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CONTINUOUS COAL QALITY CONTROL IN OPENCAST MINING

AÇIK KÖMÜR OCAĞI İŞLETMELERİNDE SÜREKLİ KALİTE KONTROLÜ

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ABSTRACT

Cost-effective processing of coal and ore requires the chemical and physical properties to be known as early as possible. The results of traditional sampling procedures and analytical methods are generally not known until such a late time hence values ascertained are useless for the process on-line control.

It is demonstrated by the example of the Garzweiler opencast mine how the lignite upstream of temporary storage in the coal stockpiles is sampled by means of the RODOS analyser system. The analytical results are considered in the stockpile balance showing what stockpile coal can be taken to ensure optimum homogenisation regarding ash and sulphur content.

OZET

Kömür ve yer alti Madenlerini en kârlı şekilde işlenmesinde, Kimyasal ve Fiziksel yapılarının en hızlı şekilde değerlendirilmesi ile olur. Değerler bu günkü bilinen Medod ve Analiz yöntemleriyle zamanında alınamanakta ve böylece hazırlama ve işlem sırasında kullanıiamaktadır.

Garzweiler açık Kömür fsletmesindeki Misalde ise, ön Depolama sırasında RHODOS-Analiz-Sistemiyle alınan örneklerin testi yapılmakta. Test Neticeleri hemen bildirilerek (Kül ve Kükürt miktarı veyahutta Orantısı), hangi yığınağın neresinden alinacak Kömürle en iyi karışımın elde edilebileceğini bildirmektedir.

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1. Practice of Coal Quality Assessment So Far

In the Rhenish mining area (Figure 1) west of Cologne lignite is extracted from opencast mines. The lignite is used for both electricity generation and production of briquettes, pulverised lignite, coke and fluidised bed lignite. Bucket wheel excavators with a daily capacity of up to 240,000 m^3 each remove the overburden and mine the lignite. Within the opencast mines, the masses are exclusively transported by belt conveyors.

The heating value of the lignite ranges between 7,100 and 10,500 kJ/kg and its moisture content between 50 and 60 %. The ash content of lignite amounts to about 2 %. In the run-of-mine lignite, this content can rise to more than 20 % which is due to dilutions caused during the deposit's genesis and in the course of mining.

The quality requirements made by the power plants and the processing plants are met by selective mining of the various seam sections, selection of cuts separating lignite from overburden and subsequent homogenisation in blending stockpiles. There are no washing plants for subsequent separation of lignite from secondary impurities.

The lignite mined is characterised by a four-digit quality code referring to the contents of ash, iron, potassium and sulphur. There are, for example, six ranks for the ash content. **The** first rank **corresponds to** briquetting lignite,

