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Control Algorithms Connected Dosing Multicomponent Ceramic Mixtures

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Abstract

The article describes the mathematical models and algorithms for process control connected batching ceramic mixtures. This allows you to combine separate metering devices into a single system of preparation doses minimizes errors in the content of its components. The influence of the corrective bonds on metering accuracy. An algorithm for phase correction of dosing.

Keywords:algorithm, mathematical models, dosing, control, phase correction, processes and manufacturing industries, extreme control system (ECS), construction mixtures.

Introduction

Multi-component dosing, is an integral part of the process of the preparation of mixtures for various purposes, including ceramic [1 – 15]. Several structural realization of such dosing schemes that can be divided into two groups:

- disconnected dosing, in which each component of the mixture is dosed in accordance with a predetermined program and excluding other components dosing results;
- connected dosing at which before dosing the next component analyzes the results of the previous dispensing components of the mixture and on the basis of the criterion of optimization process in the next dosing program component shall be amended accordingly.

Disconnected dosing is widely used in practice, and yet connected studied enough.

Mathematical Models of Process Control Dosing

When disconnected "traditional" dosing, the dose measuring result of the individual components does not affect the other components of the dosing [1 – 6]. This allows all components of the mixture dosed simultaneously in one step.

Two-stage dosing allows the first stage batching provide loading weight capacity in the "rough" weighing mode, in which the bulk material is weighed. In the second phase metering mode "dosypki" feeder translated into lower productivity, allowing accurate reception of a given dose. This principle metering reduces the influence of dynamic effect post material on exposure to fluctuations in the load of the dispenser system, thereby increasing the quality of dosing. The required accuracy is achieved in this case by lowering the equipment productivity. Therefore, the "traditional" pattern of cyclic multicomponent dosing has an advantage over a two-stage scheme for speed and efficiency.

When disconnected multicomponent weight dosing given the magnitude of the resultant mass of the mixture V_{po}. Fractional content of each component in the weight of the mixture V_{po}, gives the recipe mixture. Setting values setting devices dispensers are determined:

$$U_i = \gamma_i \cdot V_{po}; \quad i = 1,2,3$$

The resulting mass of the mixture V_{po}, is the sum of the given dose components; X_{i0}; γ_i –coefficient is the ratio of share content in a given weight of the mixture, the mass of i-th component.

The coefficient is the ratio γ_i of a given dose of the component X_{i0} to the resultant mass of the mixture V_{po} :

$$\gamma_i = X_{i0} / V_{po}, (i = 1,4)$$
.

The simultaneous dosing of disconnected components begins after the appointment setting setting devices dispensers U_i.

The control algorithm is not connected dosing, along with the operations of calculating the setting setting devices metering components, includes a number of other operations: shutter control feeders, connection metalloulovitelya inclusion bridge breaker, when "hovering" of the material in the feed hopper and others.

After the end of the dispensing cycle, the control system to the initial state and the repetition of the cycle control system reiterates prescribed program of dosing.

When connected dispensing all or part of the components of the mixture $n_j, (n_j < n)$ dosed at intervals separated by time. Upon completion of the dispensing cycle, such as component X_i, dosage can be determined by the actual weight $X_i(U_i)$ at a setpoint U_i. Measurement dosage weight component is used in steady-state error and the estimated static dosing:

$$\Delta X_i = X_i(U_i) - U_i;\ i = 1,...n, \quad (1)$$

You can use the value of the estimate of the mass of the dosed component for dose adjustment of components to be weighed at the following stages. Such correction allows to achieve a given quality of a multicomponent mixture, which depends on the accuracy of compliance with a given formulation.

Research of The Effect For Corrective Bonds on Metering Accuracy

Introduction corrective ties between dispensers provide a consistent dosing of components in a fixed sequence.

In the presence of corrective ties setpoint setting dispenser component X_i, dosed at the next stage is determined by the functional relationship of the general form:

$$U_i = F[X_1(U_1), X_2(U_2),..., X_{i-1}(U_{i-1})]; \quad i = 1, n \quad (2)$$

where $X_i(U_i)$–measured masses otdozirovannyh components X_1, X_2, … , X_{i-1}. The specific form of functional communication (2) depends on the method of correction, binding masses of the components of the mixture.

