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Compressed-Air Mixer of Continuous Action for Dry Production Construction Mixtures

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Abstract: In the article it is considered one of the developing directions of the construction industry - production of dry construction mixtures. Studied the technological chain of production of mixtures and revealed the mixing unit, which is responsible for the quality of production. For the implementation of knowledge-based innovation in the production of dry building mixtures is proposed to use mixers, working on compressed air-compressed-air mixers. Defined tasks on improvement of the compressed-air mixers. The use of compressed-air mixers of continuous action will improve the uniformity of the homogenizing powder materials, as well as to increase productivity. Invention (Fig. 1) aimed at enhancing the efficiency of mixing at the expense of speed of submission of the blend components in the area of homogenization, ensuring continuous production of dry construction mixtures with guaranteed quality. Developed the principle of homogenization vortex flows in the compressed-air mixer of continuous action for production of dry construction mixtures. The design of compressed-air mixer and principle of operation of this unit. An analytic expression for the determination of performance and capacity compressed-air mixer with regard to the production of dry construction mixtures.

Key words: Compressed-air mixer of continuous action · Dry construction mixtures · Performance · Homogenization and quality of the mixture

INTRODUCTION

One of the most intensively developing areas of the construction industry for many years is the production of dry construction mixtures. Modern dry construction mixes are the products, the production of which is based on using of high technologies. That is why the use of such mixtures can significantly increase the productivity and efficiency and improve the results of the use of the traditional sand-cement mixtures [1-3].

The technological chain of production of the dry construction mixtures, consists of the following main processes that have a significant impact on consumer properties of mixtures: preparation of components (raw), their dosing, mixing and distribution of chemical additives in the bulk product. The homogeneity of the obtained mixture is the basis of product quality.

It is to achieve high quality mixtures should pay close attention mixing node, which is considered the most responsible plot of a plant for production of composite materials. The choice of the mixing equipment is an important step in obtaining a high quality product. Mixers mechanical type, such as centrifugal, drum, gravitational and others for all their obvious advantages have large rotating mass and this means higher energy and metal consumption [4-6]. In connection with what is innovative development in the field of mixing equipment are compressed-air mixers, which have a lower metal consumption and they are no rotating parts. Currently compressed-air mixers are used for mixing dry building mixtures, molding compounds, food concentrates and pharmaceutical products. They find wide application in the chemical and plastics industry.

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The analysis of modern production technologies dry building mixtures has shown that the issues of ensuring environmental standards of production, reduction of metal consumption in comparison with a mechanical mixer, use of new kinds of raw materials and for moving from cooking relatively simple two-component mixtures for the production of new multi-component is to significantly change the traditional technological schemes.

The process of pneumatic method of mixing of granular materials is still poorly studied. However, implementation of high innovative technologies in the production of dry building mixtures the pressing issue of increasing quality and productivity of enterprises. The use of compressed-air mixer of continuous action, in addition to the above positive aspects would allow improve the uniformity of the homogenizing powder materials, as well as to increase productivity.

The main part. The comparative analysis made on the basis of contemporary sources, leads to the conclusion that for the efficient production of dry building mixtures, it is necessary to develop and use continuous mixers.

Firstly improving the quality blend uniformity could be achieved in the new designs mixers. Secondly continuity of the production process does not require the use expensive equipment for regulation of the production cycle.

When you select continuous compressed-air mixer, you must have the following. In many mixers are used internal accessories (blades) which can either facilitate the improvement of the quality of the mixture and create stagnant zones. This leads to additional treatment mixing housing, increase in maintenance decrease in the quality of ready mix. The compressed - air mixer, on the contrary, the use of additional inlets pressure and totality of the structural characteristics ensures the continuity of the process [7-9].

Currently, the industry is faucets that are due to high pressure and provide transportation of dry building mixtures. However, their operating modes are cyclical, which reduces the hourly production.

Among the promising tasks on the improvement of compressed-air mixer should include:

- Expansion of technological possibilities and modes of operation for the implementation of the mixing of different components of dry building mixtures;
- Increased productivity and product quality.

Raises the need for further development of this scientific direction and creation of a universal equipment with greater performance, high reliability and great functionality.

Based on the above, we can assume the following directions in the development of compressed-air mixer of continuous action:

- Solution of the task of process organizing continuing receipt of the dry building mixtures through new designs such mixers;
- Development of theoretical bases of calculation of their structural - technological settings applied to the dry construction mixtures.

For the implementation of the proposed directions we offer to use the following solution protected by patents of the Russian Federation for useful model depicted in Figure 1. [10].

