

## ENGINEERING MANAGEMENT OF VIBRATING MACHINES FOR TARGETED MECHANICAL ACTIVATION OF PREMIX COMPONENTS

### ІНЖЕНЕРНИЙ МЕНЕДЖМЕНТ ВІБРАЦІЙНИХ МАШИН ДЛЯ ЦІЛЬОВОЇ МЕХАНОАКТИВАЦІЇ КОМПОНЕНТІВ ПРЕМІКСУ

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#### ABSTRACT

The article shows the technological scheme and the implementation of structural vibration equipment for complex processing of bulk premix ingredients in the manufacturing of high active premix based on natural ingredients. To intensify the process of dissolution of premix ingredients by biologically active environment and to minimize the time for reaching their maximum concentration in the body, it is proposed to carry out targeted mechanical activation, which allows increasing the dispersion of the material significantly, generating more soluble polymorphic modifications with the active destruction of the crystal lattice of the treated material to its full amorphization.

#### РЕЗЮМЕ

В статті відображено технологічні схеми та конструктивну реалізацію вібраційних машин для комплексної обробки сипких компонентів преміксу при виробництві високоактивних сумішей на основі природних інгредієнтів. Для інтенсифікації процесу засвоєння компонентів біологічно активним середовищем та мінімізації часу для досягнення їх максимальної концентрації в організмі, пропонується здійснювати цільову механоактивацію, що надає можливість значно збільшити дисперсність оброблюваного матеріалу, генеруючи більш розчинні поліморфні модифікації за умови активної деструкції кристалічної решітки оброблюваної сировини до повної її аморфізації.

#### INTRODUCTION

One of the most important areas of research in physical chemistry is to link the reactivity of the reagents with their structure and conditions of the chemical reaction. Increasing solubility dosage forms is one of the most important issues, as 40% of premix substances are difficult to solubilise, and of newly synthesized substances up to 60% have low solubility in water and aqueous solutions.

Nowadays a recognized fact for solid-phase reagents is that the reactivity depends on their structure, including the presence of different kinds of micro defects. Among the methods for acquiring this condition with substantial degradation of the crystalline material is grating target mechanical activation, which received wide development as a way to regulate the reactivity of solid materials that come in a variety of chemical reactions.

#### MATERIALS AND METHODS

Growing consumer demand for premix particulate mixture of natural origin and benefits of their use cause expansion of industrial dosage forms production data (see fig.1).

One of the most important stages of the production process of premix compounds is grinding plant with gradual sifting and bringing it to a smooth consistency with additional premix ingredients by mixing. Last comes to the production as shallow dispersive loose bulks (Shakhtshneider T.P., 2013; Chueshov V.I., Hladuh E.V., Saiko I.V., 2012).

Crumbly premix mixture is the basic foundation for the production of granules of drugs, the consumption of which is the oral method and mostly depends on the parameters of the drug - physical and chemical properties of raw speed of absorption and time to reach maximum concentration in the organism (Sydorenko I.I., Kushnir A.Y., Baidzhanov S. M., 2015).

During the last three decades one of the most important criteria for assessing the quality characteristics of oral medical facilities became their capacity for absorption by which a system of bio premix

classification was made, based on the latest solubility in the liquid and the permeability degree of the active substance in the intestine wall.

