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USING THE INTENSITY OF ABSORBED GAMMA RADIATION TO CONTROL THE CONTENT OF IRON IN ORE

A. Azaryan
Doctor of Technical Sciences, Professor*
E-mail: azaryan325@gmail.com
A. Gritsenko
Researcher
Research Section**
A. Trachuk
PhD, Associate Professor*
V. Serebrenikov
PhD, Assistant Professor
Department of Higher Mathematics and Information Systems
Donetsk National University of Economics and Trade named after Mikhail Tugan-Baranovsky
Tramvaina str., 16, Kryvyi Rih, Ukraine, 50027
D. Shvets
Assistant*
*Department of Modeling and Software**
**Kryvyi Rih National University
Vitaliya Matusevycha str., 11, Kryvyi Rih, Ukraine, 50027

Викладено результати математичного моделювання інтенсивності поглиненого гамма-випромінювання для визначення вмісту заліза в ЗРС. Показано, що для підвищення точності оперативного контролю вмісту заліза в ЗРС доцільно використовувати поглинене гамма-випромінювання. Такий підхід є удосконаленням ядерно-фізичного методу визначення вмісту заліза в ЗРС. При існуючих ядерно-фізичних методах визначення вмісту заліза в ЗРС використовується відбите гамма-випромінювання. У досліджуваному методі застосовується гамма-гамма метод, особливістю якого є використання «м'якого» гамма-випромінювання. Це призводить до того, що від опромінюваної поверхні відбивається тільки незначна частина початкового потоку гамма-випромінювання. В результаті вимірювання інтенсивності розсіяного гамма-випромінювання характеризується значними відносними помилками і, як наслідок, низькою точністю оперативного контролю вмісту заліза в ЗРС. Використання поглиненого гамма-випромінювання, як основної частини потоку гамма-випромінювання, дозволяє значно зменшити відносну помилку вимірювання інтенсивності гамма-випромінювання, тобто підвищити точність оперативного контролю вмісту заліза в ЗРС.

В роботі розглянуто, як найбільш поширений, метод «центральної геометрії» вимірювання інтенсивності гамма-випромінювання. Цей метод дозволяє в математичній моделі враховувати залежність інтенсивності поглиненого гамма-випромінювання не тільки від властивостей опромінюваної поверхні гірської маси, а й від геометричних параметрів при реалізації вимірювань. Основною особливістю моделі є використання параметра альбедо, який дозволяє зв'язати розсіяне і поглинене гамма-випромінювання. Подання синтезованої моделі в безрозмірному вигляді дало можливість як спростити розрахунки, так і узагальнити результати математичного моделювання інтенсивності поглиненого гамма-випромінювання. З метою порівняння величин інтенсивностей відбитого і поглиненого гамма-випромінювань в умовах центральної геометрії були проведені відповідні чисельні розрахунки. Результати проведених розрахунків підтвердили ефективність використання поглиненого гамма-випромінювання для визначення вмісту заліза в ЗРС. Так, в діапазоні 50–60 відсотків вмісту заліза чутливість поглиненого гамма-випромінювання значно вище (в 2 рази), ніж чутливість розсіяного гамма-випромінювання

Ключові слова: оперативний контроль, поглинені, розсіяні гамма-кванти, ядерно-фізичний метод, детектор, альбедо

1. Introduction

The modern requirements to the quality of the mined iron ore raw material (IOR) indicate the need for not only accurate, but also rapid determining the content of iron. One of the ways to improve rapid control of iron content in IOR is the use of logging probes in explosion wells. Under actual conditions, the measurement of iron content in IOR, taking into consideration all factors affecting the control precision is nearly impossible. One of the possible ways to overcome these difficulties is to use the result of the interaction of gamma-radiation with the IOR as a source of information about the content of iron.

However, gamma radiation reflected from IOR that is used in measurement carries little information. This is due primarily to low intensity of the reflected flux, and, most importantly, using this flux, it is possible to estimate iron content only in the surface layer of IOR. That is why it seems appropriate for the measurement of iron content in the IOR to use absorbed gamma radiation, which considerably exceeds reflected gamma radiation and makes it possible to estimate iron content inside the IOR.

It is evident that scientific research and the practical realization of this direction are particularly relevant under modern conditions of extraction and processing of iron ore, since the demands for the characteristics of finished products of IOR processing are getting increasingly strict.

