AP23485184. Technology of nuclear geophysical testing of coals using gamma-ray spectrometry of natural radioactive elements. sc.sp. – Pak Yu.N.

Relevance

Currently, mining enterprises mainly use standard methods of coal sampling, which involve the collection of primary samples, their cutting (crushing, grinding, reducing) and direct thermal gravimetric analysis, which consists of burning an analytical sample (~0.1 mm) of coal (1-2 grams) with subsequent calculation of the ash content. Significant disadvantages of the traditional method of sampling are high labor intensity and low representativeness (the quality of a batch of coal (hundreds of tons) is assessed based on the results of thermal gravimetric analysis of the analytical sample). In some cases, the final stage of sampling is replaced by instrumental nuclear-physical methods, which involve the use of radioisotope sources of gamma and neutron radiation. At the same time, there remain errors due to the heterogeneity of coals that arise at the labor-intensive stages of sampling and sample preparation. An innovative approach to testing solid fuel is proposed that consists in measuring the spectrometry of gamma radiation emitted by natural radioactive elements (uranium-238; thorium-232 and potassium-40), which will allow assessing the quality of coals in large masses without preliminary sample preparation with high sensitivity and accuracy. The practical significance of the research results consists in the creation of a new nuclear-geophysical technology for testing coals by spectrometry of natural gamma radiation, which allows, based on operational and objective information on ash content, to introduce a quality management system in the process of coal mining and processing.

Project objective

The objective of the project is to develop a new technology of nuclear geophysical testing coals using spectrometry of natural gamma radiation of natural radioactive elements (U^{238}, Th^{232}, K^{40}) with selective consideration of the specific activity of each radionuclide based on the interpretation and algorithmic justification of complex gamma spectrometric measurements, ensuring high sensitivity of coal quality assessment in large masses.

Expected and achieved results (2024)

The features of the existing standard method of testing a batch of coal were studied, which provides for a representative selection of primary samples (their number and weight), their crushing, reduction, grinding and preparation of analytical samples (~ 0.074 mm) for thermal gravimetric analysis of ash content. At each stage of its processing, coal is considered heterogeneous. Heterogeneity is estimated by the mean square deviation of the quality parameter (ash content of coal). At each stage of standard sampling, a component error is formed: due to the selection of primary samples, crushing, reduction, grinding, preparation of analytical samples and directly thermal-gravity analysis. It was revealed that the error due to sampling was the most significant. It is about 70-80% of the total sampling error. All the stages of standard coal sampling are very long and introduce a noticeable error in assessing the quality of fuel and cannot be considered as a means of managing the quality of coal at the stages of production and processing. Based on the results obtained, materials were prepared for improving the existing sampling system based on natural gamma radiation spectrometry.

Representative primary samples of coal from the Ekibastuz and Karaganda deposits were collected. The collected primary samples of different component and granulometric composition were subjected to standard sample preparation schemes: drying, crushing, reducing, grinding and bringing to the analytical size (~0.074 mm). 200 samples of coal from those deposits were prepared for instrumental determination of concentrations (specific activity) of uranium-238 and their decay products, thorium-232 and their decay products and potassium-40 using various nuclear-physical methods (gamma spectrometry, neutron activation,

X-ray fluorescence). Work has begun on instrumental analysis of the prepared samples to assess the specific activity of various radionuclides.

The results of studies on the distribution of natural radioactive nuclides (U, Th and their decay products) in fossil coals and the forms of their occurrence are summarized. In coals with a relatively low uranium content, the mineral form of its occurrence predominates. Coals richer in uranium contain it mainly in organic matter. The bulk of Th is in the mineral part of coal. The distribution of U, Th in coal basins is generally uneven and is determined by the combined influence of a number of factors: the degree of coalification and age, heterogeneity of rock composition, ash content, etc. Preliminary results on the relationship of the main components of coal with ash content and specific activity of radionuclides have been obtained.

Expected results

An article will be published in a peer-reviewed foreign or domestic publication recommended by the CQASHE. It will deal with the technology of nuclear geophysical testing coals based on complex gamma spectrometric measurements of natural gamma radiation of uranium, thorium and potassium with selective consideration of the contribution of each radionuclide (December 2025).

A patent will be obtained, included in the Derwent Innovations Index database (Web of Science, Clarivate Analytics), dedicated to the interpretative and algorithmic justification of the new technology of nuclear geophysical testing (September 2026).

Based on the results of the carried out studies, 2 articles will be published in peer-reviewed scientific journals indexed in the Science Citation Index Expanded of the Web of Science database and (or) having a CiteScore percentile in the Scopus database of at least 50 (fifty) (October 2026).

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Information for potential consumers

The radioecological situation in the areas of thermal power plants operating based on monitoring the level of radioactivity will allow objective assessing the impact of the fuel and energy sector on the natural environment and predictive recommendations on the rational use of ash and slag waste in the construction industry.

Scope

Earth and environmental sciences.

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