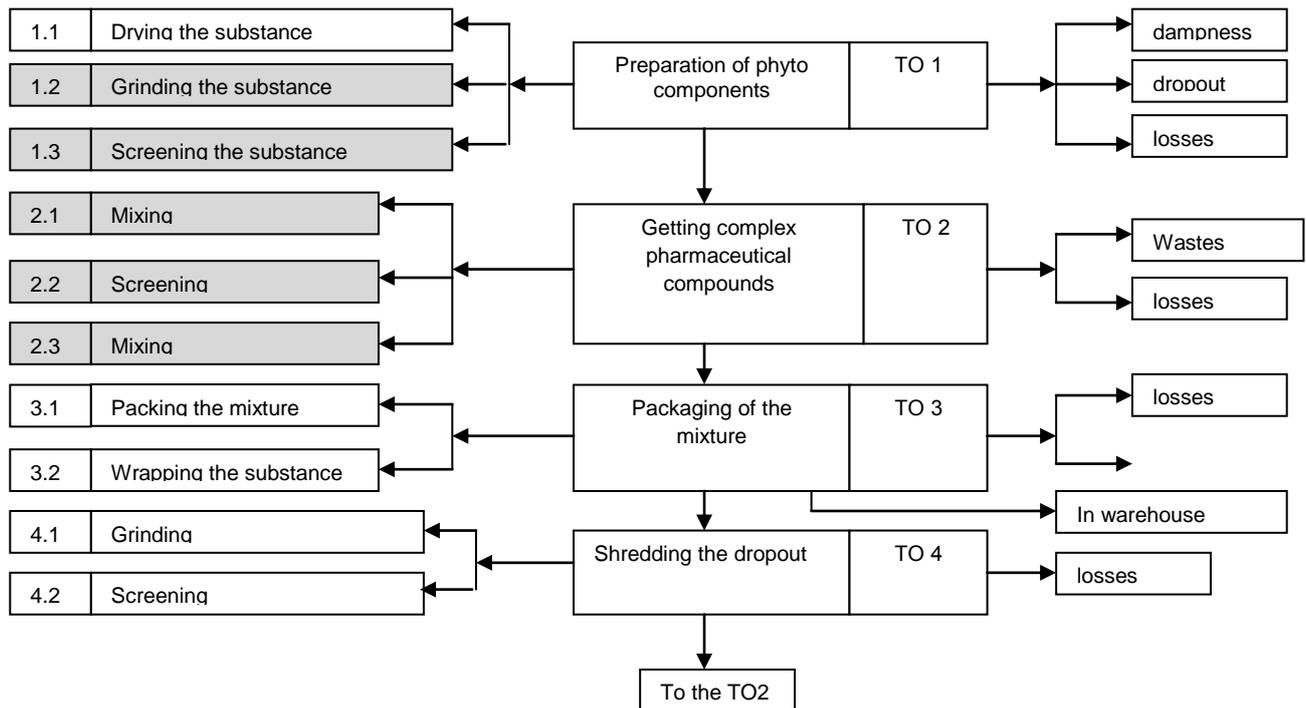


Fig. 1 - Technological scheme of complex premix compounds

The rate of dissolution of the raw material is characterized by the Neuees-Whitney equation (1):

$$\frac{dC}{dT} = SD(C_s - C) / h \quad (1)$$

where  $\frac{dC}{dT}$  the rate of dissolution;  $S$  - dissolution of the surface area;  $D$  - diffusion coefficient;  $C_s$  - solubility substance;  $C$  - substance concentration at the time  $t$ ,  $h$  - the thickness of the diffusion layer adjacent to the surface of the solvent.

The analysis of the equation led to the conclusion that the intensification of the drugs dissolution process is possible for a significant increase in the dispersion of the material and consequently the contacting area of substance or by reducing the thickness of the diffusion layer (*Cheney M.L., Weyna N., Shan M., Hanna L., Wojtas M.J., 2010*).

The solubility of solids is a complex process that combines integrated communications gap between the ions, atoms or molecules in the structure of soluble material and requires significant energy costs.

The higher the binding energy between the particles of the material, the better. Simultaneously goes the interaction of particles with a solvent that is accompanied by the release of energy. The energy intensity of the process comprehensively reflects the total energy expenditure associated with the destruction of the molecular lattice, for intensive transfer of the active substance molecules in the solution, and as a result solvation energy and entropy increases in the local system (2):

$$\Delta H_{\text{solubility}} = \Delta H_{\text{destruction}} + \Delta H_{\text{solvation}} \quad (2)$$

This equation shows that the molecular switch in solution can be intensified as a result of targeted destruction of the crystal lattice of a solid, and as a result its complete amorphization.

