THE ANALYTICAL SOLUTION METHOD OF THE ORDINARY COALS OPTIMUM BATCHING PROBLEM

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Summary. The solution method of the problem of optimization batch's composition is offered. It provides maximum of an output at a minimum of useful products' losses with a waste in conditions of raw materials' astable deliveries. The problem's decomposition with separation of restoration fractional and granulometric composition's problem under the incomplete information is carried out. It is shown that use of the offered method provides increase of a concentrating factory's overall performance.

Key words: information restoration, optimization, batch, ordinary coal, fractional composition, granulometric composition.

INTRODUCTION

Operation of ordinary coals' mix (batch) preparation is provided before their enrichment because quality of end-products depends on batch's composition. Earlier at calculations rather labor-consuming graphic much time occupying methods were used. In the conditions of unstable suppliers of ordinary coals such method is not admissible.

The direct problem consists in definition of batch's composition individual share at the set parameters of a concentrate and restrictions on a waste at the set technological enrichment's modes. Such way reaches stabilization of enrichment products' quality. The opposite problem defines enrichment's optimum technological modes at the set of the batch's composition and restrictions on a commodity output. It is possible to consider also a problem of batch's composition individual share definition and enrichment's optimum technological modes at the set quality of division.

The correct decision of a problem demands presence of the mathematical apparatus allowing to unite in a single with sufficient efficiency whole a numerous circle of problems [1,2,3,4,5], separated among themselves various principles of technology, distinction of applied methods and other reasons.

Functioning of system within the limits of synthetic model is described as information, on the basis of the given experiments or supervision with real system [6,7,8]. Information models lose to formal mathematical models and expert systems on degree of predictive ability of given out results [9,10]. However absence of restrictions on comploutputy of modeled systems defines their important practical importance.

Modeling of difficult technical systems with use of formal mathematical approaches leads to systems of the equations, not always match themselves. It concerns boundary problems of the system analysis. Construction of expert system according to classical approaches demands the considerable period of preliminary gathering of the information.

The approach uniting advantages of information and formally mathematical approaches with ability of adaptation, inherent in expert systems is perspective. It allows to pass easily to the system approach and to consider the new quality not inherent in its components. Thus, the problem solution demands either other mathematical apparatus, or replenishment by information models. For example, approbation process is labor-consuming and money-losing, therefore an experimental material quantity is always limited [11,12,13,14,15].

The work objective is development of an analytical method to mix ordinary coals at the incomplete information of initial raw materials that provides decrease in losses of useful division's products with a waste.

DECOMPOSITION OF THE OPTIMUM BATCHING PROBLEM

For the decision of batching problems it is necessary to represent adequately the information on initial raw materials, the technological scheme of factory, classification and division processes. For an estimation of results of enrichment models of composition of factory, classification and division processes at enrichment of the batch's composition received which can be corrected in case of discrepancy of expected results with shown requirements to their quality are used. The scheme of an information supply of the batching problem solution is resulted on fig. 1.



Fig. 1. The scheme of an information supply of the batching ordinary coals problem solution to enrichment

Decomposition of the optimum batching problem on subtasks is carried out to solve the problem. It presented on fig. 2.



Fig. 2. Decomposition of the optimum batching problem on subtasks

PROBLEM OF RESTORATION OF FRACTIONAL STRUCTURE

The scheme of the problem of information restoration solution on fractional composition of coal is resulted on fig. 3.



Fig. 3 The scheme of the problem of information restoration solution on fractional composition of ordinary coal

The basic requirements which should satisfy the theoretical description of fractional composition: [16]:

$$\begin{cases} 0 < \lambda_0 = \beta_0 \le \beta(\Gamma) \le \lambda(\Gamma) < 1, \beta_k < \lambda_k, \\ \lambda'(\Gamma) \ge 0, \beta'(\Gamma) \ge 0, \lambda''(1) \le 0. \end{cases}$$

Check on conformity to the received conditions and experimental data has shown that system

$$\begin{cases} \Gamma(\rho) = F(\rho) = \frac{1}{1 + (a_0 + a_i t)\sqrt{1 - t}}, t = \left(\frac{\rho - \rho_0}{\rho_k - \rho_0}\right)^2, a_0, a_1 - \mathbf{i} \, \mathbf{a} \, \mathbf{\delta} \mathbf{a} \mathbf{i} \, \mathbf{c} \, \mathbf{a} \, \mathbf{c} \, \mathbf{a} \, \mathbf{i} \, \mathbf{i} \, \mathbf{a} \, \mathbf{\delta} \mathbf{a} \mathbf{i} \, \mathbf{c} \, \mathbf{c} \, \mathbf{c} \, \mathbf{i} \, \mathbf{i} \, \mathbf{i} \, \mathbf{d} \, \mathbf{a} \, \mathbf{a} \, \mathbf{a} \, \mathbf{c} \, \mathbf{a} \, \mathbf{i} \, \mathbf{i} \, \mathbf{i} \, \mathbf{a} \, \mathbf{d} \, \mathbf{a} \, \mathbf{i} \, \mathbf{i} \, \mathbf{i} \, \mathbf{d} \, \mathbf{a} \, \mathbf{a} \, \mathbf{i} \, \mathbf{i} \, \mathbf{i} \, \mathbf{d} \, \mathbf{a} \, \mathbf{a} \, \mathbf{i} \,$$

where: Γ – the cumulative output, ρ – density, ρ_0 , ρ_k – the minimum and maximum density, λ – boundary ash content, λ_0 , λ_k – minimum and maximum boundary ash content, A^d – average ash content, adequately describes the information on fractional composition of coal.