Invention (Fig. 1.) increase efficiency mixing due to the increase of speed of submission of the blend components in the area of homogenization, ensuring continuous production of dry construction mixtures with guaranteed quality [11].

Compressed-air mixer has a supply pipe, coaxially connected with housing 2. The feed pipe 1 perpendicular to its longitudinal axis of the installed sockets input 3, each of which is connected with feed hoppers 4. Sockets input 3 are allocated evenly using the pipe length 1 and their number depends on the number of mixed components.

In the supply pipe 1 introduced extra nozzles 5,6,7 for air. They are placed so that their workers outputs are jointly to the filling 1 and ends workers outputs are on the vertical axis of each of the nozzle input 3.

Case 2 compressed-air mixer is designed as confuser and is connected to the filling 1 in front of the higher end 8. In the end of 8 on a circle are located tube 9, playing the role of nozzles. Axis all nozzles angled towards the exit into the mixing chamber in such a way that they form vortical flows. Butt 8 closed cover of 10, which forms a cavity and has a branch pipe inlet 11, through which will be compressed air under pressure p.

The inner cavity of the body (mixing chamber) 2 is divided into a zone of homogenization, the area of transportation and unloading zone.

Compressed-air mixer works as follows.

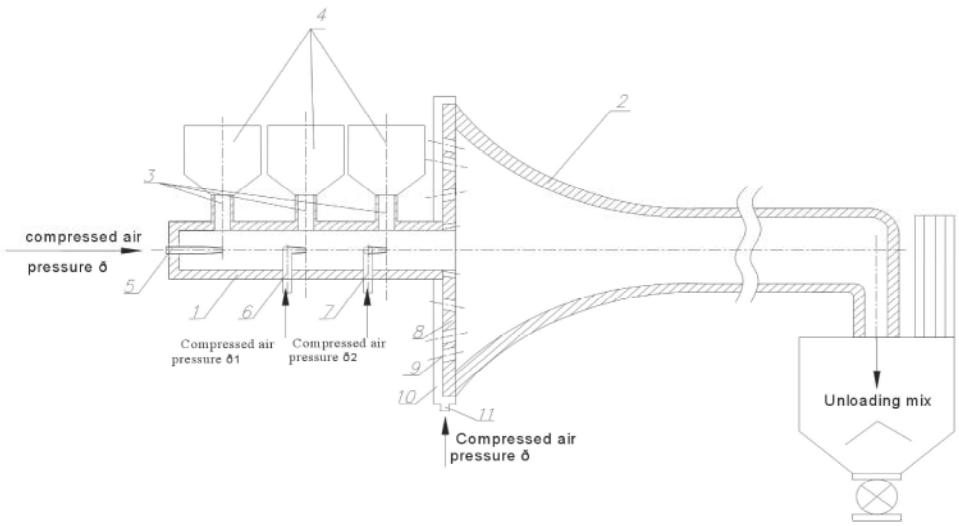

Fig. 1: Compressed-air mixer: 1 - pipe supply; 2 - case; 3 - tube input; 4 - bunker; 5,6,7 – extra nozzles; 8 - butt; 9 - nozzle; 10 - cover; 11 - supply pipe

The components of the dry construction mixtures are served in the input sockets 3 of the bunkers 4 and later in a feed pipe 1 components are dispersed compressed air supplied through extra nozzle 5,6,7 and simultaneously transported and blend. Simultaneously transport and mixing is provided due to the pressure difference p, p_1 and p_2, where p_2 - pressure applied in extra nozzle according to the preliminary calculation is made equal to 0,6 - 1 MPa. Pressure p_1 - served in extra nozzle is calculated as p_1=2/3p_2 and p - pressure applied in a pipe supply is calculated p=1/3p_2.

Then components get into the body, made in the form of a horizontal confuser. With the passage of the housing 2 in the higher end of the 8 of which are located on a circle nozzle 9, is an active mixing of components, due to the vortex flows. Air pressure p = 1/3p_2 is supplied through pipe supply 11 in the cavity formed by a cover 10 on the end of the 8. After that the ready mix is thrown into the discharge area of the mixture and then delivered to the place of packing.

Due to aeration material and powerful streams of air, the process passes in a mode of fluidization, which considerably accelerates the mixing of components. Change the pressure of compressed air, is fully controlled by the process of mixing. The estimated design allows you to mix different components and to transport the received mix mode «Dense Phase», with a minimum segregation.

