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An Improved Concept for Online Coal Analysis

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Abstract

To control the process of coal preparation plants, an online coal analyzer system should be installed on a bypass belt. Compared to main-belt installations an improved accuracy is obtained at a bypass stream, because the material stream can be crushed down to a constant particle size distribution and shaped to a constant cross section profile. To minimize this sample preparation the material running across a bypass stream should be small, but the thin material layers need a re-design of the existing coal analyzers, which are mainly optimized for large material streams on the main-belt. Three major components comprise the system: An XRF elemental analyzer, a microwave moisture and a trace element analyzer for heavy elements. The analyzer system is designed to measure the ash content as well as the complete elemental composition of ash from Sodium to Strontium, moisture, Sulphur, calorific value and Mercury. The bypass system will incorporate a sampling system designed to automatically capture samples that will be sent to laboratories for analysis. These laboratory analyses will be used for two purposes. First for initial analyzer calibration and then to validate analyzer accuracy in the coming years.

Keywords

Online measurement, moisture, ash content, calorific value, elemental analysis, Sulphur, heavy elements, Mercury, XRF, microwaves.

Introduction

The coal preparation industry needs new concepts for real time online coal analysis. Previously, it has been sufficient to measure for the moisture and ash content along the calorific value. The online moisture measurement of coal is usually based on microwave technology. Compared to a dual energy ash analyzer, the improved accuracy of the ash determination is based on the measurement of the complete elemental composition of ash. Today, specific elements become paramount in meeting customer requirements as well as complying with government regulations in plant operations such as coking plants or power generating stations. Some of these key elements include Sulphur, Sodium, Chlorine, Arsenic, and heavy elements such as Mercury.

For process control, the measuring parameters must be measured accurately and reliably. Online analyzers generally do not comply with ISO standards. This is mostly due to the slow testing methods. Online analyzers are designed to measure indirectly. The measured variables are mainly influenced by the quantity of interest (measuring parameter), but in some extent by other quantities, which disturb the measurement. The elected principle of an online analyzer for a specific application should be most sensitive for measuring parameters with negligible sensitivity for the disturbing parameter. Because of the influence of the disturbing parameters a product-specific calibration and a check of the analyser from time to time is necessary. This is accomplished by comparing the analyzer data, taken directly from the measured material stream, with the verified laboratory values of samples taken from the measured material stream at the same time. Both requirements can be met utilizing an automatic sampling system, which is a necessary part of a modern online analysis system.

A modern online analysis system for bulky materials

The sampling system

In general, online analyzers can be installed on the main belt/stream or at a bypass belt/stream. Online analyzers placed on a bypass system provide more accuracy do to more consistent material size and flow.

The start-up and the maintenance of an analyzer placed on a bypass-belt is much safer, easier and faster. Should the analyzer be installed on a main belt, maintenance becomes an issue do having to shut the belt down to facilitate analyzer access and thus possibly altering plant operations. The optimal analyzer installation would include a bypass system. The material would be taken from the main belt with the use of an automatic sampling system, sent to the bypass belt, crushed down to the optimal size of around 6 mm and then sent to the analyzer for analysis.

To avoid the additional costs of a bypass sampling system, the majority of online analyzers are currently installed on main belts with typical tonnage ranging from 500 tph to 3000 tph. Therefore, most of the online analyzers in use are optimized for large material streams. In utilizing a bypass system, the material stream is reduced to a minimum, designed to prepare only a small amount of material for the measurement. The material layer necessary for a bypass belt installation is generally around 30 mm as compared to the 100-200 mm that would typically be seen on a main belt. In using the bypass system, the online analyzers must be optimized to recognize small material streams.

The concept of the modern Coal analyzer has been painstakingly developed over years, based on the requirements of different plant applications. In Germany, this analyzer technology cannot be utilized in the future; this is primarily due to the upcoming closing of German coal mines. With the slated mine closings, the capital investment is not in the best economic interest of coal producing companies, therefore to pursue this technology any further is pointless. Now this concept could be introduced in a non-coal application within an European Research Project called DRAGON, which is currently being pursued.

Online elemental analysis

The energy dispersive X-ray fluorescence (EDXRF) is ideal for measurements on a bypass belt and the OXEA 3000 will be used. Fig. 1 shows the OXEA on a bypass belt.