Method of fractional composition model parameters restoration under the incomplete information

The initial information for selection parameters which characterize system of the equations, modeling fractional composition of ordinary coal, is the table:

ρ	γ , %	A^d , %
$< \rho_1$	γ_1	A_{l}^{d}
$\rho_{i-1} - \rho_i$	${f \gamma}_i$	A_i^d
$> \rho_{n-1}$	γ_n	A_n^d

where $\rho_{i-1} - \rho_i$ - density of narrow fraction, γ_i - an output of narrow fraction, A_i^d - average ash content narrow fraction, n - quantity of stratifications.

Thus, as the initial information we have arrases $\{\gamma_i\}$, $\{A_i^d\}$, $\{\rho_i\}$, $i = \overline{1, n}$. $\{\rho_i\}$ - the right border of each narrow fraction.

- 1. Experimental data input $\{\rho_i\}$, $\{\gamma_i\}$, $\{A_i^d\}$, $i = \overline{1, n} n$.
- 2. Calculation experimental β_k under the formula.

$$\beta_k^E = \frac{\sum_{i=1}^n \gamma_i A_i^d}{100 \cdot \sum_{i=1}^n \gamma_i}.$$

3. A choice of initial values of parameters ρ_0 , ρ_k , a_1 , a_2 , λ_0 , λ_k , b_0 , b_1 .

4. A metrics choice, for target function evaluation.

5. Doing procedure of optimum parameters search. It is necessary to make following calculation each step of the procedure*.

6. Check of an investigated point on hit in the area of admissible values defined by conditions:

$$\begin{cases} b_0 \ge 0, \\ -b_0 \le b_1 \le 8b_0 \end{cases}, \ 0,02 < \lambda_0 < A_1^d, \ A_n^d < \lambda_k < 0,98; \begin{cases} a_0 \ge 0, \\ -a_0 \le a_1 \le 8a_0 \end{cases}, \\ 1,1 < \rho_0 < \rho_1, \ \rho_n < \rho_k < 2,6. \end{cases}$$

7. Calculation of a theoretical values array $\left\{ \gamma_{i}^{T} \right\}$ in a search point:

$$\gamma_i = 100 * \left(F\left(\rho_i\right) - F\left(\rho_{i-1}\right) \right), \ i = \overline{1, n},$$

$$\Gamma(\rho) = F(\rho) = \frac{1}{1 + (a_0 + a_1 t) \sqrt{\frac{1}{t} - 1}}, \ t = \left(\frac{\rho - \rho_0}{\rho_k - \rho_0}\right)^2.$$

- 8. Calculation of a theoretical values array $\{A_i^{dT}\}$ in a search point:
- 8.1 Calculate a theoretical values array of the cumulative outputs $\{\Gamma_i^T\}$:

$$\Gamma_{i}^{T}(\rho_{i}) = F(\rho_{i}) = \frac{1}{1 + (a_{0} + a_{1}t_{i})\sqrt{\frac{1}{t_{i}} - 1}}, t_{i} = \left(\frac{\rho_{i} - \rho_{0}}{\rho_{k} - \rho_{0}}\right)^{2}$$

8.2 Calculate a theoretical values array of boundary ash contents $\{\lambda_i\} : \lambda_i = F^{-1}(\Gamma_i^T) i = \overline{1, n}$

8.3 For each pair,
$$(\lambda_{i-1};\lambda_i) i = \overline{1,n}$$
 and $\lambda_n = \lambda_k \left(\Gamma_{i-1}^T;\Gamma_i^T\right)$, we find a
theoretical values array $\{A_i^{dT}\}$, $i = \overline{1,n}: A_i^{dT} = \frac{\lambda_i \Gamma_i^T - \lambda_{i-1} \Gamma_{i-1}^T - \int_{\lambda_{i-1}}^{\lambda_i} \Gamma(\lambda) d\lambda}{\Gamma_i^T - \Gamma_{i-1}^T}$.
8.4 Calculate $\beta_k^T: \beta_k^T = \frac{\lambda_k \Gamma + \int_{\lambda_0}^{\lambda_k} \Gamma(\lambda) d\lambda}{\Gamma}$.

9. Calculate, r_1 , r_2 , r_3 , C.

10. Check execution of a search procedure stop criterion. If the criterion is true, we pass to a step 11, otherwise we repeat steps 6-9.

11. The found parameters is considered optimum with the set accuracy and we calculate arrays $\{\gamma_i^T\}$, $\{A_i^{dT}\}$, $i = \overline{1, n}$ corresponding to them.