2. Literature review and problem statement

Nuclear-physical methods for rapid control of iron content in IOR have become widely used. Paper [1] considered the use of elastic scattering of alpha particles with energy from 6.5 to 280 MeV for the analysis of differential cross sections. Taking into account that radionuclides with energy not exceeding 300 keV are used for rapid quality control of ferrous metal ores, this method is inacceptable for rapid control of iron content in ore. Paper [2] explores various types of scintillation monocrystals: germanium and NaI, activated by thallium (Tl), the one for spectrometric devices. For rapid control of the quality of mineral raw material in the context of mining production, spectrometric devices are not technologically effective, given their low rapidity and high cost.

Article [3] contains the results of research into the influence of the diameter of collimation channel by magnitude of coefficient of mass attenuation in the range of energy from 59.5 to 662 keV. The low energy source americium-241 with the fixed collimation diameter is used in the study.

Paper [4] considered the method for recording Compton scattering of gamma rays using two layers of the detector, the first to detect the electron of recoil, and the latter for scattered gamma radiation. A source with the energy of 511 keV is used in this paper. Given that with an increase in energy of radiation source both its cost and the requirements of radiation safety increase, such a proposal cannot be used for quality control of ferrous metal ores under conditions of mines, MCF and OCF.

Article [5] describes the experiments on the use of the Compton effect to determine the thickness of aluminum and iron sheets. However, given the fact that iron ore is quasi-binary medium, the results of these studies are impractical for using in the mining industry. In paper [6], it is proposed to use Compton scattering to diagnose metal surfaces. The proposed method uses X-ray radiation and is applied mainly to obtain a two-dimensional matrix representing the distribution of backscatter. This approach is strictly stationary and cannot be used for rapid control of the content of useful component in ore under conditions of the ore concentration factory (OCF) and mines.

The authors of [7] conducted a study into the use of scattered gamma radiation to control the IOR quality, but the work did not consider the problem of absorbed gamma radiation.

Among the considered publications, paper [8], in which the authors proposed to use absorbed in IOR gamma rays to measure iron content, attracts attention. It was noted that this method increases the accuracy of measurement of the content of iron. However, no specific recommendations on the implementation of the approach were given in this paper. It should be noted that in addition to the nuclear-physical methods of measuring iron content in the IOR, other methods are also applied. Specifically, paper [9] describes the magnetic metric methods to determine only the content of magnetic iron in the IOR. This considerably limits their use, since oxidized, that is non-magnetic iron, makes up a significant portion of the IOR composition. Paper [10] considers the ultrasonic methods for measurement of iron content in IOR. However, the authors stress that, because of their bulkiness, these methods are practically not applicable in confined spaces, for example, during logging of explosion wells.

Article [11] describes how to use the Mossbauer spectrometry for studying the element composition of ferromanganese ores. However, the method of Mossbauer spectrometry does not possess the necessary level of efficiency and requires the use of expensive equipment. Article [12] dealt with the use of this method to determine the iron content in the soil. Despite relatively high sensitivity, the method cannot be used under conditions of the mining industry due to the bulkiness and high cost.

The conducted analysis suggests that certainly it is appropriate to carry out research into the use of absorbed gamma radiation to measure iron content in IOR. Mathematical modeling of these measurements will make it possible to find the ways of efficient organization of the studied processes, avoiding the “trial and error” method.

3. The aim and objectives of the study

The aim of this research is to use the absorbed gamma radiation for rapid control of iron content in the IOR as a result of the dependence of intensity of absorbed gamma radiation on the iron content in IOR.

To accomplish the aim, the following tasks have been set:

– to develop a mathematical model for calculating the intensity of absorbed gamma radiation for rapid control of iron content in IOR;

– to perform a comparative analysis of intensities of absorbed and reflected gamma radiation during the operational control of iron content in the IOR.

4. Materials and methods used in the study

Nuclear-physical methods are most commonly used for rapid control of the quality of ores of ferrous metals under varying conditions of extraction and processing. In this case, the optimal choice of energy and activity of gamma radiation source is important.

Practical application of nuclear-physical methods revealed that for operational control of the quality of mineral raw materials, the sources of gamma radiation with energy of $E \leq 300$ keV are the most suitable. From the known sources for control of the IOR quality, it is advisable to use gamma radiation source based on the isotope Americium-241 with the radiation energy of 60 keV, which provides the necessary sensitivity to the change of the useful component in the rock mass and is safe to operate due to its low energy.