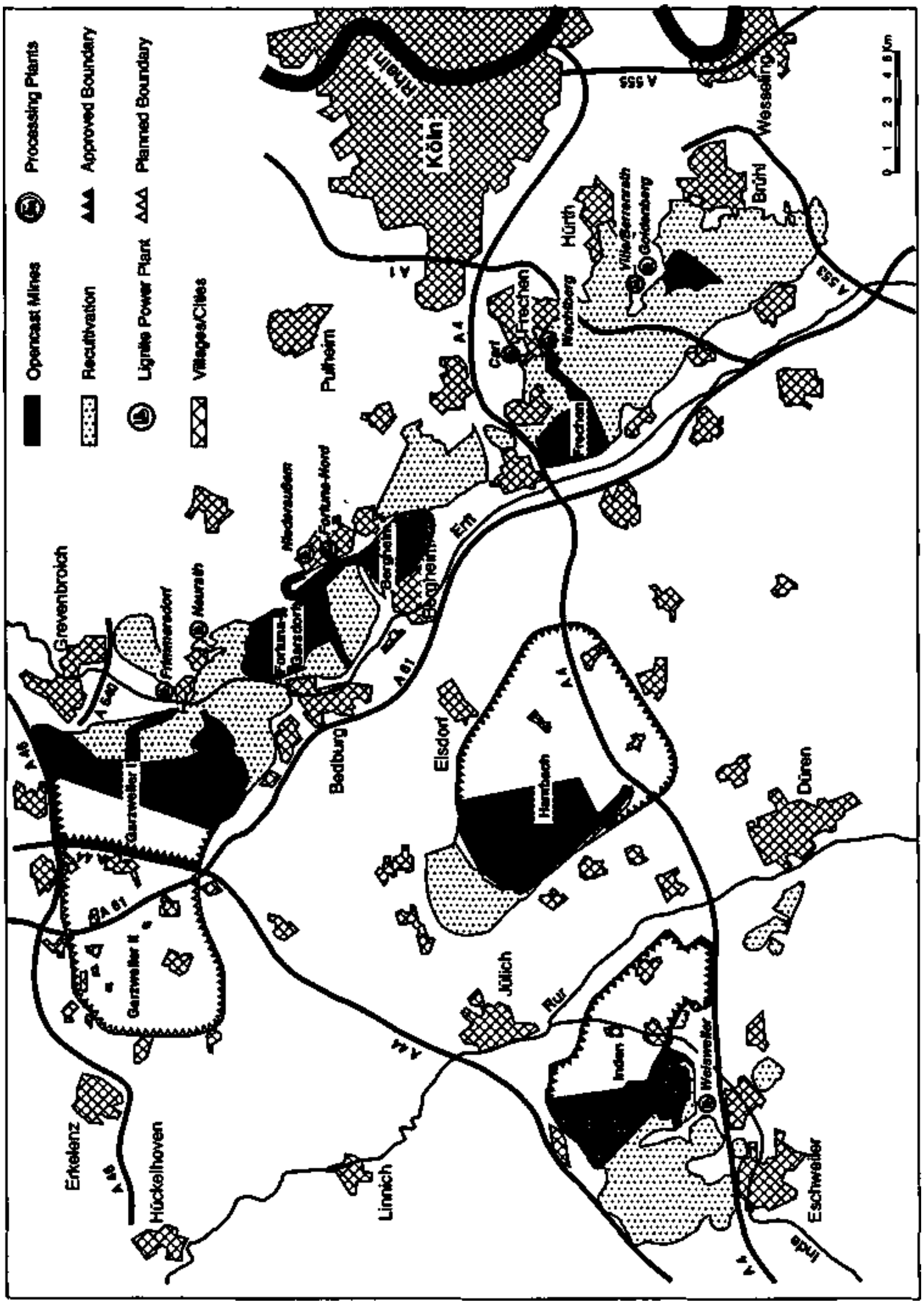

Figure 1 : The Rhenish Mining Area

and the other ranks are related to boiler lignite (Table 1). Boiler lignite with high ash, iron, potassium or sulphur contents is blended with better lignite in order to prevent any adverse effects on the boiler operation in the power plant.

Classification of Ash, Iron, Potassium, and Sulphur

	Ash %	Iron ppm	Potassium ppm	Sulphur %
Class 1	0 - 2.5	0 - 2 000	0 - 400	0 - 0.3
Class 2	> 2.5 - 7.0	> 2 000 - 3 000	> 400 - 600	> 0.3 - 0.5
Class 3	> 7.0 - 12.0	> 3 000 - 4 000	> 600 - 800	> 0.5
Class 4	> 12.0 - 16.0	> 4 000 - 5 000	> 800 - 1 000	
Class 5	> 16.0 - 20.0	> 5 000 - 6 000	> 1 000 - 1 200	
Class 6	> 20.0 - 24.0	> 6 000 - 7 000	> 1 200 - 1 400	
Class 7		> 7 000 - 8 000	> 1 400 - 1 600	
Class 8		> 8 000 - 9 000	> 1 600 - 1 800	
Class 9		> 9 000 - 10 000	> 1 800 - 2 000	
Class 0		> 10 000	> 2 000	

Example about quality information for boiler coal BC 4 2 1 1

- BC — Boiler coal
- 4 — Classification of Ash (> 12 - 16 %)
- 2 — Classification of Iron (> 2 000 - 3 000 ppm)
- 1 — Classification of Potassium (0 - 400 ppm)
- 1 — Classification of Sulphur (0 - 0.3 %)

