Use of Bourger-Lambert-Bera law for the operative control and quality management of mineral raw materials

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Abstract
Mathematical model based on the formula of Bouger-Lambert-Bera and assessment of the effectiveness of mineral processing, using formulas Hancocko-Luiken for operative control and quality management of mineral raw materials, is developed.
Key words: OPERATIVE CONTROL, MATHEMATICAL MODEL, ASSESS OF EFFICIENCY, INTENSITY, SCATTERED GAMMA RADIATION

Maintenance of metallurgical manufacture with high-quality raw material still remains the major technological task. For maintenance of the given qualitative characteristics of the mineral raw material being initial for metallurgy, it is necessary to use an effective quality monitoring and quality managements at various stages of mountain manufacture. From set of methods and ways of quality surveillance of mineral raw material it is necessary to allocate methods of the operative control of parameters of rocks: acoustic, electromagnetic and nuclear-physical. Special place among a quality monitoring occupy nuclear-physical, concerning non- destroying methods,

allowing to receive practically instant result. These methods of the operative control differ from others with relative simplicity, adaptability to manufacture and sufficiently informativeness [1].
Radiometric quality monitoring concerning nuclear-physical methods are applied both to the operative control and quality management of mineral raw material, and for preenrichment. They cover a wide spectrum of ways with the usage of both natural radio-activity, and induced with application neutron activation methods. Electronic automatic sorting also concerns to radiometric methods [1].

The theory of application of radiometric methods of sorting is based on Bouger-Lambert-Bera law, which allows to reflect interrelation between the maintenance(contents) of a useful component in mountain weight and intensity of scale - radiation registered by gauges.

Let's assume the substance radiation with intensity N0 falls, then intensity decreases owing to absorption. We admit(allow), at that moment when radiation has passed in substance distance x, its intensity became N [2]. At passage of radiation through a layer of small thickness dx, its intensity decreases on size dN, proportional to thickness of a layer and intensity N, i.e. μ

$$dN = -\mu * Ndx \qquad (1)$$

The mark "-" in this formula speaks that change of intensity dN < 0. Factor of proportionality of m - the factor of absorption dependent on material structure of ore.

Having divided the right and left parts on N, we receive:

$$dN/N = -\mu\, dx \qquad (2)$$

Having integrated the right and left parts of this expression, we receive:

$$\text{Ln}(N) + C = -\mu\, x + C \qquad (3)$$

Whence $N = \exp((-\mu * x) + C)$ (4)

$N = \exp(-\mu * x) * \exp(C)$, (5)

Let's designate exp (C) =C1

Substituting values C1 in the equations 5 we shall receive

$$N = C1 * \exp(-\mu * x) \qquad (6)$$

According to theorem Koshi at X=X0 N=N0

$$\begin{cases} dN/x = -\mu * N \\ N\big|_{x = x0} = N0 \end{cases}$$

$$N0 = C1 * \exp(-\mu\, ì * 0) = C1 \qquad (7)$$

Substituting values C1 in the formula 6 we shall receive

$$N = N0 * \exp(-\mu * x) \qquad (8)$$

For the account of material structure of mineral raw material an integrated stream of scale - radiation, we shall replace linear factor on mass μ Also we shall receive mathematical model of Bouger-Lambert-Bera law [5].

$$N = N0 * \exp(-\mu m * \rho * x), \qquad (9)$$

where N0 - initial quantity(amount) of the γ-quantum falling on test, μm - mass factor of easing. The return size of 1/μ - characterizes depth of penetration of γ-quantum, ρ- superficial density - g/sm^3, d - thickness of an absorber, sm.

On rice 1 the function chart of laboratory installation for research of process is given interaction of scale - radiation with rocks by means of law Bouger-Lambert-Bera [5].

The order of research the following: researched test of mountain weight in a ditch 1 place under a source of scale - radiation 2. The source is in the protective lead container 3. Test is irradiated with a source 1. Thus γ-quantum are in part absorbed in test, and the part of them dissipates in geometry 4π. Those γ-quantum, which reach the receiver, are registered and transferred through the amplifier to the counter of pulses 6.
Registration occurs as follows: the stream of γ-quantum falls on a surface of test and will penetrate into depth. Depth of penetration depends on energy of a γ-source and from density of substance. The more energy of γ-quantum, the more depth of penetration [5].

For clearness we shall consider interaction with substance of individual scale - quantum. The part of energy of γ-quantum is absorbed by substance, this quantum leaves test with energy $E_{scattered}$ (E_{scat}), smaller on size of the absorbed energy (E_{absorb}).

Under the law of conservation of energy we have:

$$E_{scat.} = E_0 - E_{absorb} \qquad (10)$$

The γ-quantum with energy E_p gets on a single crystal 4 gauges 5 and turns to light energy (flash). Brightness and duration of flash depends on energy E_P. Further light energy in the photoelectronic multiplier turns to electric pulses, which amplify and move through the amplifier on an input of the counter 6.