As plant material for experimental treatment valerian root and mix herbs were chosen (see fig.2.).

A promising experimental drug for the treatment of aluminum silicate glauconite was used (see fig.3.), which meets all the requirements to immune sorbents: inertia with respect to biological agents; stability properties over a wide range; it is not destroyed when exposed to microorganisms; high sorption capacity; ability to covalent binding ligand as in the initial state as in the modification.



**Fig. 2 - The plant material before and after grinding**  
*a,b – valerian root before and after grinding; c, d – gathering herbs before and after grinding*



**Fig. 3 - glauconite before and after grinding**  
*a – glauconite before grinding; b – glauconite after grinding*

## RESULTS

The current technology of bulk premix compounds, based on plant material has several disadvantages, one of which is energy intensive phased implementation process, separation and mixing of premix ingredients phytocomponents in separate powder mass (Lavrova L.Y., 2013; Nadutiy V.P., Titov A.A., 2017).

To address these deficiencies a vibrocentrifugal shredder was developed (Dudnikov A.A., Belovod A.I., Pasyuta A.G., 2015); it combines elements of a ball mill, mixer and sieve separator that provides oscillating and rotating movements in two perpendicular planes.

Schematic diagram of vibrocentrifugal disintegrator and its constructive realization are shown in fig. 4.

Vibrocentrifugal shredder includes frame 1 and two main structural paths that are driven into motion by electrical engine 2; they are interconnected by drive shaft 3, open bevel gear 4 and wedge-belt transmission system 5.

The internal circuit of the disintegrator is composed of three-chambered working container 6, sieve elements 7 and grinding bodies 8, pipes 9, 10, 11 respectively for supplying and discharging technology environment, imbalance 12 to generate power imbalance systems elastic elements 13 between the container and the rim 14, drive shaft rim 15 is placed on the support 16 nodes.

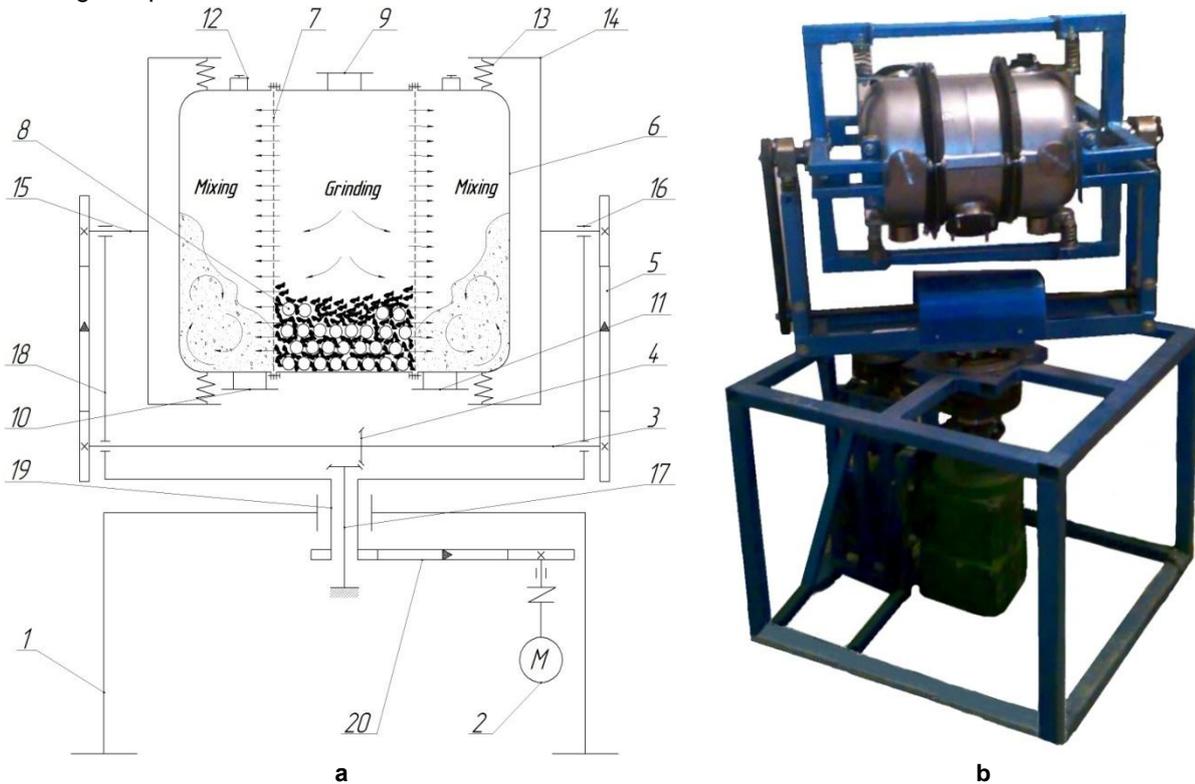
The external circuit includes the disintegrator hoop 14 with its drive shaft 15 that leads to the rotation of the motor 2 through 5 wedge-belt gear axis 17 and open bevel gear 4. The carrier 18 is driven through the hollow drive shaft 19, which, with the help of wedge-belt through transmission 20 is connected to the motor 2.

