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Modeling Mixers Gyroscopic Type

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Abstract: Considered are the peculiarities of the development of mixers gyroscopic type. There is represents the desirability of such mixers. Completed a review of Russian and foreign writers on the subject. Shows two copyright kinematic scheme of mixers gyroscopic type, describe the impact on the mixing material in two mutually perpendicular directions and in two mutually perpendicular horizontal directions. There is shows an example of the laboratory setup. Rotation of the mixing chamber is carried out by means of toothed (conical and cylindrical) programmes. The resulting complex spatial motion of material particles can be adjusted to the selection of appropriate gear wheels. It is possible to calculate the energy component for this kind of devices. They were preliminary experimental studies. The central composite orthogonal plan of fractional factorial experiment was chosen. Entrance factors for carrying out pilot studies with laboratory installation – the mixer of gyroscopic type are presented. At an initial stage were limited to four input parameters. Conclusions on experiments are drawn.

Key words: Mixer · Bi-directional impact on the mixing material · Gyroscope · Rotation around the horizontal and vertical axes · Trajectory of material motion inside the mixing chamber · Gears

INTRODUCTION

The branch equipment of the industry of building materials and allied industries is specific and very expensive energy that leads to the necessity of operation of the equipment taking into account the progressive approaches to methods of processing materials. Mixing of different materials, fast receipt of quality mixes is the problem area in processing materials [1, 2, 3].

One of these new approaches is the use of bi-directional impact on the mixing of the material in the mixers of periodic type that involves raising the efficiency of the latter [4, 5].

The Main Part: Possible addition to the existing classification of mixing machines mixers of periodic action, using the elements of the gyroscopic effect. This implies bidirectional effect on the mixing chamber, including camera rotation about the vertical and horizontal axes.

The created device in two mutually perpendicular directions impact on particles of the mixed material leads to their destruction and mixing. Under influence centrifugal forces of the material is moved by a complex trajectory determined gears.

In the general case of motion of particles of the material occurs in free fall trajectories [6].

After separation of particles from the camera freedoms motion of particles occur only under the action of weight and described by the following system of equations:

$$\begin{cases} x = x_1 + V_{x_1} t; \\ y = y_1 + V_{y_1} t; \\ z = z_1 + V_{z_1} t - {gt^2}/{2}; \\ V_x = V_{x_1}; \\ V_y = V_{y_1}; \\ V_z = V_{z_1}, \end{cases} \quad (1)$$

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where x_1; y_1; z_1; V_{x1}; V_{y1}; V_{z1} - coordinates and velocities of motion of particles of the material along the corresponding axes at the time of separation. When using the second perpendicular impact on the particle is a superposition (overlay) forces.

To use the device with two degrees of freedom similar to the effects used in gyroscopes [7, 8, 9].

In this case there is a connection between the moment of force M, the angular momentum L and the angular velocity of precession [OMEGA]:

$$M = \Omega \bullet L. \quad (2)$$

The angular velocity of precession is [OMEGA]:

$$\Omega = \frac{m.g.l}{Jx.\omega} \quad (3)$$

It should be noted that [OMEGA] independent of the angle [theta] tilt axis gyroscope and inversely proportional to [omega]. Under the elementary theory:

$$L = J.\ \omega, \quad (4)$$

where J - moment of inertia of a gyroscope with respect to its axis of symmetry and [omega] - angular velocity of own rotation. Then the moment of external forces acting on the axis, will be equal to:

$$M = \Omega \bullet \mathrm{L} = \Omega \bullet (\mathrm{J} \bullet \omega), \quad (5)$$

where [omega]- angular velocity of the forced rotation (sometimes say: forced precession).

On the basis of the analysis and literature review, device for the mixing of materials containing a mixing chamber of the spherical form, mounted on drove and drive rotation, equipped with gears, which provide rotation drove with camera around the vertical axis and directly mixing chamber around the horizontal axis [10].

The device (Fig. 1) has a small diameter of mixing chamber in order to avoid excessive loads on the bearing units. The choice of the spherical shape of the mixing chamber is due to the optimal usage of the entire working surface of the mixing chamber, the practical absence of stagnant zones.

The resulting complex spatial movement, leads to the intensification of mixing and the rapid acquisition of a homogeneous mixture, shortening of working cycle of the device.

The variation of the frequency of rotation is advisable to eliminate dead zones, load and increase of intensity of mixing, as a ratio of the frequencies occurs optimal for a given material trajectory of movement of the load, which contributes to the increase in the area of contacting surfaces, number of interactions diffusion materials. Working phase ends with switching off of the actuator within a certain time interval and unloading of the mixing chamber through the hatch.

This device uses three bevel gears, in addition there are certain inconveniences during the unloading of ready mixes from the camera.

