The study of the volume fraction of key component in the second phase of the portion mixing by means of the device of gravity type

Anna Kapranova, D.Sc.,

Ivan Verloka, Yaroslavl State Technical University, Yaroslavl, Russia

Statement of problem: the mixing process of bulk components is one of main stages of their processing. Obtaining quality mixtures of bulk materials with unequal content of their volume fractions is actual problem for various industries. Portion method of mixing of bulk components can be successfully implemented in apparatus of gravity type using the additional mixing drums with a spiral coiling of brush elements.

Introduction: Portion method of mixing of bulk components can be successfully implemented in apparatus of gravity type using the additional mixing drums with a spiral coiling of brush elements.

The mixing process of bulk components («1» - key и «2» - more voluminous transported component in mixture that with an unequal ratio of component volumes $V_1 : V_2 = K_1 : K_2$) in a gravity mixer is divided into several stages ($\tau = \overline{1, n_\tau}$). At the first step ($\tau = 1$, $k = 1$) formed rarefied flows of the mixed components «1» и «2» when interacting bulk materials supplied by batchers of and deformed brush elements ($j = \overline{1, n_b}$).

The study of mechanics of rarefied flows behavior of mixed materials in working volume of gravity type device can be performed on basis of stochastic approach. [Klimontovich Y.L.].

The purpose of this study is research of key component volume fraction in second phase of portion mixing in gravity type device.

Solution of the Fokker-Planck equation in the energy representation with diffusion and drift summands allows to determine the number of particles of component ($i = 1,2$) after interaction with the deformed brush element $j = \overline{1, n_b}$ in a phase volume element $d\Omega_{ij} = \omega^2 r_{ij} dr_{ij} d\theta_{ij}$ with radial and angular coordinates r_{ij}, θ_{ij} for transverse plane of mixing drum section

$$dN_{ij}^{(np)} = A_{ij}^{(np)} \exp\left(-\frac{E_{ij}^{(np)}}{E_{0ij}^{(np)}} + \frac{(E_{ij}^{(np)})^2}{2(E_{fij}^{(np)})^2} \right) d\Omega_{ij} \qquad (1)$$

and construct a differential non-equilibrium distribution function of particles of each varieties ($i = 1,2$) with respect to spreading angle β_{ij}

$$w_{ij}^{(np)}(\beta_{ij}) \equiv [N_{ij}^{(np)}]^{-1} (dN_{ij}^{(np)} / d\beta_{ij}) \ . \qquad (2)$$

The main energy characteristics of described model are the parameters $E_{0ij}^{(np)}$ и $E_{fij}^{(np)}$, appearing in expressions (1). For the second step ($\tau = 1$, $k = 2$)of bulk materials mixing during shock interaction of their rarefied flows with inclined surface it was proposed a relation between average spreading angle $\beta_i \equiv \sum_{j=1}^{n_b} \beta_{ij}$ and angle of reflection from bump-stop surface μ_{2i} It is proposed, taking into account form of expressions (2), to determine the differential non-equilibrium distribution function for particles of each variety ($i = 1,2$) with respect to reflection angle from the bump-stop surface in following way $u_{ij}^{(np)}(\mu_{2i})$.

Methods: On the basis of the stochastic approach the model of spreading of particles of bulk materials after interaction with brush elements is proposed as well as method of evaluating the volume fraction of a key component after the shock dispersion of the bulk components at the initial stage of batch mix.

Results: The analysis of corresponding graphs (Fig. 1) shows proximity of maximum values of functions $U_1^{(np)}(\mu_{2i})$, $U_2^{(np)}(\mu_{2i})$ with a significant overlap of the regions under these curves, which allows one to conclude that the condition for bulk components efficient mixing in gravitational mixer is performed in its first stage ($\tau = 1$).

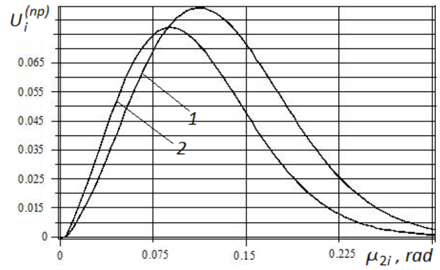

Fig. 1. Dependence $U_i^{(np)}(\mu_{2i}) = \prod_{j=1}^{n_b} u_{ij}^{(np)}(\mu_{2i})$ for differential non-equilibrium distribution functions of particles number with respect to angle of reflection from inclined plane surface of the gravitational mixer: $\tau = 1$, $k = 2$; $\omega =$ 57,57 c^{-1}; h_s =1,55·10^{-2} m; 1 – semolina GOST 7022-97 ($i = 1$); 2 – natural sand GOST 8736-93 ($i = 2$).

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.