This design works as follows: after the required amount of raw materials is downloaded in the corresponding proportions in the chamber for grinding and mixing, we switch on the electric motor 2, 6 and drive the container carrier 18.

The torque from the electric motor 2 through the wedge-belt gear 5 and bevel gear 4 creates rotation of the rim 14 and of the imbalance 12 and drives 18 relative to the perpendicular axes. Rotating of the imbalance leads to spatial fluctuations of spring-loaded three-chambered drum 6 together with the loaded raw materials and grinding bodies 8 in the form of metal balls or ceramic elements. This leads to the crushing of the treated mass.

With decreasing particle size of the crushed material under the influence of centrifugal forces and alternating loads through sieve surface, their classification by size is performed: the particle diameter equal to or smaller than sieve openings fall in the mixing compartment, others go to re-grinding.

This combination of technology and the intensification of structural factors make it possible to significantly increase the destruction degree of particles with subsequent mixing of additional components, making complex effect on the work environment.



**Fig. 4 - Vibrocentrifugal disintegrator for the production of premix mixtures:**

a) schematic diagram; b) constructive realization;

1 - bed; 2 - electric; 3, 15, 19 - drive shafts; 4 - conical transmission; 5, 20 - wedge-belt transmission; 6 - three-chambered container; 7 - sieve elements; 8 - crushing balls; 9, 10, 11 - pipes; 12 - unbalanced weight; 13 - elastic elements; 14 - hoop; 16 - bearing components; 17 - axis; 18 - drives

Modern trends in premix complex based on implementing highly efficient methods to change the substance structure are based on the facts that they provide the process of mechanical activation, which is characterized by a significant increase in the dispersion of the material and helps generating more soluble polymorphs. This process intensifies the distribution of drugs in the media, but also contributes to a significant degradation of the material crystal lattice to its full amorphization.

This technological effect is advisable to use for the production of entero- and immunosorbent glauconite powder, which makes it possible to intensify the process of binding and separation of blood antibodies or antigens.

Glauconite, a natural aluminosilicate meets all the requirements to immunosorbents: inertia with respect to biological agents; stability of properties over a wide range; it is not subject to destruction when exposed to microorganisms; high sorption capacity; ability to covalent binding ligand in the initial state and in the modified one.

