic system 3 in the form of a lattice hyperbolic torsion, fluctuations of electromagnetic vibration exciter 4, anchor which enshrined the to Cup 1, and the solenoid – to reactive plate 2, of additional cargo 6, enshrined in the periphery of reactive plate 2 with the help of springs 7 and stationary basics 5, which is based feeder through the rubber shock absorbers 8. As springs 7 (Fig. 1) applied chiseled coil springs with screw groove [3], which ensure reliable squeeze of them all, which eliminates the noise and noise in the operation of the bunker feeder. In the second version (Fig. 2) flat springs 7 are applied.

Vibratory feeder works this way. When you power on the vibration exciter Cup 1 (Fig. 1, Fig. 2) and reactive plate 2, which are connected with the main elastic system 3, carry out forced to antiphase oscillations with a frequency equal to the frequency of efforts vibration exciter 4. The amplitude of fluctuations of the Cup in respect of the real basics 5 is part of the total relative amplitude of fluctuations and is equal to approximately 2/3...3/4 of it. The amplitude of fluctuations of reactive plate is approximately 1/3 of...1/4 of the total amplitude, respectively. Fluctuations of reactive plate 2 excite fluctuations of additional cargo 6, vested in it by using springs 7, at the expense of close to resonance settings (own frequency of fluctuations of cargo 6 of the springs 7 – 47 to 49 Hz in frequency efforts vibration exciter – 50 Hz). Due to the fact that the eigenfrequencies of a cargo 6 of the springs 7 below the frequency of forced vibrations of the elements of the feeder, the fluctuations of cargo 6 are in antiphase with the vibrations of reactive plate 2. Acting as a dynamic inertial oscillation dampers of the additional cargo 6 reduce the horizontal component of amplitude of oscillations of reactive plate 2 in respect of the real basics 5 [2]. However, the relative total horizontal component of the amplitude of oscillations in system of the vibratory feeder remains almost unchanged due to the accompanying effort vibration exciter and, thus, the horizontal component of amplitude of oscillations of the Cup 1 in respect of the real basics 5 (that is, the absolute amplitude) will increase by the amount of reduction of the horizontal component of

the amplitude of oscillations of reactive plate 2. Picking up a lot of cargo 6 and the stiffness of the springs 7, you can achieve a partial reduction of the horizontal component of the amplitude of oscillation or almost complete stop of fluctuations of reactive plate 2 in the horizontal direction, thereby increasing the horizontal component of the amplitude of oscillation of the Cup 1 to the total of the relative amplitude of oscillations in system of the vibratory feeder in a horizontal direction, and that, accordingly, will increase its performance. Shock absorbers 8 provides almost all of the vibration isolation system, which gives the opportunity to consolidate feeder through a firm basis 5.

To reduce or repay fluctuations reactive plate 2 it is necessary to inertia forces of additional cargo 6, which oscillate, were close to the inertia forces of the reactive plate 2, which fluctuates, that is,

$$K \cdot n \cdot m_1 \cdot A_1 \cdot \omega^2 \le I_2 \cdot \varepsilon_2 \cdot \omega^2,$$

Where m_1 is the reduced mass of cargo 6, I_2 – is the moment of inertia of reactive plate 2, A_1 – amplitude oscillations of cargo 6, e_2 – angle amplitude of fluctuations of reactive plate 2, n – number of cargo 6, ω – is the circular frequency of forced oscillations of the vibratory feeder, K – coefficient of transfer of linear oscillations in the corner, which depends on the parameters of the main elastic system – a lattice hyperbolic torsion.
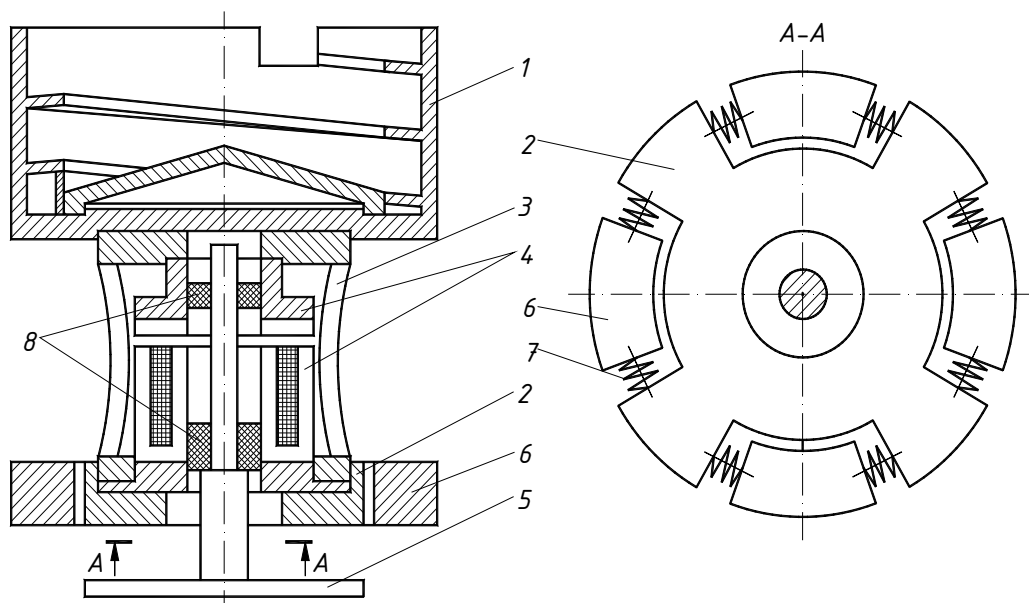

