On the features of estimating the coefficient of inhomogeneity of a loose mixture during the operation of a gravitational device

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Statement of problem: The problem of assessing the quality of the resulting loose mixture does not lose its relevance due to the extensive use of mixing equipment in various industries. The main task of the technological operation of mixing granular materials is to obtain a homogeneous free-flowing product. To successfully solve this problem, it is proposed to use a batch method of mixing loose components in a gravitational apparatus with additional mixing elements in the form of brush elements and inclined bump surfaces.

Introduction: The choice of the criterion for the quality of the mixture depends not only on the input parameters of the mixing process of the loose components (for example, physical properties of mixing materials), but also on the level of the theoretical base used in the development of engineering methods for calculating the appropriate apparatus. Such organization of the process of mixing granular components with rarefied streams with three mixing stages ($\tau = \overline{1, n_\tau}$, $n_\tau = 3$) makes it possible to obtain mixtures with the ratio V_1: V_2 = 1: 10 or more. **The study** Modeling of the quality criterion of the mixture is based on the theory of nonequilibrium processes.

The purpose of this study is to develop a method for estimating the coefficient of inhomogeneity of a loose mixture during the operation of a gravity device.. Using the proposed stochastic model of the authors, it is possible to form a functional relationship between the coefficient of inhomogeneity of the free-flow mixture obtained at each of the three stages of portion mixing, with the design, regime parameters of the device, and the physico-mechanical characteristics of bulk materials. To implement the proposed mixing method, the condition must be met that in equal parts of the volumes of the granular mixture obtained at the previous stage and a new portion of the key component. To evaluate the degree of homogeneity of the finished product, an expression is proposed at each τ-stage linking the square of the average value of the volume fraction of the key component $<\Phi_\tau>^2$ and the average of the corresponding square $<\Phi_\tau{}^2>$

$$K_{C\tau} = 100(<\Phi_\tau{}^2> / <\Phi_\tau>^2 - 1)^{1/2}, \qquad (1)$$

$$\langle \Phi_\tau \rangle^2 = \left\{ \prod_{j=1}^{2} \frac{\int_{\beta_{22\tau}}^{\beta_{22\tau}+\Delta\beta_{22\tau}/2} d\beta_{22\tau} \int_{\beta_{21\tau}}^{\beta_{21\tau}+\Delta\beta_{21}/2} \Phi_\tau(\beta_{21\tau}, \beta_{22\tau}) d\beta_{21\tau}}{(2\beta_{2j\tau} + \Delta\beta_{2j\tau}/2)} \right\}^2, \qquad (2)$$

$$\langle \Phi_\tau{}^2 \rangle = \prod_{j=1}^{2} \frac{\int_{\beta_{22\tau}}^{\beta_{22\tau}+\Delta\beta_{22\tau}/2} d\beta_{22\tau} \int_{\beta_{21\tau}}^{\beta_{21\tau}+\Delta\beta_{21}/2} [\Phi_\tau(\beta_{21\tau}, \beta_{22\tau})]^2 d\beta_{21\tau}}{(2\beta_{2j\tau} + \Delta\beta_{2j\tau}/2)}. \qquad (3)$$

Both quantities $<\Phi_\tau{}^2>$, $<\Phi_\tau>^2$ are determined using the differential distribution function of the mixed components with respect to reflection angles from the bump surface, constructed on the basis of the theory of nonequilibrium random processes.

As an example, Fig. 1 shows the theoretical dependencies of the obtained grain size heterogeneity coefficients for natural sand and semolina at each mixing stage in a gravity apparatus.

Here are denoted: ω - the angular velocity of the mixing drums; Δ - complex parameter of the apparatus reflecting the degree of deformation of the brush elements.

Results: It is obtained that at a fixed value, effective mixing (the index $K_{C\tau}(\Delta)$ has a minimum value) is achieved at practically identical angular velocities of the drum ω. An increase Δ of every 0.05 units leads to a shift of the families of graphs $K_{C\tau}(\Delta)$ to the left along the abscissa axis (see graphs 1-3).

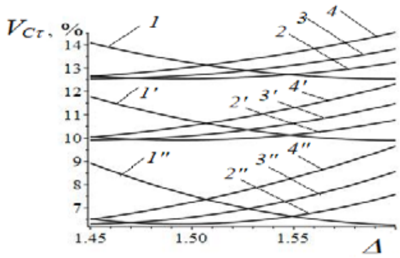

Fig. 1. Dependence Theoretical dependences $K_{C\tau}(\Delta)$ for mixtures of natural sand GOST 8736-93 and semolina GOST 7022-97 at various stages of gravitational mixing: *1-4* – τ = 1; *1'-4'* – τ = 2; *1''-4''* – τ = 3; *1, 1', 1''* – ω =46 c^{-1}; *2, 2', 2''* – ω =47 c^{-1}; *3, 3', 3''* – ω =47,5 c^{-1}; *4, 4', 4''* – ω =48 c^{-1}; h_s=1,6·10^{-2} m; ψ_1 =0,9599 rad.

Conclusions: the results obtained depend on constructive-regime parameters of apparatus of gravity type, physic-mechanical properties of mixed materials. Results could be used as the basis for development of an evaluation method for the degree of homogeneity of the granular mixture in the engineering method of calculation of specified device parameters. The applied model operates with no equilibrium distribution functions for the number of particles by the characteristic parameters of the mixing process. The results of modeling the coefficient of inhomogeneity of the loose mixture allow us to choose rational ranges for changing the regime parameters of a new designed mixer and to develop an engineering method for its calculation.