At the interaction of gamma quanta with rocks, within a specified range of energy, there are three kinds of secondary radiation: back scattered $N_{scat.}$, past $N_{p.}$ and absorbed $N_{abs.}$. The sum of all three types of secondary radiation is intensity of gamma radiation source N_o and is determined from

$$N_o = N_{scat.} + N_{p.} + N_{abs.}. \quad (1)$$

At present, almost all measuring devices in the mining industry are based on the measurement and comparison of the intensity of scattered gamma radiation with the content of useful components. The proportion of back scattered radiation in equation (1) is low enough, which does not ensure the necessary precision of operational quality control of mineral resources.

That is why it was proposed to check the possibility of using the intensity of absorbed gamma radiation for rapid control of iron content in IOR.

The feature of mathematical modeling of the process for measuring the iron content in IOR implies the construction of such model that would take into consideration the dependence of intensity of absorbed gamma radiation flow on the measured parameters. At central geometry of IOR irradiation, along with the intensity of a gamma radiation source, the measured parameters are geometric ones: the distance between a radiation source and a detector, the distance between a detector and a reflecting surface.

It is logical to begin the synthesis of the model for assessment of iron content in IOR with the known and proven in practice formulas that describe the propagation of gamma radiation flux in the medium [13]. The circuit of the modeled interaction of gamma radiation with a substance is shown in Fig. 1.

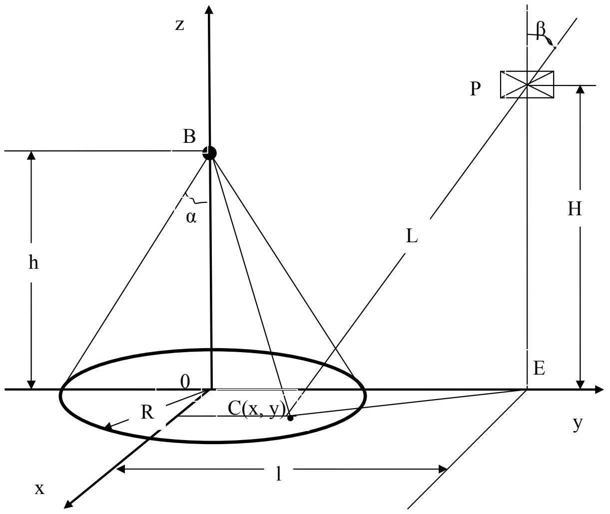

Fig. 1. Circuit of interaction between gamma radiation and a substance

A flux of gamma-quanta comes out from point *B* in the form of a circular cone with cone aperture angle 2α. Further, this flux reaches the irradiated surface, forming a "spot" in the form of a circle. Each point of this "spot" is a source of secondary (reflected) gamma radiation. Reflected gamma radiation carries the necessary information about the status of iron ore, which includes information about the content of iron in it [14, 15]. The detector, located at point *P* records and measures the magnitude of intensity of gamma radiation. According to the circuit of propagation of gamma radiation, shown in Fig. 1, the element of intensity of gamma radiation flux that reached irradiated surface at point $C(x, y)$, from the source of gamma radiation with intensity Q, located at point B, is written down in the form

$$dN(x,y)=\frac{Q\cdot h}{\left(x^2+y^2+h^2\right)^{\frac{3}{2}}}dxdy, \tag{2}$$

where Q is the intensity of the source of gamma radiation, 1/sec, h is the distance from the source of gamma radiation to the irradiated surface, m, $dxdy$ is the element of the surface in the Cartesian coordinate system, m^2.

Then the total intensity of the gamma radiation flux that reached the surface is found by integrating over region D in the form of a circle

$$N=Q\cdot h\iint\limits_D\frac{\mathrm{d}x\mathrm{d}y}{\left(x^2+y^2+h^2\right)^{\frac{3}{2}}}. \tag{3}$$

To calculate the double integral (3), it is necessary to reduce it to repeated integrals. Integration region D is restricted by a circumference, the canonical equation of which has the form of

$$x^2+y^2=R^2, \tag{4}$$

where R is the radius of the circumference, limiting the "spot" of the surface of the irradiation surface, m.

