Automation of iron ore raw materials beneficiation with the operational recognition of its varieties in process streams

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Abstract
The problems of the iron ore raw materials beneficiation process automation with a justification of method of prevailing technological variety operational definition in ore preparation process streams are presented.
Keywords: ORE BENEFICIATION AUTOMATION, TECHNOLOGICAL VARIETY, HIGH-ENERGY ULTRASOUND

The energy consumption of concentrating factory technological complexes is largely determined by the quality of ore technological varieties which come for processing. To reduce negative impact of the input ore characteristics changes on the energy consumption of the concentrating factory technological complexes and at the same time to maximize the productivity on concentrate of specified quality is possible only while the presence and use of operational information about the main characteristics of raw materials and beneficiation products within automation systems.

The complex geological conditions of domestic mining and processing plants, which are characterized by a variety of mineral ore varieties and significant scale of mineral content in it, attach the particular importance for the stabilization problem of qualitative parameters of the ore which is coming to beneficiation input.

Along with the content of useful component in the processed ore on the efficiency of its beneficiation processes the nature of useful component mineral grains inclusions affects significantly [1-4]. The ore grinding fineness for the best disclosure of the useful component depends on the nature of the inclusions [3]: the thinner the inclusions, the thinner must be the grinding. Thus, for each ore technological variety during its grinding-classification for full useful component disclosure a certain particle size distribution should be formed and should be maintained in all process equipment operating modes [1, 4].

In this regard, the task of the ore varieties operational definition in the ore preparation process streams and use of the obtained data in the process control of automated systems to maintain optimum particle size distribution of the processed iron ore is becoming urgent

The control processes modern multi-level structure in terms of mining and processing enterprises while implementing the above principles of energyefficient control should be considered.

Typical elements of this structure are as follows. At the production control level there operate the systems of: strategic production planning, cost and quality monitoring, equipment performance, energy consumption, operational planning, production, statistical data processing and analysis, optimization of production indicators [5, 6].

At the process control level there are subsystems of the receiving hoppers optimal loading control, ore lines optimal control, iron ore characteristics operational control in the process streams. At each control interval (a work shift, a day) during the current optimization period (several days, a week) from the upper level control system into the production indicators optimization system (PIO) comes the task: $[\beta_l, \beta_h]$ — is the limiting values of iron content in the concentrate; $[\Omega_l, \Omega_h]$ —is the concentrate volume limits in the stock.

The PIO system determines the optimal processing amount of each *i*-th ore technological variety $\overline{\psi^*} = \{\psi^*_{i,t} \mid i = 1 \ldots N_r, t = 1 \ldots T\}$ on the basis of information about the technological process parameters provided by the systems listed above, and set intervals of concentrate quantity and quality. Thus, it is possible to determine the optimal mass fraction of each *i*-th variety for each *t*-th technological control interval

$$\xi^*_i(t) = \psi^*_i(t) \Big/ \sum_{j=1}^{N_r} \psi^*_j(t), \quad i = 1, \ldots, N_r,\ t = 1, \ldots, T; \qquad (1)$$

where $\xi^*_i(t)$ — is the optimal mass fraction of *i*-th technological variety in ore for *t*-th control interval; $\psi^*_i(t)$ — is the optimal weight of each technological variety for *t*-th v; N_r — is the number of technological varieties; *T* — the number of intervals in the control period.

Provision of the optimal weight ratio of technological varieties in the ore, which is coming into the technological lines of the ore-dressing factory within each optimization interval, is complicated by the presence of technological, organizational and random disturbances, which can lead to undesirable deviations of the ore stream characteristics from the setpoints.

The stabilization of iron ore raw materials characteristics is advisable to carry out in the receiving hoppers loading control process of the ore-dressing factory production lines.

Under the energy efficiency terms of iron ore processing control while loading of the ore-dressing factory receiving hoppers in the each control cycle it is necessary to provide the lowest average deviation of all ore technological varieties mass fraction in each *i*-th hopper [5]

$$J_{\xi}^{(КЗБ)}(p,k) = \max_{i=1 \sim N} \left\{ \frac{1}{N_r} \sum_{j=1}^{N_r} \left(\frac{\left| \xi_{i,j}(p,k) - \xi^*_{i,j} \right|}{\xi^*_{i,j}} \right) \right\} \to \min, \quad k = 1, \ldots, K, \qquad (2)$$

where *p* — is the number of hopper for loading selected on the *k*-th control cycle; *N* — is the number of hoppers; $\xi_{i,j}$, $\xi^*_{i,j}$ — is the current and optimal specific gravity of the *j*-th ore technological variety in the the *i*-th hopper respectively; *K* — is the number of cycles in the control interval.

In addition to the criterion (2), in the loading process control automation of the beneficiation line receiving hoppers it is necessary to consider claims arising from the technological features of the loading process and aims, which are discussed in detail in [5, 7].

Along with information about the characteristics of the ore, which is incoming from the receiving hoppers for the control formation of the ore-dressing plant technological units section, it is also necessary the operational information about the processed materials characteristics at the different stages: the mineral content in the pulp solid phase, the particle content of the particulate material size control.

The methods for iron ore raw materials characteristics operational control at various stages of its processing using modern methods are well studied in [8-20]. It is advisable further to explore the possibility of using such methods in the problems solution for obtaining timely information about the characteristics of the processed materials at various stages of beneficiation.

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