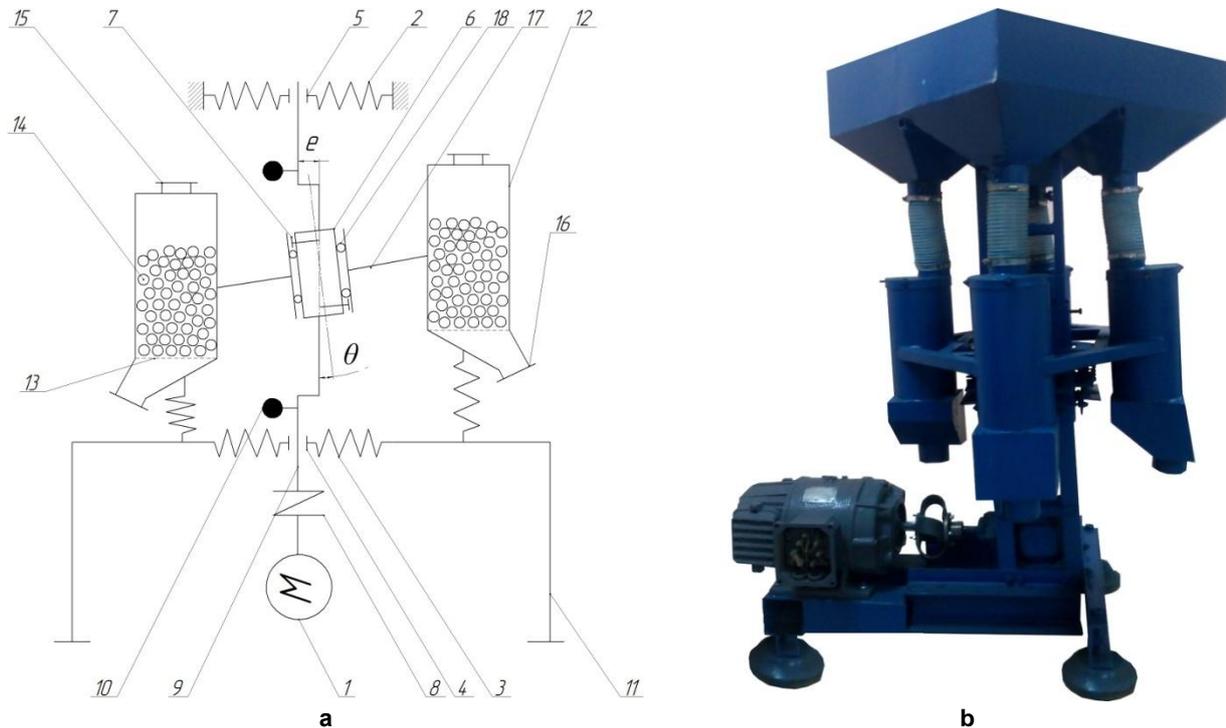
Based on the analysis of manufacturing processes and design schemes of existing equipment (Poluljakh D. A, 2017; Kuzo I.V., Lanets O.S., Gursky V.M., Shpak Y.V., 2015) for the fine grinding process, the vibratory mill was developed, which implements the idea of superfine grinding of glauconitic material and it provides significant activation of the newly formed particles surface.

Schematic diagram of a vibrating mill volume fluctuations and its constructive realization are shown in fig. 5.

The vibrating mill contains two main structural contours, which are driven by an electric motor 1, which are interconnected by elastic elements 2, 3, bearing units 4, 5, and a spindle 6, with an angle of inclination  $\theta$  which is regulated by screws 7.

Such rotating technological movement of the mill's executive body makes it possible to significantly increase the force influence of the crushing balls on the processing material, and as a result it helps increasing the productivity and quality of the specified process.

The inner contour of the mill is composed of: elastic coupling 8 and a kinematic drive shaft 9 with eccentricity  $e$  and balancing masses 10 to create a combined power and momentary imbalance of the system.



**Fig. 5 - Vibration mill for glauconite**

a) schematic diagram; b) constructive realization; 1 - electric motor; 2, 3 - elastic elements 4,5 - bearing assemblies; 6 - gyrations sleeve; 7 - adjusting bolts 8 - elastic sleeve; 9 - kinematic drive shaft; 10 - balancing weight; 11-frame; 12 - cylindrical container; 13 separation elements; 14 - crushing balls; 15 16 - pipes for loading and unloading the surface of the material; 17 - drive platform; 18 - bearing.