At the transition to polar coordinates

$$x=R\cdot\cos\phi,\quad y=R\cdot\sin\phi,$$

equation (4) is recorded as

$$r=R,\quad \left(0\le\phi<2\cdot\pi\right). \tag{5}$$

According to (5), integral (3) will take the form

$$N=Q\cdot h\iint\limits_{D^*}\frac{1}{\left(r^2+h^2\right)^{\frac{3}{2}}}r\mathrm{d}r\mathrm{d}\phi, \tag{6}$$

where $r{\cdot}drd\varphi$ is the element of the square in polar coordinates, m^2; $D^*=\{(r;\varphi\,|\,r=R;0\le\varphi<2\cdot\pi\}$ is the region of integration in polar coordinates.

To calculate double interval (6), it is necessary to reduce it to repeated integrals.

Given the integration boundaries, double integral (6) will be written in the form

$$N=Q\cdot h\int\limits_0^{2\pi}d\phi\int\limits_0^R\frac{rdr}{(r^2+h^2)^{\frac{3}{2}}}. \tag{7}$$

By integration, we derive

$$N=2\pi\cdot Q\cdot\left(1-\frac{h}{\sqrt{R^2+h^2}}\right). \tag{8}$$

Bearing in mind that the radius of the circumference of the "spot" on the irradiation surface is derived from formula

$$R=h\cdot tg\alpha,$$

formula (8) is reduced to the form

$$N=2\pi\cdot Q\cdot\sin^2\alpha. \tag{9}$$

Then the intensity of the flux of gamma-radiation reflected from the surface is calculated from formula

$$M=2\pi\cdot Q\cdot A\cdot\sin^2\alpha, \tag{10}$$

where A is the albedo coefficient.

Albedo coefficient A shows the share of intensity of flux incident on the irradiation surface, reflected from the irradiated surface. It is obvious that the intensity of the absorbed gamma radiation flux can be found as the difference of (9) and (10)

$$N_n=N-M$$

or

$$N_{abs.}=2\pi\cdot Q\cdot\sin^2\alpha\cdot(1-A). \tag{11}$$

In turn, the element of intensity of gamma radiation flux, determined from formula (2), is a source of secondary flux of gamma radiation. In this case, the intensity of the secondary flux of gamma radiation, getting onto detector located in point *P* from point *C*(*x*, *y*) is derived from formula

$$dM(x,y)=\frac{A\cdot h\cdot S}{L^3(x;y)}dN(x,y), \qquad (12)$$

where *L*(*x*, *y*) is the distance from point *C*(*x*, *y*) to point *P* of the detector location, m; *S* is the area of the detector, m^2.

According to the circuit of propagation of gamma radiation flux, presented in Fig. 1, it is possible to write down [16]

$$L(x,y)=\sqrt{x^2+(l-y)^2+H^2}, \qquad (13)$$

where *l* is the distance between the source of radiation and the detector, m.

Taking into consideration (2) and (13), formula (12) takes the form

$$dM(x,y)= \\ =\frac{Q\cdot A\cdot h\cdot H\cdot S}{((x^2+y^2+h^2)(x^2+(l-y)^2+H^2))^{1{,}5}}dxdy. \qquad (14)$$

To find the total intensity of the secondary flux of gamma radiation entering the detector, it is necessary to integrate by region *D*

$$M=Q\cdot A\cdot h\cdot H\cdot S\times \\ \times\iint_D \frac{\mathrm{d}x\mathrm{d}y}{((x^2+y^2+h^2)(x^2+(l-y)^2+H^2))^{1{,}5}}. \qquad (15)$$

To calculate double integral (15), it is necessary to reduce it to repeated integrals. By transition to polar coordinates, integral (15) is reduced to repeated integrals and takes the form

$$M=Q\cdot A\cdot h\cdot H\cdot S\times \\ \times\int_0^{2\cdot\pi}\mathrm{d}\phi\int_0^{h\cdot tg\alpha}\frac{r\mathrm{d}r}{((r^2+h^2)(r^2-2r\cdot l\cdot\sin\phi+l^2+H^2))^{\frac{3}{2}}}. \qquad (16)$$

Formula (16) makes it possible to find the magnitude of albedo coefficient by the magnitude of intensity of the flux of reflected gamma-radiation, measured by the detector

$$A=\frac{M}{Q\cdot h\cdot H\cdot S\int_0^{2\cdot\pi}\mathrm{d}\phi\int_0^{h\cdot tg\alpha}\frac{r\mathrm{d}r}{((r^2+h^2)(r^2-2rl\sin\phi+l^2+H^2))^{1{,}5}}}. \qquad (17)$$