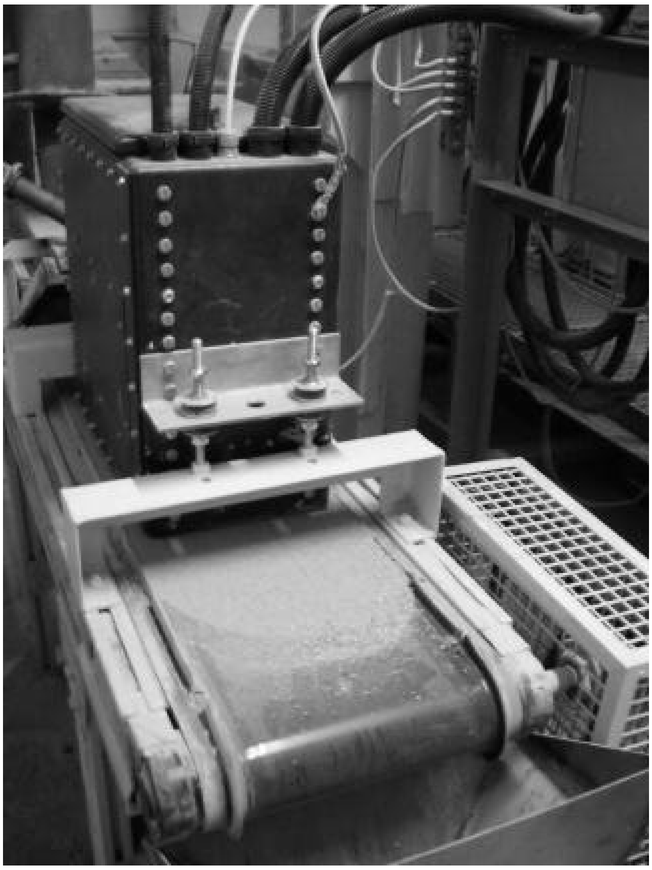

Fig. 1; OXEA on a bypass measuring magnesite ore (2004)

The OXEA 3000, including the type recognition software is described in detail (Klein, Ma, Rullang, 2010). Now the type recognition feature is designed, to automatically switch the calibration curve, if the constituents of the material are changing.

A second topic is to improve the spectra quality for the low elements from Na to Cl.

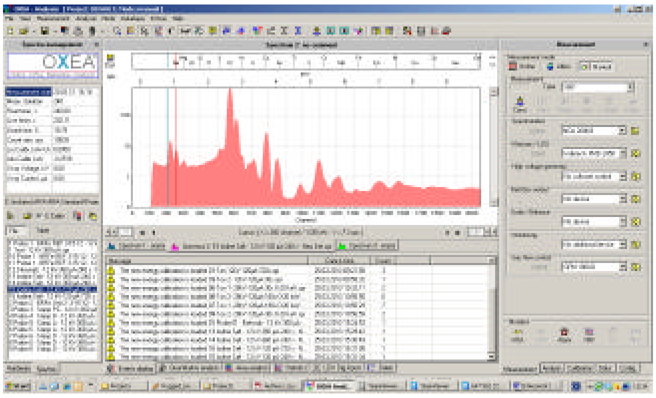

Fig. 2: Spectrum of table salt measured with OXEA 3000 with an improved sensitivity for the low elements.

Indutech has modified the OXEA 3000 to improve the limit of detection of the low elements. A spectrum of table salt obtained with these modifications is shown in fig. 2. to demonstrate that sodium can be measured with the OXEA 3000 analyzer. The peak left of Na is the ESC-Peak of chlorine and was erroneously interpreted as Na in some publications. This created the rumour that Na can directly be detected with a standard online EDXRF device without these modifications. In most cases, measuring Na under online conditions is difficult.

These above modifications improve the limit of detection and the accuracy of the elements Al, Si, and S, which are important when taking coal measurements. Fig. 3 shows a typical spectrum of coal obtained with an OXEA 3000 with the modifications.

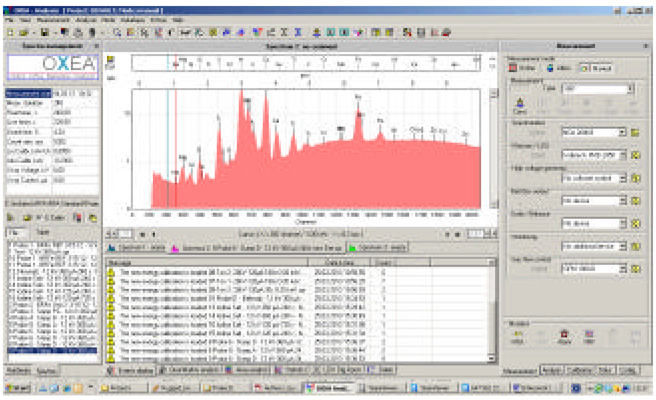

Fig.3: Coal spectrum obtained with an OXEA 3000 optimized for low elements.