The outer contour of the mill contains the frame 11, cylindrical container 12 with perforating elements 13 and 14 crushing balls, pipes 15, 16 for loading and unloading of the surface of the material, the drive platform 17 and bearing 18.

Vibration mill works as follows:

If you put the motor 1 torque with the help of elastic sleeve 8 it will transmit to the kinematic drive shaft 9 with eccentricity  $e$  and balancing masses 10 by rotation which is rolling the bearing 18 to relatively graceful sleeve 6 forcing through the drive platform 17 at the same time to carry out horizontal vibrations and graceful movement of spring-loaded cylindrical containers 12 together with 14 manufacturing crushing balls material that is continuously supplied through pipes 15 and as a result of crushing balls 14 force through pipes 16 is discharged from the mill.

The proposed construction implements the idea of a combined interaction of the containers vibration motion with the possibility to realize the milling process, which is provided by the highly dynamic condition of the crushing balls.

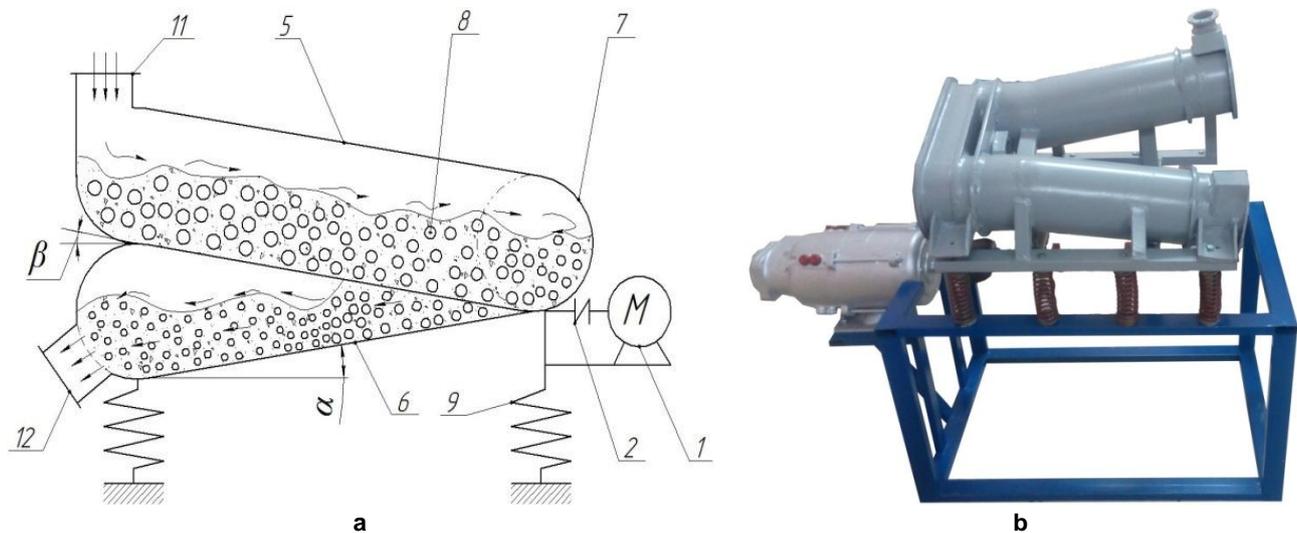
Today, one of the most common dosage forms in the world are forms for pre-oral usage, most of which are in the solid state and their active interaction with the body starts as a result of dissolution of premix ingredients and subsequent penetration of the active substance through the mucous membrane of the gastrointestinal tract.

The analysis considered approach shows that significant reduction in particle size, more soluble polymorphs, and distribution of drugs and the destruction of the crystal lattice of the complete amorphization may be implemented with the help of energy-mechanical and chemical processing methods of premix raw materials that can be implemented by energy-mechanical processing methods of premix substances (Shakhtshneider T.P., 2013).