Table 1 : Classification of Ash , Iron, Potassium, and Sulphur

Due to the difficult geological conditions prevailing in the Garzweiler opencast mine it is especially important to ensure reliable and rapid determination of the ash contained in the lignite mined. In former times the lignite quality in terms of ash content was classified by visual assessment during the mining process itself. This classification was supported by the data from lignite quality maps and sections of the deposit. In addition, the conventional method of lignite sampling at the face or in the stockpile was applied in critical boundaries of workability, and the samples taken were then analysed in the laboratory. The results were available within some hours at the earliest, and they were thus too late for having an influence on direct operational control. In the case of doubt, certain seam sections had to be rejected in terms of lignite mining as a result of the inaccurate assessment possibility. In addition, this process involved considerable personnel costs.

In critical deposit areas, for example in fault zones, further samples had to be taken manually in order to determine iron and potassium contents. In former times, taking of representative samples from the belt conveyor, which was only possible in the case of lower lignite extraction rates, was ruled out for hourly conveyance capacities of up to 12,500 tonnes with grain sizes of up to 800 mm and high belt velocities. Up to now, direct radiometric measuring techniques have likewise not been available for these operating conditions prevailing at conveyors with steel-cord belts.

2. Development of the RODOS Analytical System

In 1984, *Rheinbraun AG* together with *Batelle Institut e. V., Frankfort,* and *Analytische Produktions-, Steuerungs- und Kontrollgeräte GmbH (APC)* started developing the rapid analytical process called RODOS (Rapid Qn-line ßeterminator 0_n £ite)(1). The fundamental idea of this process is to suck off a dust sample from a belt transfer point and analyse it by means of the X-ray fluorescence method (Figure 2). Preliminary tests showed that in **a**

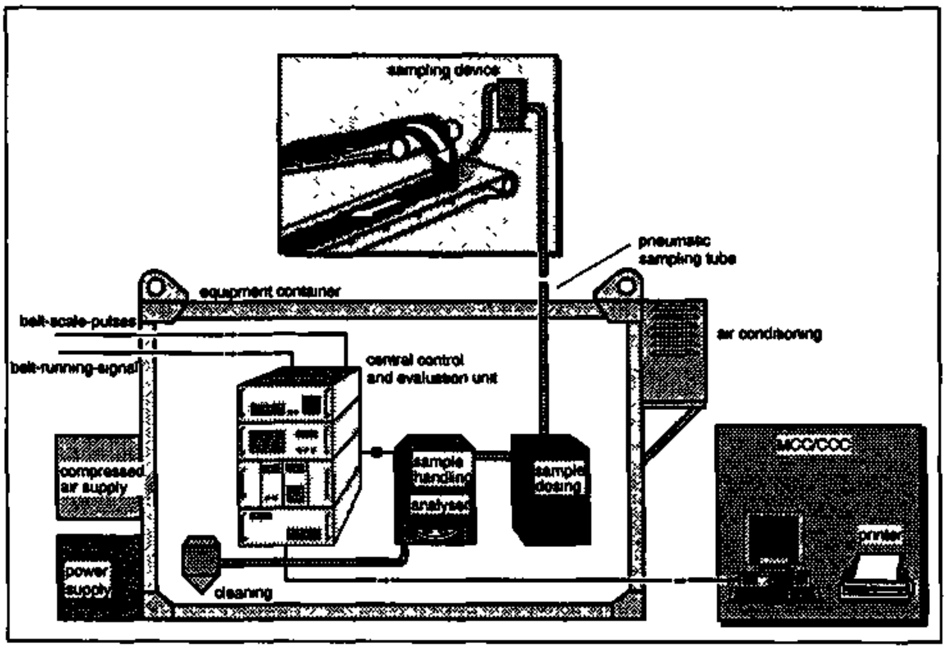

Figure 2 : Continuos Lignite Quality Control System

grain size range of between 30 urn and 210 ^m ash and sulphur contents very well correlate with the results obtained from samples that were manually taken from a belt conveyor and then analysed. From 1987 to 1989, a prototype was tested under operational conditions. Since mid-1990, two improved systems have been working in the Garzweiler opencast mine.