It is possible to modernize equipment for mixing of materials, implements impact on the mixing material in two mutually perpendicular horizontal directions (Fig. 2). The aim of creating a useful model to simplify the design of devices for mixing of materials.

In this case, the drive rotation is equipped with gears, which provide rotation drove with camera around the horizontal axis and directly mixing chamber around the second horizontal axis perpendicular to the first.

The proposed design of the device reduces the number of bevel gear up to one and provides effective unloading of ready mix from the camera.

Besides, the drive of rotation is made with the ability to change speed and direction of torques both clockwise and counterclockwise.

Let's show option of realization of the mixer of periodic action taking into account bidirectional impact on a mixed material of the mixing camera in two mutually perpendicular horizontal axes.

The option of laboratory installation on hashing of materials is presented in Figure 3. The presented option doesn't turn on the electric motor and the device of reception of a ready mix.

The offered design of the device for hashing of materials passes check on patent purity.

Calculation of reduction rates is realized on the following methods:

$$U_{12} = \frac{z_2}{z_1}; U_{34} = \frac{z_4}{z_3}; U_{56} = \frac{z_6}{z_5} = 1, \quad (6)$$

where U_{12}, U_{34}, U_{56} – reduction rates of appropriate kinematic pairs (cylindrical and conic tooth gearings);

z_2, z_1, z_4, z_3, z_6, z_5 – number of teeths of a gear wheel and wheel of the corresponding kinematic couples (cylindrical and conic tooth gearings).

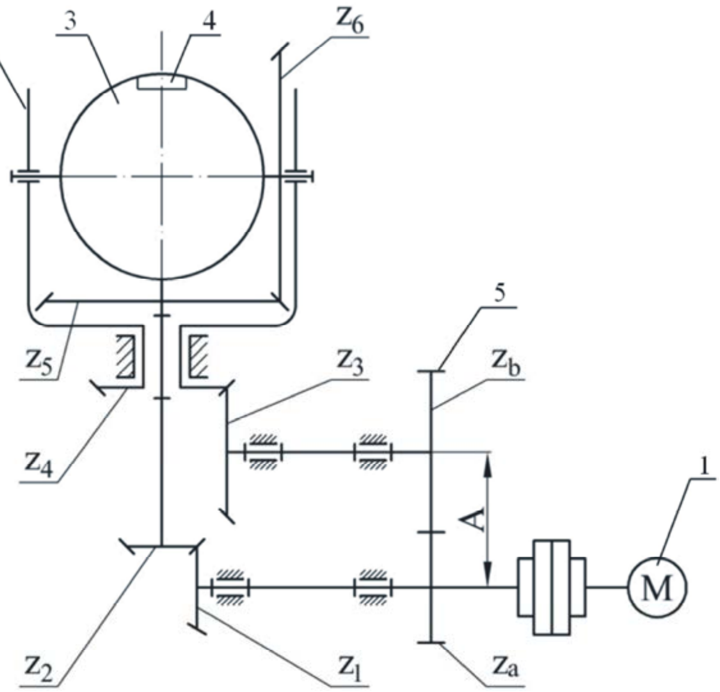

Fig. 1: Kinematic scheme of the device for the mixing of materials with a camera rotation around the vertical and horizontal axes. 1. drive; 2. rotating planet carrier; 3. mixing chamber; 4. loading hatch; 5. gear