If you select circuit connected cyclic multicomponent dispensing with the "leading" the dispenser, the condition relating corrected weight of the components will be:

$$\beta_i = X_{i0}/X_{j0};\ i = 1,n;\ j = 1,n;\ i \neq j \quad (3)$$

where X_{i0}–sets an array component "lead" the dispenser; X_{j0}–defined mass of the mixture components "slave" dispensers.

If the dosage on the first stage weight component X_{i0} dispenser is not specified, then the condition (3), i.e., rule that will be corrected dose components "slave" feeders:

$$U_{i+1} = X_1(U_1)/\beta_i; \quad \mathrm{i} = 1, \mathrm{n}-1, \tag{4}$$

where $X_1(U_1)$ – dosage weight component "lead" the dispenser; $U_1 = X_1$–setting the setpoint "lead" the dispenser; U_{i+1}, $(i = 1, n-1)$–adjusted setpoint setting devices "slave" dispensers.

If the selected coupling condition between the masses in the form of mixtures of components:

$$\beta_i = X_{(i-1)0}/Xi0; \; i = 2,n, \tag{5}$$

after dosing component X_{i-1} setpoint dispenser component X_i, dosed at stage $j+1$ defined by the relationship:

$$U_{j+1} = \gamma_{j+1} \cdot X_j(U_j)/\gamma_j; \quad \mathrm{j} = 1, \; \mathrm{n}-1, \tag{6}$$

where $X_j(U_j)$ – dosage on *j-th* stage mass component X_{i1}; $\gamma_j = X_{i0}/V_{po}$, $(\mathrm{i} = \mathrm{j} = 1, \mathrm{n})$–share coefficients of components of the mixture; U_{j+1}–setting the setpoint dispenser component X_i, dosed by *(j + 1)-th* stage.

For example, if the value of a given weight of the resulting mixture components–V_{po}, in line with the desired setpoint:

$$U_1 = \gamma_1 \cdot V_{po} = X_1 \tag{7}$$

dispensing the first component is made first dispenser. In accordance with the magnitude of the measured weight $X_1(U_1)$ of the first component of the metered dose $X_1(U_1)$ adjusted setting next component X_2 dosed in the second stage:

$$U_2 = X_1(U_1) \cdot \gamma_2/\gamma_1 . \tag{8}$$

Similarly, the setpoint is adjusted successively dosing the remaining components of the mixture. For example, setting the setpoint dispenser component X_n dosed on *n - th* stage, will be equal to:

$$U_n = X_{n-1}(U_{n-1}) \cdot \gamma_n/\gamma_{n-1} . \tag{9}$$

At the end of a dose resulting mass of the mixture is the sum of the masses of components dosage – $X_1(U_1), X_2(U_2), \ldots , X_n(U_n)$.

Increment resulting mass of the mixture at the end of the cycle ΔV_p dosing will depend on the conditions of linking mass of *i-th* and *j - th* component, and on the order of dosing

In addition to the above conditions connected doses control components can be used condition control component doses in terms of "moving average masses" and the condition when setting the setpoint dispenser *i - th* component dosed at the next stage, is adjusted according to the values of dosing errors of previous components based on the minimax criterion.

In a first embodiment, before the next *j - th* stage dosing dispenser setting this corrected largest mass $\overline{V_j}$, defined as the mean value of the masses $V_1, V_2, \ldots , V_{j-1}$:

$$U_j = \gamma_j \cdot \overline{V_j} = \gamma_j \cdot \sum_{i=1}^{j-1} \frac{V_i}{j-1}; \ \ \mathrm{i} = 1, \ \mathrm{j}\text{-}1, \tag{10}$$

where $V_i = X_i(U_i)/\gamma_i$ – mass of the mixture, providing zero error dosing *i-th*component; γ_i - equity ratio of the content of the *i - th*component in a given mass V_{po}; U_j– setting the setpoint adjusted dosing of *j - th*component dosed at the next *j - th*stage.

In the second version before the next dose of component *j -th*stage dosing is adjusted according to a data value is an average of the maximum and minimum masses V_i, *(i=1, j-1)*:

$$U_i = \frac{\gamma_i \left[\max\{V_1, V_2, ..., V_{j-1}\} + \min\{V_1, V_2, ..., V_{j-1}\}\right]}{2}. \tag{11}$$

If disconnected multicomponent dosing increase dosing accuracy is achieved by improving the metrological characteristics vesodoziruyuschego elements of the dispenser when connected dosing this problem is solved in the process of maintenance dosing given the weight ratio between components.