This task can be implemented by creating vibrating mills, including plant material, which is provided by oscillating movement of preconceived milling blends of camera that are performed in two parallel placed

cylindrical containers placed at an angle to the horizontal pipe that connects the transition to the effective transport of the crushed plant matter (Solona O.V., Yanovych V.P., 2016).

Fig. 6 presents a schematic diagram and the implementation of mill structural vibration for plant material



**Fig. 6 - Vibrating mill for plant material**

a) schematic diagram; b) constructive realization; 1 - electric motor; 2 - flexible coupling; 3 - a power shaft; 4 - imbalance; 5, 6 - cylindrical container; 7, 8 - transitional tubes; 8 - crushing balls; 9 - elastic elements; 10 - crosspiece; 11, 12 - tubes for supplying and discharging the treated material

Vibrating electric mill that has 1, 2 elastic coupling, connected to the drive shaft 3 on which is placed imbalance 4 of the grinding chamber performed as two parallel cylindrical containers 5, 6 placed at an angle  $\alpha$  and  $\beta$  to the horizon, which joined the transitional pipe 7 and complete crushing balls 8, the elastic elements 9, arms 10 tubes 11 and 12 respectively for feeding and unloading material.

Vibration mill works as follows: the motor 1 through flexible coupling 2, transmits the torque to the drive shaft 3 with imbalance 4, by rotation as tightly as traverse 10 is placed and it creates a combined power and vibration of unbalanced milling mixture made of cylindrical containers 5, 6 and transition pipe 7, that in their turn are filled with crushing balls 8 and helical milling chamber. Processing material which is continuously supplied through the loading pipe 11 is actively grained as a result of force of crushing balls 8 in spiral trajectories and it is transported to the pipe 12 to unloading out of the vibration mill.

This type of fluctuation of the pouring medium provided by the working chamber can significantly increase the effect of process capacity and the transport speed of the filler, as well as increase the productivity and quality of the intended process.

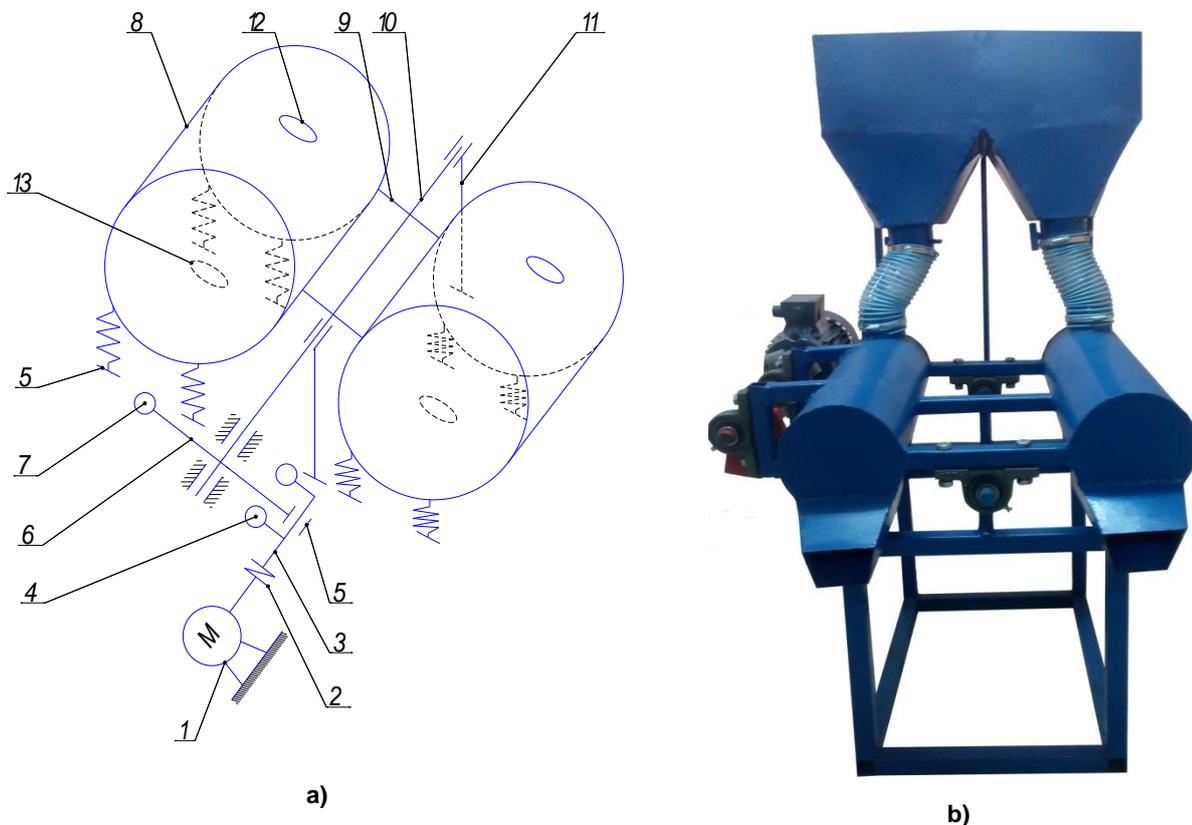
To activate the mechanical auxiliary components tablet form (lactose, talc) vibratory mill was developed, in which by changing the design of drive mechanism, the intensification of material grinding is achieved and quality milling of weight minimize energy consumption (Chueshov V.I., Hladuh E.V., Saiko I.V., 2012).