In the continuous mixing of the components of the mixture are served in individual dispensers, the number of feeders corresponds to the quantity of the blend components. The process of mixing in a continuously operating mixer depends on the adjustable parameters of the system (input parameters), which include speed of the expiration of compressed air; the rate of entry into the mixing chamber particles mixture components [v]υ. To describe the process of mixing chamber of the mixer make a number of assumptions:

1. We assume that the quality of the individual components coming from feeder is a constant value, which in turn is the reason for the lack of impact of perturbing parameters.
2. The initial value of the concentration of a key component of a mixture is determined by the total law dosing.
3. Movement of the blend components in the feed pipe is done without taking into account the interaction.

Established isothermal gas movement in the mixing chamber is described by a system of three equations:

1. The equation of motion:

$$\frac{dp}{g\rho}+\frac{d\theta}{2g}+dz-\lambda\frac{dx\theta^2}{2Dg}=0 \tag{1}$$

where [p] p–pressure of air in the volume, Mpa; [je] g – free fall acceleration, m/s^2; [ro] ρ - density of the air in the flow, kg/m^3; [v] ϑ- flow velocity in the pipeline, m/s; [zet] z- energy absorption, m/s; [d] D - cross section diameter, m; [lyambda] λ–coefficient of hydraulic resistance during the flow of gas through the pipeline is determined by the formula:

$$\lambda = 0{,}067\left(\frac{158}{Re} + \frac{2k_9}{D}\right)^{0.2} \qquad (2)$$

where [ka] k_9- equivalent roughness of the pipe.

The state equation: $p = \rho z R_\Gamma T$, (3)

where [r] R_Γ- universal gas constant, [t] T– temperature.

The equation of balance of the amount gas or mass flow:

$$G = \rho\vartheta S = const, \qquad (4)$$

here $$\vartheta = \frac{G}{\rho S}. \qquad (5)$$

The first term in equation (1) is the potential energy of the gas pressure, the second is the kinetic energy of a moving gas, third - energy provisions; the fourth - lost head.

In the derivation of formulas for the calculation of the performance of the third member of neglect, i.e. it is considered that the increase in speed of movement of air in the pipeline with variable cross section occurs due to non-linearly decreasing diameter (volume) [12, 13].

Under these assumptions, equation of motion takes the following form:

$$\frac{dp}{gx} = \lambda\frac{dx\vartheta^2}{2Dg} - \vartheta\frac{d\vartheta}{2g}. \qquad (6)$$

Multiply the p^2, we get:

$$\rho dp = \lambda\frac{\vartheta^2\rho^2 dx}{2D} - \vartheta\frac{d\vartheta\rho^2}{2}. \qquad (7)$$

Substituting the expression (7) instead of [v] ϑ value from the balance equation, we get:

$$\rho dp = \frac{\lambda G^2 dx}{S^2 2D} - \frac{\vartheta d\vartheta\rho^2}{2}, \qquad (8)$$

from the state equation (3) expressing ρ as:

$$\rho = \frac{p}{zR_\Gamma T}, \qquad (9)$$

and substituting (8) we obtain:

$$\frac{pdp}{zR_\Gamma T} = \frac{\lambda G^2 dx}{S^2 2D} - \frac{\vartheta d\vartheta\rho^2}{2}. \qquad (10)$$

Intergrate equation within the initial pressure to end in the chamber (Fig. 2) length from 0 to L and speed ϑ_1 to ϑ_2 - at the beginning and end of the mixing chamber:

$$\frac{1}{zR_\Gamma T}\int_{P_1}^{P_2} pdp = \frac{\lambda G^2}{S^2 2D}\int_0^L dx - \frac{\rho^2}{2}\int_{\vartheta_1}^{\vartheta_2}\vartheta d\vartheta. \qquad (11)$$

We obtain the expression:

$$\frac{(P_2^2 - P_1^2)}{2zR_\Gamma T} = \frac{\lambda G^2 L}{S^2 2D} - \frac{(\vartheta_2^2 - \vartheta_1^2)\rho^2}{2}. \qquad (12)$$