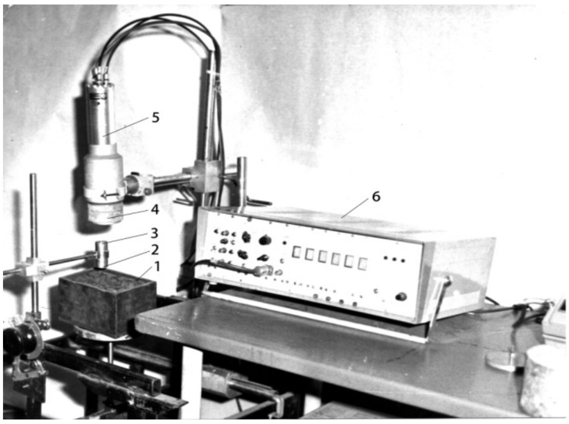

Figure 1. Functional diagram of laboratory devices

All γ –quantum, which have got on a single crystal of the gauge 5, are similarly registered. By amount of the registered pulses proceeding from already available ratio, define the maintenance of a useful component in researched test. Thus function is realized

$$N = f(Fe),$$

where N - amount of the registered γ-quantum. The given function submits to Bouger-Lambert-Bera law:

Laws of interaction of γ-radiation with substance are various, depending on density of substance. And the more the atomic number, the smaller the number of scattered γ-rays as wherein more absorbed in the material (or vice versa).

Graph of the intensity of the integrated flux scattered and absorbed gamma radiation from the mineral content in mineral raw materials is shown in Fig. 2.

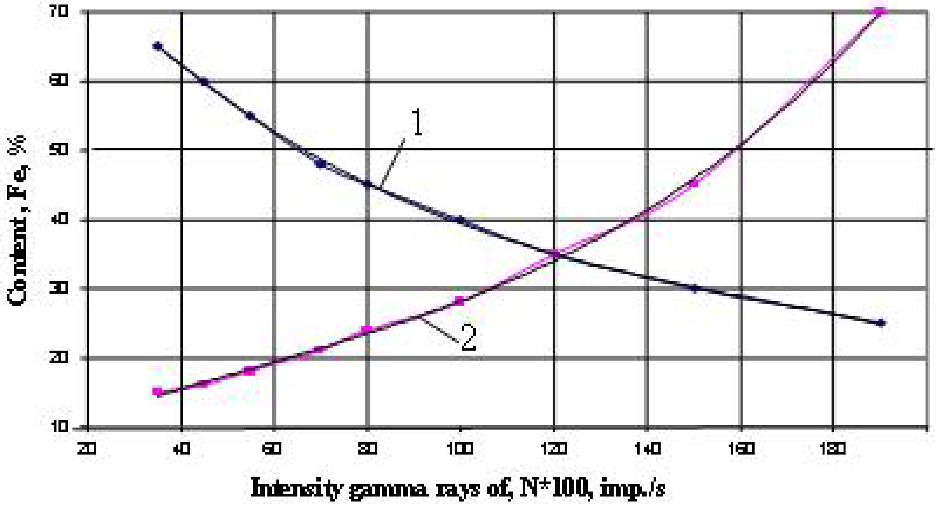

Figure 2. Dependence of the intensity of scattered and absorbed gamma radiation from mineral content in mineral raw materials: 1. N = f (Fe) - scattering; 2. N_{abs} = f(Z) – absorption

This pattern $N_0 * \exp(-\mu_M * \rho * x)$ used for operational control and quality control of mineral raw materials in various technological point of extraction and processing [3,4,5].

On the accuracy of any system of operational control and quality control of mineral raw materials influenced by many factors, including the important role played by the mutual arrangement of sensors and gamma-ray sources, geometrical parameters of the measuring unit. The studies established basic geometrical parameters of the system of operational control and quality control of mineral raw materials [7,8, 12, 13].

Currently, the problem-research laboratory of the Ministry of Industrial Policy of Ukraine at the Krivoy Rog National University developed portable and stationary systems for operational control and quality control of mineral raw materials, using depending law of BOUGER-LAMBERT-BERA. In this case, the construction of a mathematical model that takes into account the influence of physical, chemical and physico-mechanical properties of rocks, increases the accuracy in controlling the quality and efficiency of the separation of mineral raw materials for food enrichment sorting [1,4, 9-11].

To evaluate the effectiveness of mineral processing to "concentrate" and "middling" using radiometric sorting methods were selected representative samples of iron ore with the content (mass fraction) of the useful component in the range of 46.8 to 52.8%. Efficacy was evaluated using Hancocko-Luiken formula.

$$X = \frac{\gamma(C_k - C_{исх})}{C_{исх}(1 - C_{исх})} = \frac{\gamma(\beta - \alpha)}{\alpha(1 - \frac{\alpha}{\alpha_{мин}})} = \frac{\gamma(\beta - \alpha)\alpha_{мин}}{\alpha(\alpha_{мин} - \alpha)} \quad (11)$$

$$\varepsilon = \frac{\gamma_{conc}(\beta_{conc} - \beta_t)}{\alpha(100 - \alpha)} 100\% \quad (12)$$

where γ_{conc} - concentrate output, %, β_{conc}- Fe content in the concentrate,% β_t - mass fraction of iron in the tailings,%, α - mass fraction of iron in the original ore,%.

For the original ore mass fraction of iron 46,8-52,8% produced the following results: the iron content in the concentrate β_{conc} = 54,1-60,4% concentrate output γ_{conc} = 62,4-73,0% iron content middling β_t = 34,7-32,2%. The effectiveness of enrichment for the two groups of selected samples was 48.6 and 82.7 %, respectively [4].

Thus, the use of mathematical model of operational control and quality management of mineral resources from the formula of Bouger-Lambert-Bera made it possible to increase the mass fraction of iron in the concentrate for more than 7%.

Conclusions

Developed the mathematical model based on Bouger-Lambert-Bera formula for operative control and management of mineral materials is developed.

Assessment of the effectiveness of mineral processing using Hancocko-Luiken formulas is performed.

It was found that the use of mathematical model operative control and quality management of mineral resources from BOUGER-LAMBERT-BERA formula can increase the mass fraction of iron in the concentrate for more than 7%.

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