Measurement Techniques, Vol. 55, No. 7, October, 2012

PHYSICOCHEMICAL MEASUREMENTS

MEASUREMENT OF THE MOISTURE CONTENT OF BROWN COAL FROM THE ANGRENSK DEPOSIT AND PROBLEMS OF METROLOGICAL ASSURANCE

P. I. Kalandarov[1] and B. P. Iskandarov[2]

UDC 621.3.083

Questions related to the measurement of the moisture content of brown coal and estimation of the metrological assurance of moisture monitoring devices are considered.
Keywords: *measurement and control of moisture content, brown coal, lignite, moisture meter, metrological characteristics.*

An analysis [1–4] indicates that existing methods of monitoring the moisture content of brown coal (lignite) from the Angrensk deposit do not correspond to the needs of industry not only as regards rapidity, but also as regards precision. Thus, it is necessary to select a method and evaluate the methodology of studies of the electrophysical parameters of coal from this deposit in order to create devices for express measurement of moisture content on the basis of these parameters.

In order to realize this objective, studies are needed on the dependence of the electrophysical parameters of brown coal on moisture and other non-information-bearing parameters (temperature, density, chemical composition of the material, and others) in a field of electromagnetic waves and the influence of these non-information-bearing parameters on the electrophysical characteristics of the particular material under the conditions of a selected method.

The moisture content of coal is one of the basic parameters in its extraction, transport, and refining. Reliable and precise measurement of this parameter is needed at all stages and exerts a substantial influence on the effectiveness and efficiency of different processes. The problems that arise in measurement of the moisture content of coal may be divided into three groups with respect to different processes in the coal industry: extraction at deposits and refining sections; transportation; and commercial accounting. Moist coal is heavier than dry coal, which increases the cost of transporting the coal. In winter it is congeals more severely and, consequently, requires more fuel to be warmed up and for evaporation of the moisture contained within. According to [5], water that is found within rock may precipitate as a result of adsorption onto a surface and into pores or hydration of polar groups of macromolecules, or may occur in the lattice of crystallites of the mineral part.

A coal mass that is received by a customer is said to be working coal. If it is dried at room temperature, a sample will enter a dry air state following evaporation of external moisture. After being pulverized down to 0.2 mm, a mass of such a sample is called an analytic coal mass. However, there still remains within the particles a significant quantity of moisture retained by means of capillary and sorptive forces. To remove this moisture, the coal is heated to 105°C. Some of the water that has evaporated in the course of heating belongs to the total moisture content of the working coal mass. As a result, there

[1] Tashkent State Technical University, Tashkent, Uzbekistan; e-mail: Polvon_1955@yahoo.com.
[2] Asia Pacific University College of Technology and Innovation (UCTI), Kuala Lumpur, Malaysia; e-mail: bek3006@bk.ru.

Translated from Izmeritel'naya Tekhnika, No. 7, pp. 70–72, July, 2012. Original article submitted December 12, 2011.

remains a dry mass m_d of coal. Further heating leads to rupture of the bonds in the crystallohydrates and release of chemically bound water, silicates, and WM gypsum.

The moisture content of a working coal mass is equal to the ratio of the mass of moisture released at the temperature of dehydration to the mass of the analyzed sample and is expressed by the formula

$$W = \frac{m_a - m_d}{m_a} \cdot 100,$$

where m_a is the mass of a sample of coal in different methods of analysis.

The magnitude of the moisture content depends on the structure, i.e., to a significant degree on the carbonification of the rock. The moisture content of coal decreases in the following series from left to right: peat → brown coal → anthracite → hard coal. Anthracite which violates this law is distinguished by fine porosity of its structure, which amplifies sorption processes on the surface, and for precisely this reason the amount of moisture that it contains is greater than in macroporous hard coal [5].

Control of measurements of the moisture content of coal at accounting centers is mandatory, since any deviation from the specifications that have been agreed to by the supplier and customer entails serious penalties. Therefore, moisture content monitoring devices at accounting centers must exhibit a high rate of response, a feature that makes it possible to avoid extraction of large volumes of substandard product as well as ensure reproducibility of the results of measurements so as to assure observance of requirements in the specification of commercial coal.