Then, taking into consideration (17), formula (11) takes the form

$$N_n=2\pi\cdot Q\cdot\sin^2\alpha\times \\ \times\left(1-\frac{M}{Q\cdot h\cdot H\cdot S\cdot\int_0^{2\cdot\pi}\mathrm{d}\phi\int_0^{h\cdot tg\alpha}\frac{r\mathrm{d}r}{((r^2+h^2)(r^2-2l\cdot r\sin\phi+l^2+H^2))^{1{,}5}}}\right). \qquad (18)$$

Analysis of formula (18) shows that the intensity of the absorbed gamma radiation flux N_n depends on seven variables: *Q, M, S, h, H, l,* α. The study of formula (18) as the function of seven variables causes certain difficulties. Therefore, the problem of the number of significant variables, determined as a combination of seven variables, is exceptionally important. Application of the theory of similarity and analysis of dimensionality [17, 18] makes it possible to represent formula (18) in the form

$$N'_{abs.}=2\pi\cdot\sin^2\alpha\times \\ \times\left(1-\frac{M'}{H'\cdot S'\cdot\int_0^{2\cdot\pi}\mathrm{d}\phi\int_0^{tg\alpha}\frac{\hat{r}\mathrm{d}\hat{r}}{((r'^2+1)(r'^2-2l'\cdot r'\sin\phi+l'^2+H'^2))^{1{,}5}}}\right), \qquad (19)$$

where $N_{abs.}'=N_{abs.}/Q$, $M'=M/Q$, $H'=H/Q$, $r'=r/h$, $l'=l/h$.

Analysis of formula (19) indicates that the number of significant variables is equal to five, that is, it was reduced by two units.

To compare the magnitudes of the reflected and absorbed gamma radiations during irradiation of the samples under conditions of central geometry, the appropriate numerical calculations were carried out. To do this, we composed the ratio of (20) to (11), making it possible to estimate the corresponding magnitude in the dimensionless form

$$E=\frac{A}{1-A}\frac{H'\cdot S'}{2\pi\sin^2\alpha}\times \\ \times\int_0^{2\cdot\pi}\mathrm{d}\phi\int_0^{tg\alpha}\frac{r'\mathrm{d}r'}{((r'^2+1)(r'^2-2r'\cdot l'\cdot\sin\phi+l'^2+H'^2))^{\frac{3}{2}}}, \qquad (20)$$

where $E=M/N_{abs.}$, $S'=S/h^2$.

5. Results of the study into construction of a mathematical model for calculating the intensity of absorbed gamma radiation for rapid control of iron content in IOR

Calculations from formula (20) were carried out with the help of software complex Mathcad [19]. In calculations, the magnitudes of parameters $H'=1$, $S'=1$ were taken into account Fig. 2 shows the diagrams of dependence of ratio *E*, derived from formula (20), depending on distance *l'*, at various magnitudes of *A*.

The diagrams shown in Fig. 2 indicate that the share of the reflected intensity of gamma radiation compared to absorbed intensity of gamma radiation decrease as the distances between the radiation source and the detector increase. At the same time, as albedo decrease, this fraction becomes smaller. The obtained result makes it possible to draw a conclusion on the feasibility of using the intensity of absorbed gamma radiation while measuring the iron content in the IOR, as it leads to fewer errors. Estimation of the magnitude of iron content in the IOR should be carried out according to formula (19), which, using the information about the intensity of the reflected gamma radiation flux, makes it possible to calculate the intensity of the absorbed gamma radiation flow, without the use of albedo.

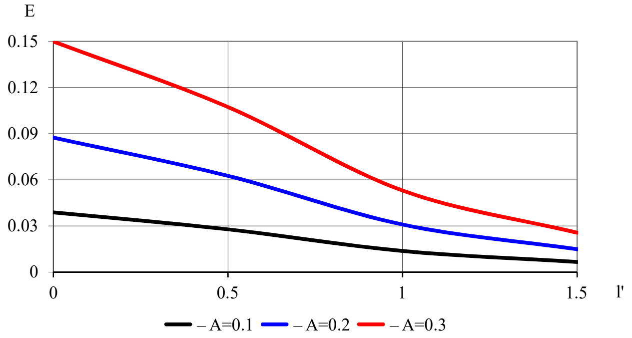

Fig. 2. Dependence of ratio *E* on distance *l'* for different magnitudes of albedo *A*