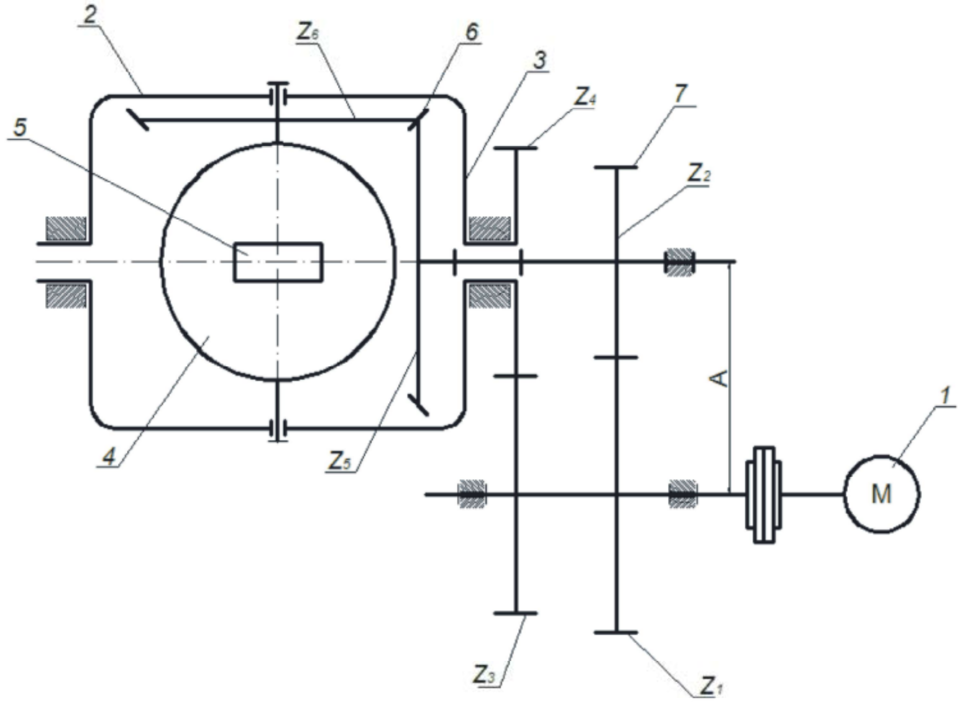

Fig. 2: The kinematic scheme of the device for hashing of materials with camera rotation round two mutually perpendicular horizontal axes

1. drive; 2. the rotating drove; 3. vertical òàðåëü; 4. mixing camera; 5. loading hatch; 6. conic tooth gearing; 7. cylindrical tooth gearing

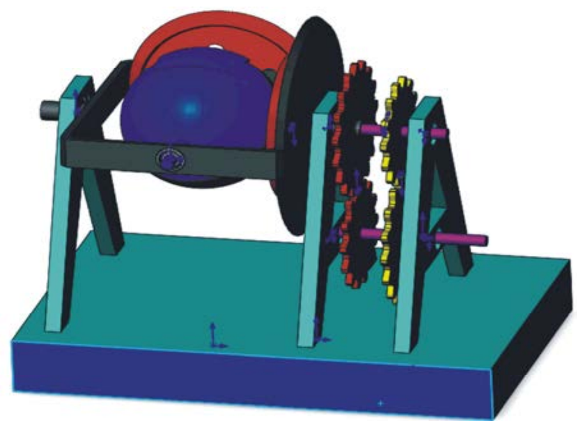

Fig. 3: Laboratory installation on materials mixing

If it is necessary to provide a certain transfer relation of U *, we will receive $\frac{\omega_1}{\omega_2} = U^*$ or $\frac{\omega_3}{\omega_4} = U^*$, where [omega]1, [omega]2, [omega]3, [omega]4 – angular speeds of gear wheels and wheels of cylindrical tooth gearings.

Then number of teeths of a gear wheel and a wheel of a cylindrical tooth gearing, for example, z1 and z2 is defined from expressions (at a fixed value of interaxal distance of A):

$$z^2 = U^* . Z_1; \quad (7)$$

$$A = \frac{m}{2}(z_1 + z_2) = \frac{m}{2}\left(z_1 + U^* \cdot z_1\right) = \frac{m \cdot z_1}{2}\left(1 + U^*\right), \quad (8)$$

where A – interaxial distance, mm, m – meaning of module transmission, mm.

The cycle of hashing of particles of a material proceeds before obtaining the set quality of hashing of a mix on the basis of in advance made experiments.

For this device pilot researches [11] were conducted. Conclusions about possibility of use of such mixers, extents of influence on compliance of results of pilot studies and results of industrial tests can be made as a result of comparison of the parameters of processes of mixing calculated by means of a developed technique. Experiments were made according to the central composite orthogonal plan of fractional factorial experiment. The plan of carrying out such experiments assumed change: [phi] - coefficient of loading of the mixing camera; n - rotation frequencies, with-1; [rho] - a krupnost of particles of a loaded material, m; t - time of hashing of a loaded mix, with;

Criterion of an optimality of such plans is orthogonality of all a vector columns of a matrix of planning of experiment that provides independence of estimates of coefficients of the equation of regression.

Definition of the optimum is constructive - technological parameters of mixers the simplex - a method with use of mathematical model of a multiphase motion cycle of a mix is carried out for example, consecutive.

Conclusion: Use of the described devices is acceptable only for low-tonnage production.

The principle of operation of mixers of periodic action, feature of impact on a mixed material and the small sizes of the device promote decrease in energy consumption at their operation.

CONCLUSIONS

- The analysis of work of the existing mixing equipment and theories of process of mixing showed need of development of a technique of determination of optimum parameters of interactions of mixes with concrete physicomechanical characteristics and the set quality of hashing of a mix.
- The technique of pilot studies on mixing in devices realizing bidirectional impact on a material is developed.
- Experimental installations are created and the necessary number of experiments according to the central composite orthogonal plan for the purpose of a set of statistical information and achievement of adequacy of the received square regression dependences is carried out.
- On the basis of mathematical model of the device for hashing of materials optimum trajectories of movement of particles of a mix for most its effective homogenization are revealed.
- Received information is necessary for determination of optimum constructive and technological parameters of mixers of periodic action.
- On a design of devices for hashing of the materials developed taking into account the offered technique, copyright certificates on useful model are received.

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