Measurement Equipment. Let us now analyze existing devices used for measurement of the moisture content of coal.

1. Mikroradar 113AN flow-type moisture meter, a microwave device manufactured with the use of centrimetric wavelength technology, thus assuring extraordinarily low sensitivity to the temperature of the material and the content of salts. The operating principle of the moisture meter is based on measurement of absorption of microwave energy by a moist substance and transformation of this quantity into digital code with the use of modern microprocessor technology. The range of measurement is 0.5–60% with error in the range 0.15– 2.0%.

2. CS 2800 conveyor analyzers from the firm of SCANTECH (Australia) are used for simultaneous determination of the ash content and moisture content of coal traveling on a conveyor belt in real time. This makes it possible to instantaneously calculate the calorific power of a current batch of coal and monitor its subsequent use or treatment. The advantages of the model derive from the fact that the results of an analysis correspond to the current batch of coal and are independent of the mass of the test material, the thickness of the layer, and the vertical inhomogeneity; sampling is not required in the ordinary operating regime; the analyzer does not touch the conveyor belt or the material being transported; the procedure involved in obtaining and processing the data is fully automated; the device may be incorporated into a computerized production control system. The operating principle of the device is based on a determination of the absorption and phase shift of microwave radiation passing through a flow of friable material on a conveyor belt. The measurement range is 1–30% with error 0.3%.

3. TGA-701 Analyzer, the latest generation of analyzers from the firm of LEGO Corp. (United States) for thermogravimetric analysis. It is used for determining the moisture content, ash content, yield of volatile substances or loss of mass upon heating of different organic, inorganic, and synthetic materials. The sample weighs 5 g; the sensitivity of the scale is 0.1 mg/div. The device conforms to the techniques of Russian and international standards (ASTM, DIN, GOST) and may be used in different branches of industry and for different materials, including coal, coke, and cement.

4. OXEA and GTA measurement complexes from the firm of INDUTECH (Germany) are used for the measurement of the moisture content of coal without preliminary preparation of the sample. To improve the performance of the measurements, the device is provided with scales that make it possible to adjust for variations in the density of a substance. The range of measurement is 3–20% with error in the measurement of the total moisture content ±(0.3–0.6)%; the minimal weight of a sample (when working with a laboratory model of the OXEA analyzer) is 10 g; a single measurement takes 3 min.

Brown coal is a multicomponent and inhomogeneous substance in terms of composition and properties, since it is obtained by means of flotation of several components. These features must be taken into account in selecting the method to be used for the measurements and in the development of moisture content monitoring devices.

Monitoring devices and, especially, sensors that function as constituent elements of automatic systems must exhibit a high degree of reliability, minimal number of moving parts, ideal dynamic characteristics, interchangeability, and minimal overall dimensions and minimal total weight.

Metrological requirements are not limited to high degree of precision and sensitivity; measurements of moisture content are performed over extraordinarily broad ranges that encompass several orders of magnitude of the measured quantity. In the case of devices used to monitor the moisture content of substances analogous to coal (aluminosilicate catalysts, pigments, fluoroplastic, and synthetic polymer materials), the lower limit of the range of the device may amount to several fractions of a percent, and the upper limit may be close to 100%, for example, in the case of brown coal the mean moisture content amounts to 35%, while in plants and other living things containing water, 50–80% of the total mass [6].

Recommendations. Achievement of our objective – i.e., measurement of the technological parameters of brown coal from the Angrensk deposit entails carrying out the following steps:

1) critical analysis of the modern state of the theory and practical application of measurement of electrophysical characteristics and the identification of trends in their further development and improvement;

2) development and realization of devices for monitoring the moisture content of coal in accordance with the requirements imposed on the latest generations of devices for thermogravimetric analysis;

3) investigation and selection of a method as well as realization of a general-purpose device on the basis of a method that executes several monitoring functions, including monitoring moisture content, ash content, and yield of volatile substances (loss of mass upon heating) of different organic, inorganic, and synthetic materials;

4) realization in accordance with the selected technique of a device for monitoring moisture content and its use in different branches of industry and the development of recommendations for different materials, including coal, coke, cement, and similar substances; and

5) combination of the advantages of preceding generations of devices, such as precision, with the new capabilities of contemporary devices, and the availability of highly efficient systems of weighing and monitoring the temperature of a system in the course of its operation (prediction of temperature).

