INFLUENCE OF PARTICLE COARSENESS ON THE RESULTS OF THE GAMMA ALBEDO METHOD

Yu. N. Pak and A. V. Vdovkin

Variable coarseness, not the analytical coarseness, is one of the destabilizing factors in the instrumental nuclear physics analysis of friable materials. Papers [1-5] examine the question of the influence of coarseness. They are concerned mainly with the study of the influence of this parameter on the results of x-ray methods.

The dispersion of material of elevated coarseness (more than several mm) can be subjected to analysis in the gamma albedo methods based on recording gamma radiation scattering. The analytical estimation of the perturbing action of coarseness in application to the gamma albedo method is an urgent problem.

The expression for the intensity of noncoherent scattering of gamma radiation in the approximation of plane-parallel single-grain layers [4] consisting of a homogeneous filler and grains of the component to be determined which is of cubical shape can be written to the accuracy of a constant factor as

\[ N = N_0 \sigma_{nc} \frac{\mu - (\mu_A - \mu_H) c/c_1^{-1}}{\mu_H} \]

where \( \mu_A = \mu_s^A + \mu_s^A \) is the mass coefficient of noncoherent scattering of the primary radiation by the medium; \( \mu_s^A, \mu_s^A \) are the mass coefficients of attenuation of the primary and scattered radiation, respectively, of the component being determined; \( \mu_s^H, \mu_s^H \) are the same for the filler; \( c, c_1 \) are the content of the component to be determined in the grain and in the medium, respectively; \( c/c_1 \) is the grain content in the medium; \( d \) is the grain size;

\[ \rho = \rho_A \rho_H \left[ \rho_A + (\rho_H - \rho_A) \frac{c}{c_1} \right] \]

the density of a two-component medium, and \( \rho_A, \rho_H \) are the densities of the component being determined and of the filler, respectively.

Presented in Fig. 1 are values, computed by means of (1), for the intensity of noncoherently scattered gamma radiation as a function of the particle coarseness and the content of the component being determined in the medium. A 60-keV primary gamma radiation, which corresponds to the radiation energy of the source Am-241, is used. Limestone, iron ore, and coal, approximated, respectively, by the binary mixtures CaCO₃ + SiO₂, Fe₂O₃ + SiO₂, and SiO₂ + C, were selected for study. The components analyzed are the calcium oxide in limestone (C₁ = 0.56), iron in the iron ore (C₁ = 0.7), and silicon oxide (ash) in coal (C₁ = 1).

An increase in particle coarseness results in an increase of the scattered gamma radiation intensity. The growth is here differentiated as a function of the real composition of the material being studied. As the concentration of the component to be determined rises, the radiation intensity is legitimately reduced in the whole coarseness range investigated. However, depending on the coarseness, the degree of differentiation of the magnitude of the intensity from the concentration is distinct.

Therefore, the inhomogeneity of the material being analyzed according to its grain-size distribution exerts influence on the nature of the interrelation between N and the concentration and on the magnitude of the intensity.

Uncontrollable fluctuations of the particle size introduce a definition error in the result of the method, which can be found from the expression

\[ \sigma = \left( \frac{S_d}{S} \right)^2 \cdot D \]

where S_d and S are, respectively, the sensitivity of the method to the particle size and the content of the component being determined, and D is the variance of the coarseness.

The sensitivity is defined as the relative \( (dN/N) \) increment in the scattered gamma radiation intensity per unit (dm) change in the magnitude of the parameter under investigation

\[ S_m = \frac{1}{N} \cdot \frac{dN}{dm} \]

Differentiating (1) with respect to C and substituting into (3), we obtain a formula to estimate the sensitivity of the method to the component being determined

\[ S = -\frac{1}{c_1 - c} \cdot \frac{\mu_A - \mu_H}{\mu} \cdot \frac{\mu - (\mu_A - \mu_H) c}{c_1 - c} \]

As \( d \to 0 \) (the case of a homogeneous medium), by setting \( e^{-\mu} = 1 - \mu \), it can be shown that \( \bar{\mu} = \mu_H + (C/c_1)(\mu_A - \mu_H) \). Substituting this latter into (3), we obtain

\[ S(d \to 0) = -\frac{1}{c_1} \cdot \frac{\mu_A - \mu_H}{\mu_H + (C/c_1)(\mu_A - \mu_H)} \]