Moisture and ash contents in coal

Moisture

Run–of mine coal is wet while from economical point of view burning coal of low water content is necessary. Therefore, the coal moisture is an important property which should be frequently analyzed and monitored. There are different types of moisture in coal. Groundwater and other extraneous moisture makes the coal wet and it is called the *adventitious* moisture. This water can be readily removed by evaporation at room temperature. Moisture held within the coal itself is known as *inherent* moisture is more difficult to remove. Its level can be analyzed by means of laboratory tests.

Moisture in coal may occur in four possible forms. It can be surface, hydroscopic, decomposition and mineral moisture. The surface moisture results from water held on the surface of coal particles or macerals. Hydroscopic moisture is caused by water held by capillary action within the microfractures of coal. Decomposition moisture is due to water held within the coal's decomposed organic compounds. Mineral moisture is a result of water which comprises part of the crystal structure of hydrous silicates, especially clays minerals.

Moisture is usually determined as total moisture, calculated as the loss of weight between the untreated and analyzed samples. Moisture can be determined by different methods including heating coal with toluene, drying in a minimum free-space oven at 150 °C in nitrogen atmosphere, and drying in air at 100 to 105 °C.

The first two methods can be used for low-rank coals. The third method is for high-rank coals (for low-rank coals oxidation may take place). The third method can also be used for determination of the inherent moisture. However, the analysis should be run in vacuum.

Details on total moisture determination in hard (bituminous) coal can be found in Polish Standard PN-ISO 589:2006 (Wegiel kamienny -- Oznaczanie wilgoci całkowitej) and ISO 589:2003 [IDT].

Ash

The ash content in coal is another important parameter of coal. Ash reduces the calorific value of coals. Burning coals on a large scale requires knowledge of their ash contents. The ash content is determined by heating and burning coal samples in the presence of air and determining the mass loss. The exact procedure of ash determination is different in different countries. Two of them (Polish and American) are briefly presented below.
American procedure (ASTM, D 3174)

Ash content determination in coal relies on weighing, with a high accuracy, about one gram of dry coal in a crucible and putting the sample into a cold furnace. Next, the crucible is heated up to 450–500°C within 1 hour. After 2 hours of heating at this temperature the roasting temperature is increased to 700–750°C. At this temperature the sample is kept for 2 hours. During ash determination a significant amount of air should have access to the furnace.

Polish procedure


There are two approaches to ash determination: complete and simplified.

In the **complete** coal ash determination procedure based on the Polish Standard weigh, with a high accuracy (at least 3 decimal points), a 1 (to 2)-gram dry coal sample and place it into the non-heated furnace. Heat the sample to 500°C within 30 minutes. After 30 to 60 minutes of heating at this temperature the temperature should be increased to 815 ±15°C. The sample should be kept at this temperature for 120 minutes. Remove the sample from the furnace, put it on a heat resistance plate to cool down the sample in air to room temperature. Weigh the sample.

In the **Simplified** coal ash determination procedure based on Polish Standard PN-G-04512:1980/Az1:202 preheat the furnace to 815 ±15°C. Weigh, with a high accuracy (at least 3 decimal points), a 1-gram sample and place it in the front of the furnace either on a special heat-resistant plate on put-horizontally the front wall of the furnace. Keep the sample here for preheating for 10 minutes and next, gradually moved the sample into the heating zone of the furnace with the speed of 2 cm/min. Close the furnace and heat the sample at 815 ±15°C for either 25 minutes (lignite, subbituminous coal), 35 minutes (coal) or 90 to 120 minutes (coke, semicoke). Remove the sample from the furnace, put it on a heat resistance place to cool down the sample in air to room temperature. Weigh the sample. To make sure that the coal is completely burned out, put the sample slowly (2cm/minute) to the furnace again for 15 minutes for burning at 815 ±15°C.
When the weight of the sample is not the same as after first combustion, repeat the 15-minute burning procedure until the difference between two weights is smaller than 0.001 g.

Ash content calculation

Ash content is determined by using the following relation:

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\text{Ash content in coal sample, } \% = 100\% \cdot \left( \frac{\text{mass of dry ash after roasting the sample, g}}{\text{mass of initial sample, g}} \right).
\]

LOI

Ash content can also be characterized by loss-on-ignition (LOI) parameter. LOI refers to the mass loss of a combustion residue whenever it is heated in an air or oxygen atmosphere to high temperatures. Usually the term LOI normally refers to a mass loss in a sample heated to 950°C. In some fields heating to 750°C is used. LOI values from these test methods can be used by industries that utilize combustion residues in various processes and products.

It should be noted that LOI not necessarily agrees with the carbonaceous matter calculated as 100% - ash %. For precise determinations of the carbonaceous matter other tests are available.

Combustion residues produced in furnaces using different methods provide slightly different ash yields due to chemistry of the process. Combustion causes removal of water, and carbon dioxide from carbonates, as well as conversion of metal sulfides into metal oxides, metal sulfates and sulfur oxides, etc. The results of these reactions depend on how they are conducted.

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