2.1 Principle of the Sampling Procedure

The measuring principle is that a dust sample is taken and then analysed immediately (Figure 3). The dust sampling system takes a dust fraction whose composition is representative of the material being conveyed.

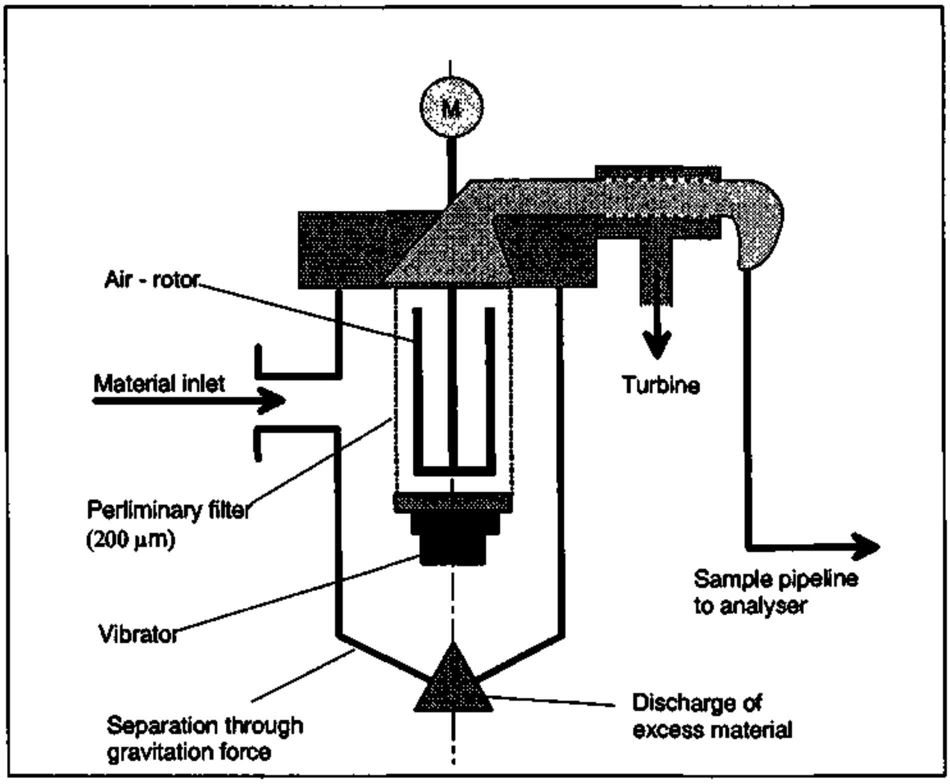

Figure 3 : Sampling System

The dust sample is obtained through suction. A specific fraction is selected by screening and separation through gravitational force. Both the upper and lower grain size limits are variably adjustable and can therefore be adapted to the various types of lignite and/or minerals.

Each sample taken is pneumatically conveyed to the analyser.

2.2 Efficiency

The analytical efficiency of RODOS has been demonstrated in large-scale tests with lignite. The values, which RODOS determined on the basis of the dust samples, were compared to the corresponding laboratory findings for samples taken manually (Figure 4).

For the determination of the ash contents, for example, a linear regression analysis of 33 pairs of values disclosed a correlation coefficient of R = 0.98. Figure 4 compares the different measured values. A corresponding procedure was followed in determining the sulphur content. Figure 4 also shows the measured results. Here again, the correlation coefficient R