If the problem of an optimum parameters finding is solved, fractional structure restoration under the incomplete information is reduced to the solution of system (1) with the set parameters.

THE OPTIMUM BATCHING PROBLEM SOLUTION

The optimum technological scheme finding problem solution is connected with batching [17, 18,19]. The batch can be made of ordinary coals $D_1 D_2 \dots D_n$ from different mines. On a dominating component \square xTb from – the $D_1 D_n$ optimum scheme steals up D_n . Offered searching procedure of batch components individual share together with the corresponding technological scheme sets iterative process. Process will be stopped with execution of the criterion function connected with interests of the manufacturer, for example minimization of expenses. Instead of expenses well-founded monotonous function can be used.

Models of enrichment processes use model of the fractional composition restoration described above. In models of coal classification process [20] the information about initial coal are set by means of function F(x) – weight distribution by size. The mathematical model of division process allows to receive extraction function $\varepsilon(x)$ in a mesh minus product. From here it is possible to receive granulometric composition $F_p(x)$ a mesh minus and $F_i(x)$ an oversize product. Setting value boundary size x_{gr} , it is possible to find extraction and division products (value boundary size x_{gr} can be defined as the value which minimizing clogging it is

similar to triangles of errors in gravitational processes). Mathematical models of the basic division processes should convert an initial product the information so that there was a possibility of the information reproduction and its transfer for processing on model of the following device in a technological chain.

The problem of the most favorable division mode choice for the target of the maximum profit earning needs to be solved particularly for each factory. The algorithm of this problem solution enter into automated control system of concentrating factory. Thus it can be considered major or smaller quantity of the factors defining management by a division mode.

At construction of model it is possible to present a product in the form of the information composition containing parameters of a product: Q -weight of a dry product, T; V -water volume 1^3 ; $\gamma_{i\bullet}$ -participation in a product of a i class, %; $A_{i\bullet}$ - ash content a i class, %; $\gamma_{\bullet j}$ - participation in a product of j fraction, %; $A_{\bullet j}$ - ash content j fractions, %, $i = \overline{1..n}$, $j = \overline{1..m}$. Most convenient form of the factory scheme information representation is the graph which each node represents the converter having certain quantity of inputs and outputs (products).

In article [21] influence of increase of stability of quality of a concentrate on its output and economy of concentrating factories is considered.

Ash content fluctuations of a concentrate concerning average value are characterized by an average quadratic deviation σ_N ash content of the coal parties, named instability. Distribution ash content of the concentrate shipped consignments submits to the normal law, and for each factory at the established raw-material base and technology of enrichment σ_N is rather steady. Between an output γ and ash content of the concentrate A^c in a zone of its real change there is a dependence which is expressed by the equation $\gamma = \alpha + \beta A^c + \theta A^c$, where $\gamma = \alpha + \beta A^c + \theta A^c$, $-\alpha, \beta, \theta$ equation parameters.

Taking into account its normal distribution it is possible to present mathematical expectation with formula $M_{\gamma} = \alpha + \beta m + \theta (m^2 + \sigma_N^2) = \gamma_m + \theta \sigma_N^2$, m - average value of the concentrate's ash content, γ_m , % - an output corresponding to the average ash content. Parameter $\theta < 0$. So, the mathematical expectation of output M_{γ} decreases linearly depending on values σ_N^2 and with growth of ash content fluctuations the difference between $\Delta \gamma_1$ and $\Delta \gamma_2$ increases.

The mathematical expectation of the concentrate costs will be a square trinomial relative to $m: M_P = a\alpha + (a\beta - ab)m - b\beta m^2 - b\beta \sigma_N^2$.

Thus, concentrate cost decreases linearly with growth σ_N^2 . So, increase of stability of coked and power concentrates quality leads to increase in their output and growth of the realization sum for a commodity output.

CONCLUSION

1. For the batch optimum composite finding before enrichment problem solution it is offered to execute its decomposition including problems of the missing information restoration about fractional and granulometric composites of initial raw materials and modeling of concentrating factory node.

2. The method of the analytical problem solution of the initial raw materials information restoration, based on weight functions of distribution, taking into account physical sense of occurring processes is offered.

3. The universal model of the devices description and scheme of an concentrating factory is offered, allowing to define optimum batch composite and to process raw materials with the greatest profit and the least losses of a useful product with a waste.

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МЕТОД АНАЛИТИЧЕСКОГО РЕШЕНИЯ ЗАДАЧИ ОПТИМАЛЬНОГО ШИХТОВАНИЯ РЯДОВЫХ УГЛЕЙ

Ульшин В.А., Грачев О.В.

Аннотация. Предложен метод решения задачи оптимизации состава шихты, обеспечивающий максимум выхода при минимуме потерь полезных продуктов с отходами, при нестабильных поставках сырья. Выполнена декомпозиция задачи с выделением задачи восстановления фракционного и гранулометрического составов по неполной информации. Показано, что использование предложенного метода обеспечит повышение эффективности работы обогатительной фабрики.

Ключевые слова: восстановление информации, оптимизация, шихта, рядовой уголь, фракционный состав, гранулометрический состав.