The elements Mg-Fe are needed to determine the ash and sulphur content. Together with a moisture measurement the calorific value can be determined.

Online Microwave moisture measurement

The recommended microwave moisture meter is based on the measurement of the attenuation and phase-shift of a microwave beam transmitted though a material layer (Klein, 1981). This technique has been proven over the years and today is widely accepted as the best method for accurately determining the moisture content in coal. On a main belt, the material layers are typically 100 to 200 mm. These material layer thicknesses are ideal for the microwave transmission method; however, the obtained accuracy is sometimes diminished due to large particle size.

To insure the highest accuracy, the microwave moisture meter should be installed on a bypass system. Here the particle size distribution is rather constant and the maximal particle size is small. This small size and even distribution create ideal conditions for a microwave moisture measurement, however, the layer thickness of 20-30 mm is rather low and the long-term stability of the existing moisture analyzer, based on current microwave transmission technique, is not sufficient to measure such thin layers. A long-term drift is created by a drift in the electronics to a lesser extent, but mainly temperature and other effects from the microwave cables. Both effects could be remarkably reduced with the development of the novel microwave moisture meter. The current microwave moisture meter utilizes an integrated unit consisting of the microwave transmitter, the microwave receiver, and the evaluation unit. The novel microwave moisture meter has 3 separate cabinets. The microwave transmitter is installed close to the transmitting antenna, the microwave receiver is installed close to the receiving antenna, and the evaluation unit can be installed at an ergonomic place. The length of the microwave cables will be reduced from 4 m to about 40 cm. The drift caused by the temperature effect of the cables is proportional to the length of the cables. With the short cables this disturbance is reduced by a factor of around 10.

The electronics of the novel microwave moisture meter are completely redesigned. The long-term stability of electronics in the new moisture meter is specified with a 2° and 0.2 dB for the temperature range –10 to 60°C. The improved temperature and long-term stability of the novel microwave moisture meter enables the measurement to be taken at thin material layers.

The frequency range of the new instrument is extended to 1.5 GHz–6 GHz. The use of the full range of the moisture analyzer is not possible due to the bandwidth of several components being too narrow. For example, the antennas used in the PMD2450 cover the frequency range 2.4 to 4 GHz. The new moisture meter allows selecting between different frequency ranges with a few changes such as the installation of a different pair of antennas. When using a higher frequency range, the moisture measurement of thin layers becomes more accurate. This increased accuracy is caused by both measuring parameters: Attenuation and phase-shift.

The novel microwave moisture meter is not only designed for bypass installations with thin layers but is also designed for main-belt or chute applications with a large measuring path. The extremely high dynamic range of 110 dB allows for the measurement of thicker material layers than with existing microwave moisture meter technology.

Online trace analysis of heavy elements

The energy dispersive X-ray fluorescence is restricted because of the limit of detection of about 10-1 ppm. First measurements taken with a new online trace element analyzer show, that the limit of detection is improved by a factor of 10 to 100 compared to the EDXRF. This enables accurate measurements of trace elements down to the ppb range. This instrument is optimized to detect high elements with an atomic number > 46 and can measure elements ranging from Ag to U. The content of Mercury in coal is important in many regions.

The concept of the improved Analyzer System

The analyzer would be installed on a bypass belt. The width of the belt is typically 400 mm. The material is taken by the mechanical sampler from the main belt. The material is crushed down to a particle size in the required <6 mm range. The material is collected in a hopper. The level in the hopper is controlled to provide a continuous material stream with a constant layer thickness on the sampling belt. At the sampling belt the analyzers are installed. The order of the analyzer on the belt should be selected to minimize interferences between the different instruments. An optimal installation, in order, would be as follows:

1) OXEA 3000 analyzer.

2) Gamma-ray transmission line used for area-weight compensation for the moisture meter. This is optional and is only needed if the density of the material is varying in a larger range.

3) Microwave moisture meter. The moisture content is used to calculate the ash content on dry basis and the Calorific value of coal. The moisture reading is needed to compensate for the OXEA 3000 moisture reading.

4) Trace analyzer for heavy elements. This is optional.

5) Depending on application, further analyzers can be installed to measure parameters which cannot be measured with the afore mentioned instruments.

To provide the laboratory with accurate samples for analysis, an automatic sample system can be employed to capture samples in containers. To insure non contamination of the samples, these containers will be designed to capture samples in plastic bags for sealed transportation to the selected laboratories.

The rejects from the sample system will be transported back to the main belt and used accordingly.

Literature

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Disclaimer

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