Phase Correction Algorithm Dosing Process

Gradual correction in the dosage increases the cycle time of dosing. This reduces the productivity of the mixing unit. However, in parallel operation on one mixer feeders, weighing cycle time and stirring the mixture are in the ratio 1/5, which determines the reserve downtime dispensers that can be used for the organization of the system for the connected dosing.

When connected dosing increases the coefficient of variation of the resulting mass of V_p. This is due to the fact that the accuracy of dosing the *i - th*component are compensated by dose component dosed in fixed sequence after the *i - th*.

Batch control components of the mixture is realized under the conditions:

$$X_i^H \le X_i^{\Phi} \le X_i^B, \tag{12}$$

or

$$\left|\Delta X_i\right| \le \Delta X_i^{\partial on.},$$

where X_i^{Φ} – the dosage weight of *i-th*component; X_i^H, X_i^B –respectively allowable upper and lower limits of variation of the dosage weight of *i - th*componen; $\Delta X_i = X_i^{\Phi} - X_{i0}$, $\Delta \mathrm{X}_\mathrm{i}^{\text{доп.}}$ – obtained by dosing permissible absolute error *i - th*component.

Relative error for the *i - th*component dosing:

$$\left|\frac{\Delta X_i}{\Delta X_{i0}}\right| \le \delta_i^{\partial on.}, \tag{13}$$

where $\delta_i^{\partial on.}$ – permissible relative error of dosing the *i - th*component.

For a given formulation mixture, multicomponent cyclic dosing can use the relationship:

$$\gamma_i^H \le \gamma_i^\Phi \le \gamma_i^B; \quad \mathrm{i} = 1, \mathrm{n}, \tag{14}$$

where:

$$\gamma_i^H = \frac{X_i^H}{V_p^H}; \quad \gamma_i^B = \frac{X_i^B}{V_p^B}; \quad \gamma_{\mathrm{i}}^\Phi = \frac{X_i^\Phi}{\sum_{i=1}^{n} X_i^\Phi} = \frac{X_i^\Phi}{V_p}. \tag{15}$$

The absolute error of dosing the *i - th*component of the concrete mix, given its resultant mass:

$$\Delta U_i = X_i(U_i) - \gamma_i \cdot V_p; \quad \mathrm{i} = 1, \mathrm{n} \tag{16}$$

where $X_i(U_i) = U_i \pm \Delta X_i$ – the dosage weight of *i - th*component; U_i – setpoint setting dosing the *i - th*component; ΔX_i - absolute error, dosing *i-th*component; V_p – the resulting mass of the mixture in the *k-th*cycle dosing (*k= 1, N*):

$$V_p = \sum_{i=1}^{n} X_i(U_i) = \sum_{i=1}^{n} U_i + \sum_{i=1}^{n} \Delta X_i; \quad \mathrm{i} = 1, \mathrm{n}. \tag{17}$$

The value $\gamma_i \cdot V_p = X_{i0}^*$ – estimated weight of the *i - th*component, providing zero error dosing *i-th*component– $\Delta\gamma_i = 0$

$$\Delta\gamma_i = \frac{X_{i0}^*}{V_p} - \frac{X_{i0}}{V_{p0}} = 0; \quad \mathrm{i} = 1, \mathrm{n}. \tag{18}$$

Dividing both sides of (16) by a specified amount of equity content of the i-th component of the mass in a given weight of the mixture γ_i, *(i = 1,n)*:

$$\Delta V_i = V_i - V_p; \quad \mathrm{i} = 1, \mathrm{n}., \tag{19}$$

where V_i – the current weight of the blend, in which the dosing error $\Delta\gamma_i$, obtained at each stage of a multi-connected discrete dosing is zero.

Conclusion

Connected components measuring building mixes allows combining separate dispensers cyclic operation in a single system with interdependent processes of dosing, use the mechanism vzaimokompensatsii dosing errors at each stage set doses of the individual components, bringing the percentages of the components in the resulting array to the optimum.

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