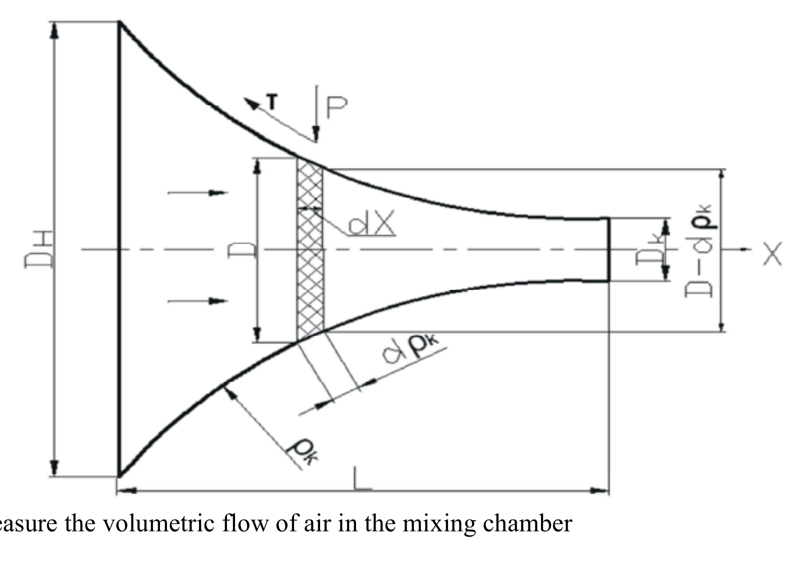

Fig. 2: Scheme to measure the volumetric flow of air in the mixing chamber

Instead of square substitute its value, we obtain finally:

$$\frac{2\lambda G^2 L}{\pi^2 D^5} = \frac{(P_2^2 - P_1^2)}{2zR_\Gamma T} + \frac{(\vartheta_2^2 - \vartheta_1^2)\rho^2}{2}. \quad (13)$$

Expressing from equation (13) mass flow G, we obtain:

$$G = \sqrt{\frac{\pi^2 D^5 \left\{ \frac{(P_2^2 - P_1^2)}{2zR_\Gamma T} + \frac{(\vartheta_2^2 - \vartheta_1^2)\rho^2}{2} \right\}}{2\lambda L}} \quad (14)$$

Volumetric gas flow rate $G = \frac{G}{\rho}$ is:

$$G = \frac{\pi D^{\frac{5}{2}} k_0}{\rho} \sqrt{\frac{\pi^2 D^5 \left\{ \frac{(P_2^2 - P_1^2)}{2zR_\Gamma T} + \frac{(\vartheta_2^2 - \vartheta_1^2)\rho^2}{2} \right\}}{2\lambda L}}, \quad (15)$$

where $k_0 = \frac{\pi\sqrt{R}}{4\rho}$ – adiabatic factor.

Thus, the expression (15) allows to calculate the volumetric flow of gas necessary for the implementation of the process of moving particles of dry bulk materials in the mixing chamber compressed-air mixer proposed design [14].

In various areas compressed-air mixer distributed density of the mixed material in the air can be determined by the formula:

$$\frac{1}{\rho_{CM}} = \frac{x}{\rho_{cp}} + \frac{1-x}{\rho_0}, \quad (16)$$

where [ro] ρ_{CM} – density of the air-material mix, kg/m^3; [ro] ρ_{cp}– average density of the mixed material, kg/m^3; [ro] ρ_0– density of the air at an average temperature of air, kg/m^3; is determined by the formula:

$$t_{cp} = \frac{t_{ex} + t_{BbLx}}{2} \quad (17)$$

[iks] X – mass fraction of solid substances in air, kg/kg

Substituting expression (14) (13) we obtain the expression for calculation of the performance compressed-air mixer for dry construction mixes:

$$Q = \frac{\pi D^{\frac{5}{2}} k_0 \rho_{cp} \rho_0}{X\rho_0 + \rho_0(1-X)} \sqrt{\frac{\pi^2 D^5 \left\{ \frac{(P_2^2 - P_1^2)}{2zR_\Gamma T} + \frac{(\vartheta_2^2 - \vartheta_1^2)\rho^2}{2} \right\}}{2\lambda L}}. \quad (18)$$

Power consumption compressed-air mixer can be estimated by the following empirical formula:

$$Pnom = P_{CM} \cdot V.n, \quad (19)$$

where [pe] P_{CM}– pressure in the mixing chamber, Pa; [v] V – volume of mixing chamber, m^3; [n] n – frequency shaft rotation of the compressor motor, 1/sec.

The expression (19) to determine consumed compressed-air mixer capacity establishes the dependence between the parameters of the operation of the compressor, compressed air and constructive - technological parameters of work of the unit. The expression on 18 and 19 are required to determine the specific energy consumption per process of mixing in compressed-air mixer developed design during the production of dry construction mixtures.

Summary. On the basis of a brief analysis of technological solutions and equipment used for its production of dry building mixtures, it is concluded, that the use compressed-air mixer of continuous action, the basis of the principle of action of which laid the method of homogenization vortex flows. The design of the compressed-air mixer and how it works.

CONCLUSIONS

The article presents the conclusion of the analytical expressions for the determination of performance compressed-air mixer of the proposed design.

It was established that productivity depends on the constructive - technological parameters and physico-mechanical characteristics of mixed components of the mixture.

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