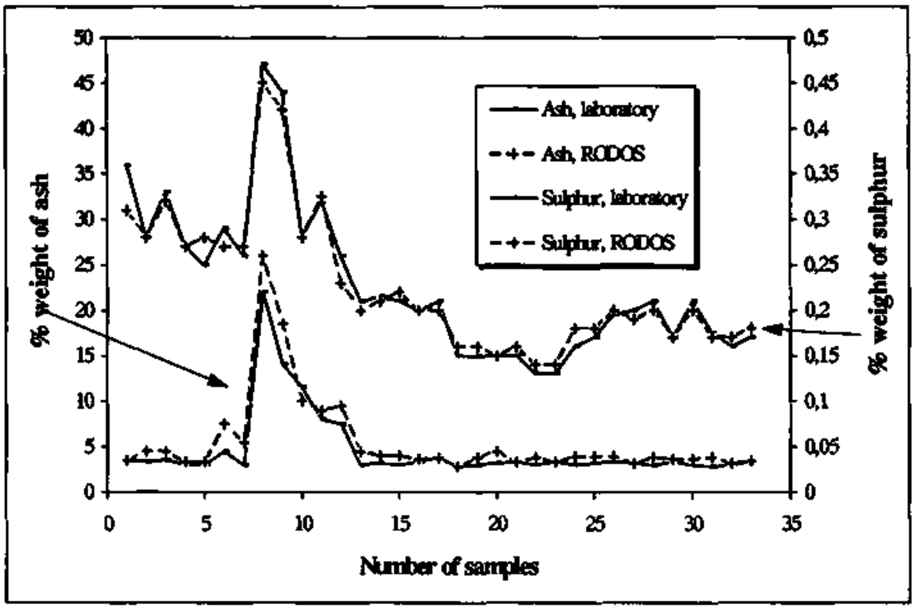

Figure 4 : Comparison of Ash and Sulphur Content Value by the RODOS System and in the Laboratory

obtained is 0.98. The RODOS technique has therefore proved to be an efficient, highly accurate analytical system for virtually continuous analysis of large lignite masses, making it possible to use these figures for the routine supervision and control of conveyance operations. The measuring cycle time, i.e. the time between the generation of two measuring times, amounts to some 70 s; withdrawal, transport and dosing of samples are tuned to the measuring process in such a way that representative analytical values will be obtained for the lignite transported by the conveyor.

The controlling element of the system is a central computer, which temporarily stores the values obtained and transfers them to a computer in the opencast mine's control centre for further evaluation and graphical representation of results. The data that can be retrieved are ash and sulphur contents of the individual analyses of the mining outputs and integrated values over freely selectable time intervals.

3. Use of Analytical Data for the Stockpile Balance of the Garzweiler Opencast Mine

To allow the smallest number of analysers possible to sample the lignite extracted as comprehensively as possible, these analysers are installed in the two conveying routes towards stockpile feeding (see Figure 5).