Schematic diagram of angular oscillation of vibration mill is shown in fig. 7.a, and there is its constructive realization in fig. 7.b.

The vibrating mill contains an electric motor 1, an elastic coupling 2, a drive shaft 3 which has imbalance 4, which in turn, through the bearing unit 5, is mounted locally to the rod 6 at the prop side end of which is counterbalanced 7, spring-loaded grinding chambers 8 are connected by traversing 9 and equilibrium on the central axis 10, which is located on the racks 11, the pipes 12 and 13, respectively, for feeding and unloading.

If you switch on the motor torque 1 through elastic coupling 2 it is transmitted to the drive shaft 3 of imbalance 4, its rotation leads to the creation of a combined power and torque imbalance of the rod 6, which is a consequence of moving the central fastening and inertial influence counterweight 7, it causes the

appearance of angular oscillations, as a result traverse connection 9 through the central axis 10, which are transmitted to the spring-loaded grinding chamber 8.



**Fig. 7 - Vibration mill of volume oscillations**

- a) schematic diagram; b) constructive realization;  
 1 - electric motor; 2 - elastic sleeve; 3 - drive shaft; 4 - imbalances; 5 - bearing assembly; 6 - pole;  
 7 - counterweight; 8 - spring-loaded grinding chamber; 9 - arms; 10 - axis; 11 - racks;  
 12 13 - pipes respectively for feeding and unloading process environment

Such oscillating technological movement of the mill's executive bodies makes it possible to significantly increase the force influence of the crushing balls on the processing material, and as a result it helps increasing the productivity and quality of the specified process.

## CONCLUSION

Based on the analysis of the technological features of manufacturing premix bulk mixtures based on natural substances the following means were elaborated:

- Vibro-central shredder for complex implementation processes of crushing, separation of premix ingredients, which combines elements of a ball mill, mixer and sieve separator that provide oscillating and rotating movements in two perpendicular planes;
- Vibratory mill for the production of mechanically activated entero - and immunosorbent glauconitic powder application which makes it possible to significantly increase the degree of destruction of natural aluminum silicate particles with substantial degradation of its molecular structure, and consequently to increase its solubility and absorption of the active substance in the body;
- Vibratory mill for plant material, which provided a significant degradation of the material during its processing by activating sorption properties of the original product;
- Vibratory mill for mechanical activation of auxiliary components of tablet form (lactose, talc) which, by changing the design of drive mechanism, is achieved by intensifying the process of material grinding and the quality of the milling machine by minimizing energy consumption.

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