

Water, ash and volatile contents in coal or other solid fuels

Introduction

The basic analysis of solid fuels is the determination of water (W), ash (A), volatiles (V) and fixed carbon (FC). The sum of these four values gives 100 wt.% (equation 1). We can calculate sum of volatiles and fixed carbon contents from the determination of the water content and ash content.

$$W + A + V + FC = 100 \text{ wt. \%} \quad (1)$$

Water

All solid fuels contain water and the water content is one of the basic fuel properties. Fuel moisture is to some extent undesirable because it reduces the energy value of the fuel, but a low moisture content can sometimes have a beneficial effect on combustion rate, boiler temperature, etc.

Moisture content varies over a wide range: for coal, for example, between 1 and 60 % by weight, for peat it can even be over 90 % by weight. The moisture content depends on the type of fuel, where it is obtained, its treatment, etc. In general, it can be said that geologically young fuels contain more water than highly carbonised fuels.

Only free and (capillary) bound water is relevant for routine analysis. Free water can be separated from the fuel mechanically (e.g. by centrifugation, dripping or filtration). During free air drying, fuels gradually lose capillary water up to a certain limit. Drying the fuel at an elevated temperature of 105°C releases the hygroscopic water from the fuel and this amount of water is called analytical water. Residual water is the small amount of water that is not released from the coal even by forced drying and is only released at the decomposition temperatures of the fuel - the small fraction of water bound to the ash (hydrates) and the fraction of water **chemically** bound to the organic matter of the fuel are not determined in routine analysis.

Ash

The ash is the part of the fuel that is obtained from the complete combustion of the fuel. It is formed from the mineral components contained in the burned fuel, called ash. When a fuel is burnt, the ash is decomposed by heat in an oxidising atmosphere and the volatile fraction passes into the flue gas. Fly ash is therefore a non-volatile fraction of the ash. Ash, like water, is an undesirable component of the fuel, both in terms of calorific value and fuel behaviour (sintering, slagging, dustiness of the flue gas, etc.). It is also important to know the composition of the ash to better describe its behaviour.

Instructions

Sample preparation:

Prepare an analytical sample (fraction < 0,2 mm) from the original sample. All chemical properties of the sample must be retained during preparation.

Determination of the moisture content:

1. Weigh approximately 1 g of the sample into a pre-weighed porcelain crucible.
2. Place the prepared samples in an oven heated to 105 ± 2 °C for about 2 hours.
3. Place the samples in a desiccator and allow to cool to laboratory temperature.
4. Weigh the samples.
5. Return the samples to the oven and allow to dry for a further half hour. Weigh the samples again. Repeat until two consecutive measurements are identical to two decimal places.
6. Calculate the mass water content of the fuel (be sure to include the equation used to calculate this in the report).

Determination of the volatile matter content:

For the dried samples, after the determination of the moisture content, determine the volatile combustible content (V) by placing a crucible in an oven heated to 900 ± 10 °C for seven minutes (the crucible must be covered with a lid) and leaving it to cool to laboratory temperature in a desiccator. The loss of weight is a volatile fuel.

Determination of the ash content:

Determine the ash content of the samples:

1. Place the samples in a cool muffle furnace.
2. Heat the furnace as indicated in the table in Appendix 1.
3. Maintain the temperature for at least 60 minutes.
4. Allow the samples to cool to laboratory temperature and weigh.
5. If there is any doubt as to the complete combustion of the sample, follow the instructions in Appendix 1.

Appendix 1

Fuel type	Parameter									
	Water			Volatile matter			Ash			
	Mass [g]	Temperature [°C]	Residence time [min]	Mass [g]	Temperature [°C]	Residence time [min]	Mass [g]	Temperature [°C]	Heating rate	Residence time [min]
Solid fuel	min. 1 g	105±2	120 – 180	1±0,1	900±10	7	min. 1 g	815±10	8 °C/min to 500 °C, hold for 30 min, 8 °C/min to 815 °C	to a constant weight (min. 60)
Solid biofuel	min. 1 g	105±2	120 – 180	1±0,1	900±10	7	min. 1 g	550±10	6 °C/min to 250 °C, hold for 60 min, 10 °C/min to 550 °C	to a constant weight (min. 120)
Solid alternative fuel	min. 1 g	105±2	120 – 180	1±0,1	900±10	7	min. 1 g	550±10	6 °C/min to 250 °C, hold for 60 min, 10 °C/min to 550 °C	to a constant weight (min. 120)