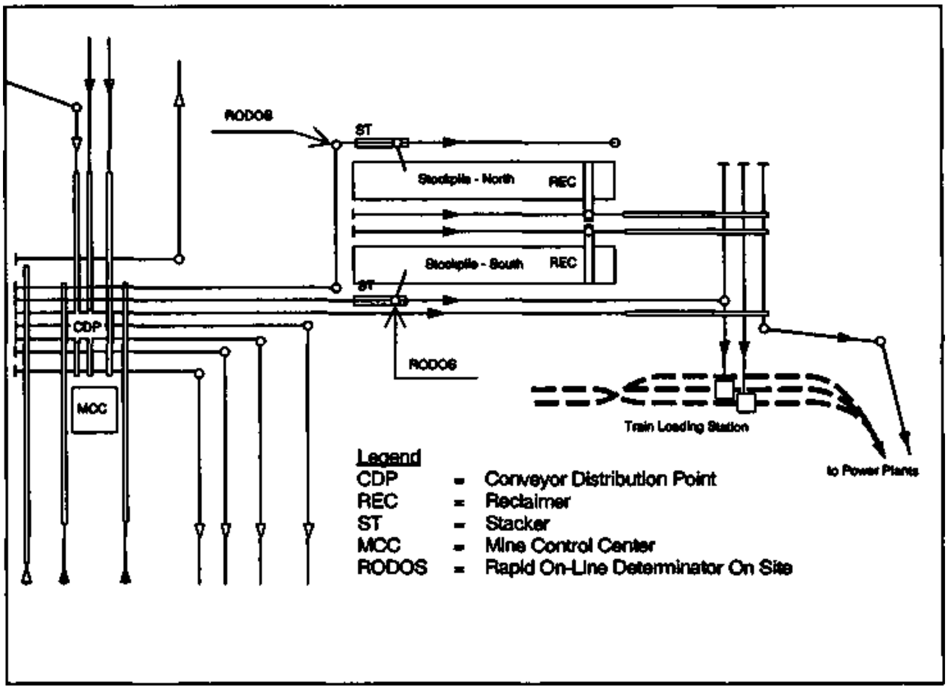

Figure 5 : Location of RODOS - Systems

Since each of these conveying routes is supplied by only one excavator with lignite, the analytical results can be directly assigned to the lignite excavators and used there to optimise the mining process itself. Furthermore, the quality-specific data of the lignite stored are available to the stockpile's blending concept.

The blending concept is based on the knowledge that greater quality variations of the run-of-mine lignite as a result of the excavator's operation normally occur at short intervals. Therefore, the blending concept has to be «timed at making optimum use of the stockpile content of 2 x 300,000 tonnes for homogenisation, which is relatively big for a daily amount of some

120,000 tonnes to be handled. The lignite is piled up in block operation (Figure 6). The cross-sectional area of the block is the total filling cross section of a stockpile compartment. When feeding the stockpile, the stacker used for that purpose will move over a short distance in the direction of the stockpile's longitudinal axis only when the outer limit of the filling cross section is reached by the lignite stacked. In this way, some 430 tonnes of lignite is filled per running metre of stockpile length. The bucket wheel reclaimers, on the other hand, work in bench operation, i.e. during reclaiming they are constantly moving in the direction of the stockpile's longitudinal axis. During this process, the lignite is reclaimed by means of the bucket wheel boom advance from four slices over several blocks or pockets. One stockpile compartment is divided into 70 pockets containing approx. 4,300 tonnes so that the cut-set consisting of slices and pockets will total 280 panels. Computer-aided selection and determination of the number of sampling

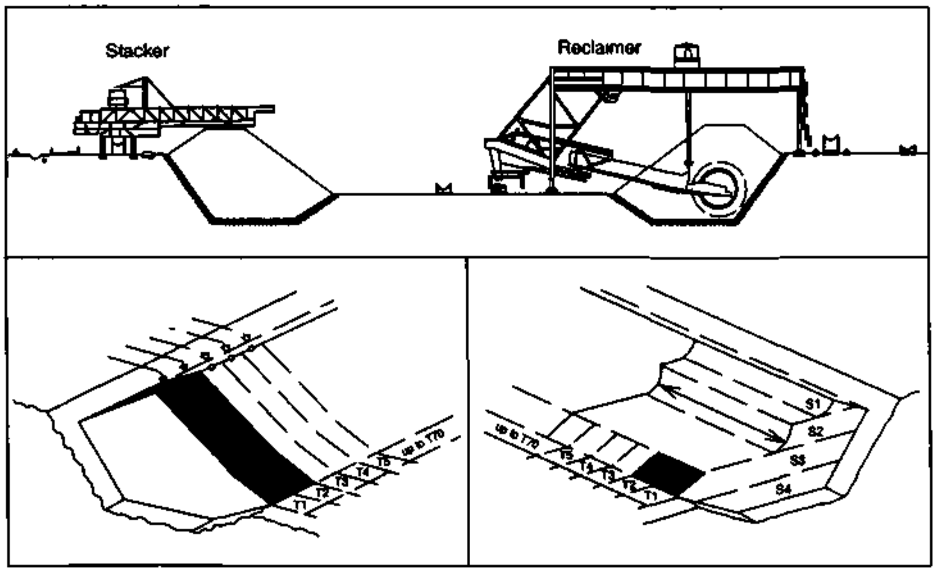

Figure 6 : Stockpile and Blending System in Opencast Mine Garzweiler

sections consisting of several panels help control the blending process. This, however, calls for topical information on the stockpile content.