Results of local measurements of the moisture content of solids, i.e., information not only about its integral values, but also about the distribution of the moisture content at individual points of a test medium [6], are needed for scientific studies in many branches of industry and in the solution of a wide range of application problems.

Two basic constituent elements of moisture content monitoring devices may be identified: the sensor and the measuring instrument. By a sensor is understood a structural aggregate of transducers (in most cases, the sensor is not realized in the form of an individual functional element) and instruments for introducing the test material into the transducer and its transport and discharge, as well as additional instruments for obtaining information about the values of external influencing actions or stabilization and compensation of these actions.

In automatic moisture content monitoring devices, the operation (either continuous or discrete) of the sensor and measuring instrument do not require human intervention. In non-automatic devices, operations that are needed for performing measurements, or at least some of these operations (loading and discharging the sample, equilibration of the measuring instrument), are performed by an operator and these devices are generally designed for discrete action [6].

In developing a device for monitoring moisture content by a thermogravimetric method, the device must be equipped with built-in high-precision analytic scales in order to reduce the error of the analysis down to thousandths of a fraction.

In the case being considered here, processes involved in the transformation of the electrophysical characteristics of friable materials of brown coal from the Angrensk deposit intended for combustion in boiler units for generating electricity are the subject of the studies. Based on the present analysis, we may state the basic requirements for express-analysis devices for discrete monitoring of moisture content and their metrological characteristics for the brown coal of the Angrensk deposit as follows:

range of measurements	10–50%
permissible relative error	10%
mass of sample for discrete measurements	5–20 g
measurement time	30 sec

The amplitude and phase methods which are used here and which are based on the dependence of the absorption or reflection of the energy of microwave radiation on the content of water in the extractant belong to the class of nondestructive monitoring methods. Microwave moisture meters for different branches of industry that may be used for monitoring the moisture content of the above types of materials have been developed on the basis of these methods. They assure the necessary degree of precision of measurements, are reliable, and are simple to use [5].

In the course of further studies in this area it will be necessary to:

1) develop scientific recommendations and identify the range of standardized metrological characteristics of the measuring instruments and a technique for experimental estimation of these characteristics;

2) propose measures designed to assure the uniformity of measurements as well as evaluate accuracy charts for new devices and methods of monitoring the products of concentration; and

3) establish rules and standards for the use of moisture content monitoring devices; this is needed to achieve uniformity of measurements and a required level of precision based on scientific, technical, managerial, and legal foundations.

REFERENCES

1. *Moisture Content. Vol. 4. Principles and Methods of Measuring Moisture Content in Liquids and Solids* [in Russian], Gidrometeoizdat, Leningrad (1968).
2. P. I. Kalandarov, *Analysis of Thermogravimetric Methods of Monitoring Moisture Content* [in Russian], Tashkent (1993), deposited at GFNTI RUz, No. 1946.
3. P. I. Kalandarov and P. R. Ismatuplaev, "Comparative studies of methods of monitoring the moisture content of substances in the agricultural and production complex," *Vestn. TashGTU*, No. 1–2, 45–49 (1994).
4. E. S. Krichevskii, *High-Frequency Monitoring of Moisture Content in Concentration of Minerals* [in Russian], Nedra, Moscow (1972).
5. ZAO UK PORT, www.ukport.ru/humidity, accessed Nov. 10, 2011.
6. M. A. Berliner, *The Measurement of Moisture Content* [in Russian], Energiya, Moscow (1973).
7. P. I. Kalandarov et al., Patent No. FAR 00679, Republic of Uzbekistan, "Automatic microwave moisture meter," (2010).