Formula (19) makes it possible to estimate sensitivity of intensity of the absorbed gamma radiation flux relative to the intensity of the reflected flux of gamma radiation measured by a detector. For this, formula (19) is written down in the form

$$\frac{dN_{abs}}{dM}=$$

$$=-\frac{2\pi\cdot\sin^2\alpha}{\hat{H}\cdot\hat{S}\cdot\int\limits_0^{2\cdot\pi}\mathrm{d}\phi\int\limits_0^{tg\alpha}\frac{\hat{r}\mathrm{d}\hat{r}}{((\hat{r}^2+1)(\hat{r}^2-2\hat{l}\cdot\hat{r}\sin\phi+\hat{l}^2+\hat{H}^2))^{1,5}}}. \tag{21}$$

Fig. 3 shows the results of calculations from formula (21) at *S'= 0.7.*

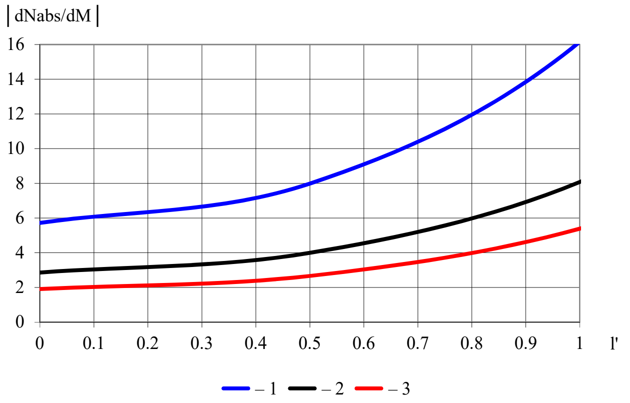

Fig. 3. Dependence of sensitivity of distance l':
1 — *H'*=0.5; 2 — *H'*=1.0; 3 — *H'*=1.5

The diagrams shown in Fig. 3 indicate that sensitivity of the intensity of the absorbed gamma radiation flux relative to the intensity of the reflected flux of gamma radiation increases as the distance between the radiation source and the detector increases. Moreover, this sensitivity increases as the height of the detector over the irradiated surface increases.

For the purpose of establishing and recording the intensity of absorbed gamma quanta in order to control quality of mineral raw material, the representative samples of ore within the range of the Fe content of 10–60 % were selected.

As shown in equation (1), during the interaction of gamma radiation with rocks, three kinds of secondary radiation occur. Given the "saturation thickness" of the sample, we ignore the intensity of passed gamma radiation. In this case, expression (1) takes the form

$$N_0=C\cdot N_{scat}+N_{abs}. \tag{22}$$

C is the dimensionless correction factor, which takes into consideration the number of unregistered back scattered gamma quanta. This factor is the function of the area of monocrystal of the detector, energy, radionuclide activity and of the distance "source-sample-detector".

The numeric value *C*, depending on the activity of the source may vary from 1.7 to 3.5.

According to the research results, the diagrams of dependences of intensity of scattered and absorbed gamma radiation on the iron content in IOR were plotted (Fig. 4).

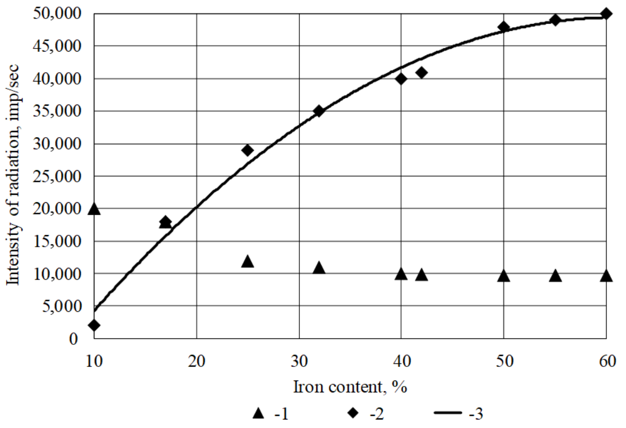

Fig. 4. Dependence of intensity of scattered and absorbed gamma radiation on the iron content in ore: 1 — scattered radiation, 2 — absorbed radiation, 3 — approximation

The diagram shows that intensities of scattered and absorbed gamma radiation are equal at the content of useful component Fe=17 %.