Fig. 1. The constructive scheme of the vibratory feeder (option with coil springs 7)

With the conditions determined amplitude of fluctuations of additional cargo 6, necessary for the repayment of the fluctuations of reactive plate 2. This amplitude is implemented by the choice of own frequency of fluctuations of cargoes at reinforcement springs 7, which is achieved by choosing the stiffness of the springs.

Due to the extra cargo, which are fixed on the periphery of the reactive plates with the help of additional springs, there is no need in a classic ratio of the mass and moments of inertia of the Cup and of reactive plate (1 to 2...3) and the ratio in the offered design is 1 to 1. This significantly reduces the weight of the vibratory feeder and metal consumption, and the necessary ratio of the amplitudes of the oscillations of the Cup and of reactive plates will be achieved at the expense of dynamic damping of the oscillations amplitude of reactive plates additional supplies and a corresponding increase in the amplitude of oscillation of the Cup in respect of immovable Foundation [3].
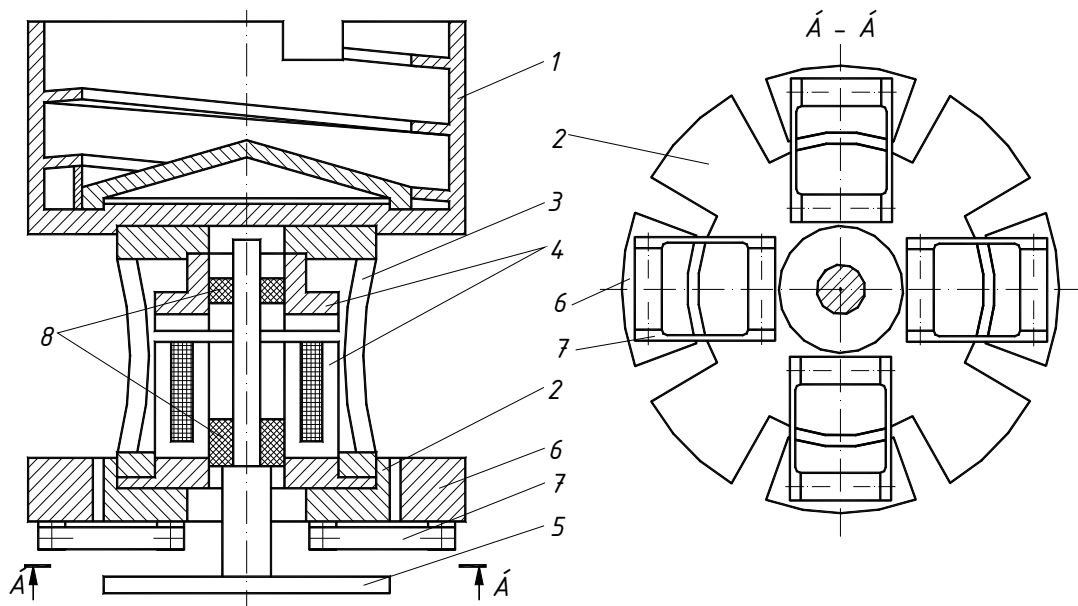
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Fig. 2. The constructive scheme of the vibratory feeder (a variant of the flat springs 7)

Conclusions. Proposed in the new design of dynamic oscillation dampers of reduced horizontal component of amplitude of oscillations of reactive plate, which is almost zero. But due to the fact that the relative total horizontal component of the amplitude of oscillations of the vibratory feeder, which depends on the power of the vibration exciter and the main parameters of oscillatory system remains unchanged, the horizontal component of the amplitude of the Cup in respect to the real basis grows and becomes almost equal to the amount of horizontal component of the relative total amplitude of fluctuations, that is, the value of its increase in about 1,2...1,3 times (20...30 %). Therefore, productivity of the vibratory feeder due to the increase of the horizontal component of the amplitude of oscillations of the Cup is not at the expense of increase of capacity of the vibration exciter, but at the expense of internal redistribution of energy between the elements of its oscillatory system, which allows more efficient use of energy of the vibration exciter to perform useful work, that is, increase the coefficient of its efficiency. In addition, at the same time decreasing the mass and the consumption of metal constructions of the vibratory feeder.

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