Automation of the ore varieties recognition process in the technological process streams based on the dynamic effects of high-energy ultrasound

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Abstract
The problems of operational recognition of the dominant technological variety in the ore preparation process streams and usage of obtained data in the automated control systems of iron ore beneficiation are considered.
Keywords: AUTOMATION, BENEFICIATION, TECHNOLOGICAL VARIETY, HIGH ENERGY ULTRASOUND

Mining and metallurgical complex is one of the most important components of the domestic industry. However, over the past decades, iron content in the processed ore was reduced on average by more than 10%, which has increased the resource intensity of production and the cost of finished products. In these circumstances, the improvements can be achieved through the development and deployment of energy efficient technologies and means of control processes automation of ores beneficiation.

The nature of mineral components inclusions significantly affects the efficiency of its beneficiation processes [1-4]. For each technological ore variety during grinding-classification process for complete useful component disclosure the defined particle size distribution must be formed, which must be maintained in all operating modes of the technological equipment [1, 4]. In this regard, the urgent task is the operational definition of ores varieties in the ore preparation process streams. In modern control processes multi-level structure in terms of mining and processing enterprises, both the planning and management systems and operative reception and statistical analysis systems are included [5, 6].

On the basis of information about the technological process parameters provided by the systems listed above, and the specified intervals of the quantity and quality of the concentrate, the optimization system of production indicators determines the optimal volume of processing of each *i*-th technological ore variety $\overline{\psi^*} = \left\{\psi^*_{i,t} \mid i = 1\ldots N_r, t = 1\ldots T\right\}$.

The stabilization of the mass fraction of iron ore raw materials technological varieties is partly carried on in the control process of receiving hoppers loading of the ore-dressing plant technological lines. This takes into account the requirements due to technological features of the loading process and discussed in detail in [5].

The methods of operational control of iron ore raw materials characteristics at different points of the technological process of beneficiation using modern methods discussed in [7-11, 13]. It is advisable to explore the possibility of their use in solving the problems of modeling and optimization of separation processes of iron ore raw materials beneficiation, represented by several technological varieties.

The studies have shown that ore technological varieties identification is advisable to perform on the base of estimates of density and grindability (particle size distribution) [12]. At the same time, the ore grindability depends on a complex of properties (hardness, elasticity, crystalline structure, etc.) and therefore can not be evaluated by one of them. For recognition of processed ore varieties the method based on the FCM-algorithm (Fuzzy Classifier Means) of its features fuzzy classification is developed. A feature of this algorithm is that each object belongs simultaneously to all classes, but with varying degrees. In this case, the initial information is an estimate of crushed ore particles distribution function by size and density in a sink of spiral classifier of the first grinding stage at a certain pulp density.

To estimate the velocity vector field of the pulp solid phase particles and the function of γ (ξ, x, y, z, t), it is necessary to carry out their spatial separation using radiation pressure force of high-energy ultrasound. Increasing the intensity of the ultrasound to specific value, while maintaining a constant pulp flow rate, it is possible to displace the crushed material particles of certain size classes

$$F(r) = \left(\int_0^{r_1} f(r) r^3 dr + \int_{r_1}^{r_2} f(r) r^3 dr + \ldots + \int_{r_{m-1}}^{r_m} f(r) r^3 dr \right) \Big/ \int_0^{r_m} f(r) r^3 dr$$

(1)

where *r* - is the radius of the ore particles.

The results of ultrasonic field parameters spatial modeling and the effects of radiation pressure of high-energy ultrasound source on the pulp flow are presented in Figure 1. For analysis convenience the flow cross sections in different planes are shown.