Dependence 1 (Fig. 4) shows that at the content of Fe≥40 % the intensity of scattered radiation decreases sharply and enters the zone of weak sensitivity.

Given that the IOR with the content of Fe≥65 % is competitive in the international market, the appropriateness of using the intensity of absorbed gamma radiation for rapid quality control of ore in the region of high iron content becomes even more urgent.

Sensitivity is determined from formula

$$K=(\mathrm{N}_1-\mathrm{N}_2)/(\mathrm{Fe}_1-\mathrm{Fe}_2)=\Delta\mathrm{N}/\Delta\mathrm{Fe}. \tag{23}$$

Sensitivity to scattered and absorbed gamma radiation in the range of 50–60 per cent of iron content is

$$K_{scat.}=500/10=50\ \text{imp/\%};$$

$$K_{abs.}=1000/10=100\ \text{imp/\%}.$$

One can see that the sensitivity of absorbed gamma radiation is significantly higher (by 2 times) than the sensitivity of scattered gamma radiation.

Coefficient of determination between calculated and experimental data is R^2=0.98.

6. Discussion of results of studying the use of intensity of absorbed gamma radiation by IOR for measuring the content of iron

The idea of this work is to find the ways to improve the accuracy of control of the content of useful component in iron ore in the region of mass share of Fe>40 %.

Analysis of the results of research into the intensity of absorbed gamma radiation of IOR for the measurement of iron content made it possible to explain the obtained results by the features of nuclear-physical interaction of gamma quanta of low energy from the substance. The advantage of the proposed solutions is that at an increase in iron content in IOR up to 50–60 % sensitivity of absorbed gamma radiation is significantly higher (by 2 times) than sensitivity of scattered gamma radiation. Thus, the obtained results of studies on the use of intensity of absorbed gamma radiation of IOR prove an increase in accuracy of rapid control of the content of iron. It must be emphasized that the alternative methods for measuring the iron content, based on the measurement of the intensity of scattered gamma radiation lose their effectiveness at an increase in the iron content in IOR Fe>40 %.

It must be stressed that the results obtained both in the experiments, and by mathematical modeling pointed out the direction of development with a view to practical implementation. The devices designed based on the studied problem will make it possible to implement such control of iron content, which will enhance the efficiency and required quality of production processes of mining and metallurgical cycle. However, it should be noted that when planning further study, there may arise problems of measuring iron content in iron ore, associated with the geological features of developed deposits. Consideration of these features will require linking the studies to the specific conditions of IOR mining.

Imperfection of the proposed method is the lack of technical possibility of immediate recording the intensity of gamma radiation absorbed by the ore.

7. Conclusions

1. We have constructed a mathematical model for calculating the intensity of absorbed gamma radiation for rapid control of iron content in iron ore, the specific feature of which is the application of central geometry when designing the devices to measure the content of iron in IOR. The novelty of modeling is related to the fact that considering the known laws of the interaction of gamma-radiation with a substance, we obtained the structure of the model, which is significantly non-linear with the use of the central geometry of measurement. Availability of statistical material on measurement of iron content in IOR makes it possible to use the tools of IT-technologies to find the parameters contained in the structure. A specific feature of the synthesized model is that there is a possibility to adapt it to changing conditions in measuring the iron content in IOR, such as geological conditions of IOR deposits. The adequacy of the mathematical model is proved by both statistical estimates, in particular the coefficient of determination, and the results of experiments.

It has been proved that when iron content in IOR exceeds 50 %, the calculation of iron content in IOR based on determining the intensity of absorbed gamma radiation is more effective than the existing method, based of taking into account the intensity of reflected gamma radiation. At the same time, in the studied range of iron content in IOR, sensitivity of measurement of iron content in IOR by the intensity of absorbed gamma radiation is significantly higher (by 2 times) than the sensitivity of measuring iron content in IOR by intensity of scattered gamma radiation.

2. A comparative analysis of the intensities of absorbed and reflected gamma radiation in IOR depending on the iron content was conducted experimentally with a view to rapid control of iron content in IOR. It is established that at the content of iron in IOR of more than 50 %, the sensitivity of measurement of iron content by intensity of absorbed gamma radiation is significantly higher (by 2 times) than the sensitivity of measuring iron content in IOR by intensity the scattered gamma radiation. Coefficient of determination between calculated and experimental data in this case is 0.98.

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