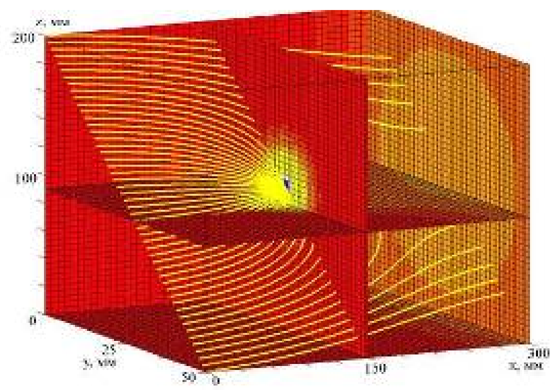

Figure 1. Simulation of the influence of the high-energy ultrasound radiation pressure on the pulp flow

The dynamics of pressure in front of the high-energy ultrasound pulse of ultimate duration during its distribution in pulp flow is shown in Figure 2.

Numerical characteristics of ultrasonic pulse distribution in the pulp obtained by using

HIFU Simulator v 1.2. Characteristics of ultrasonic radiation are presented in Figure 3.

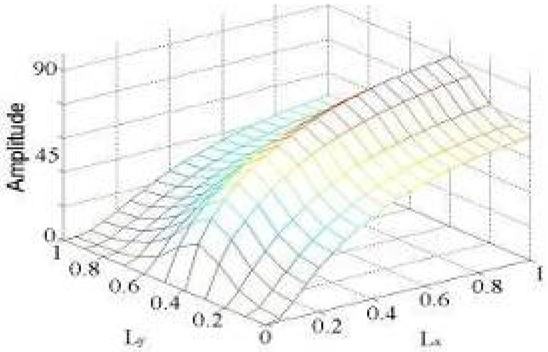

Figure 2. The results of spatial modeling of pressure variations during high-energy ultrasound pulse distribution in the pulp flow

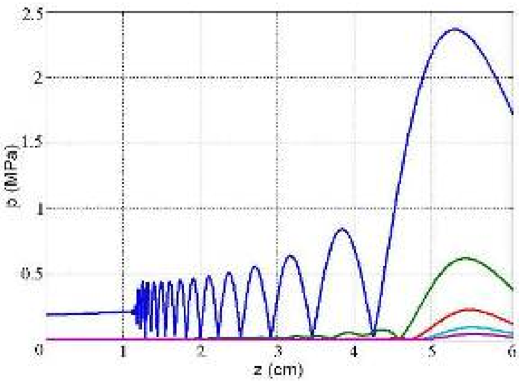

Figure 3. The first five harmonics axial pressure distribution of ultrasonic radiation

Based on the above study results of ultrasonic pulse front propagation the calculation of high-energy ultrasound power is made. This allows to carry out the predictable displacement of ground ore particles of a certain mass in the pulp flow. The simulation results of the ore particles displacement trajectory of the three fractions sizes in the pulp flow under the influence of high-energy ultrasound radiation pressure are shown in Figure 4. The positions of the particles of each size in the 10-th step are connected by solid lines.

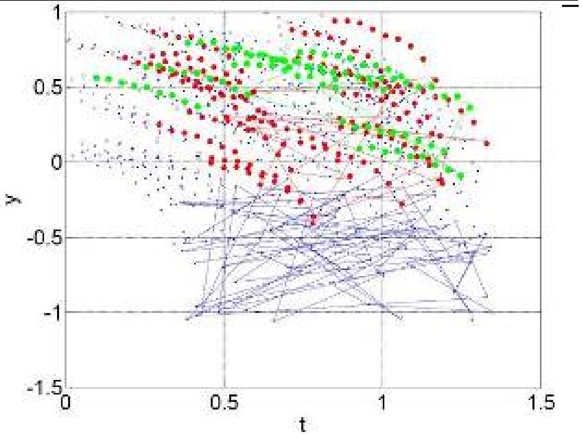

Figure. 4. The modeling results of particle displacement under the influence of the radiation pressure of the high-energy ultrasound

Developed program calculates the intensity of high-energy ultrasound at a certain point of the measuring zone and allows to carry out predictable displacement of ground ore particles of a certain mass and fractional composition changing of the pulp solid phase under the controlled influence of a high-energy ultrasound radiation pressure.

Conclusions

Thus, the recognition of the processed ore technological varieties during the technological process is advisable to carried out by estimation of the changes in the particle size distribution function in the the pulp flow, which is caused by the radiation pressure of the high-energy ultrasound with determined intensity.

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