For this purpose, an evaluation computer is used, where a stockpile model corresponding to the actual conditions is programmed with the division into pockets and slices already mentioned. Simultaneously with the operational processes in the lignite stockpile, this stockpile model copies the stacking and reclaiming processes. During stacking, the lignite amount, its contents of ash, sulphur, iron and potassium, the supplying excavator and the place of stacking in the stockpile are automatically recorded in the stockpile model. The lignite amount is measured by belt scales installed in each of the two excavator feeding routes and transported to the evaluation computer. In parallel with this process, the quality classifications for the ash and sulphur contents delivered by RODOS as well as the code of the active excavator are supplied to the evaluation computer and combined with the associated quantity data. The stacking place in the lignite stockpile results from the location of the track-mounted stacker at the lignite stockpile and the position of its slewing belt. The location of the stacker is measured by means of a rail-mounted friction belt, and the position of the slewing belt via an angle transmitter, and on the basis of the values thus obtained the stacking place is calculated. An evaluation computer supports the selection of possible reclaiming zones in the lignite stockpile in two alternative ways. Either a reclaiming zone extending over several pockets is specified by dialogue mode with the computer, which will then calculate and indicate the lignite's average quality, or the required lignite quality is stipulated by dialogue mode with the computer, for which it will propose a reclaiming zone extending over several pockets by means of a search algorithm. In the case of several possible reclaiming zones, the computer will always select the zone that is situated next to the current reclaimer's location. The lignite quantities taken from the stockpile are determined either by means of belt scales or by the capacity of lignite trains and deducted in the stockpile model of the evaluation computer.

4. **Operational Experience**

During the two years of the prototype's operation, the expectations in respect of the measuring accuracy, the availability and the maintenance costs were fulfilled to such an extent that it was possible to take the decision in favour of the construction of improved systems suitable for continuous operation.

The analytical accuracy of the instruments was verified by several reference sample collections. During that process, the dust samples' ash and sulphur contents, each of which was determined by the RODOS system, were compared with those of samples, which were conventionally shovelled off the conveyor belt and analysed in the laboratory. For both sulphur and ash very good correspondences were obtained. In addition, several large-scale tests were made where lignite sampled by means of RODOS was selectively fired in separate power plant units. Lignite sampling upstream of the boiler confirmed the ash and sulphur contents specified. According to the experience available, the system is capable of indicating the sulphur content with a standard deviation of 0.08 % in absolute terms for raw lignite with a sulphur content ranging between 0.25 % and 1.2 %. For the ash content, the accuracies obtained are sufficient for operational purposes and have a standard deviation of 1 % in absolute terms in the case of an average ash content of 10%.

With regard to the systems installed from mid 1990 till today it can be stated that the results are confirmed. The break down and maintenance cost to be spent for each of the RODOS systems are summing up to one man year in labour cost per year. It covers cleaning work, replacement of consumables and trouble shooting. The material cost per year of operation can be considered in the range of 1% to 2% of the initial investment cost. The availability in average is 77% of the operation time. The mayor trouble is observed during winter season and in cold and wet environment. Hence sucked material transport is hindered.

The operational advantages expected from continuous quality data for the lignite extracted have been fully confirmed by the experience gained:

- The power plants were supplied with much more constant lignite qualities. Sudden changes in the ash content entailing increased boiler plates' wear, slagging or ash removal problems were largely avoided.

- Continuous quality information and selective blending of lignite considerably increase the scope to take decisions in respect of lignite extraction from boundary areas of the deposit. Thus, the deposit's output is stepped up.

5. Summary

Cost-effective processing of lignite and ore requires the materials' chemical and physical properties to be known as early as possible. When the traditional sampling procedures and analytical methods are employed, the results of the quality control are generally not known until such a late point in time that the values ascertained are useless for the on-line control of conveyance, transfer and treatment processes.

The RODOS analyser system (Rapid On-line Determinator On Site) has been developed to remedy this situation. It allows the quality of large mass flows to be determined on a continuous basis.

The basic components of the RODOS system are:

- Dust sampling equipment
- analyser
- central computer for system control and monitoring and for evaluation of analytical data.

For the analysis, the sampling equipment takes samples of the dust produced by materials being moved, for example at belt transfer points. Due to this sampling principle, the system is suitable for large and small mass flows as well as for materials of greatly differing lump sizes. Lignite quality measurements are therefore possible during the mining process despite fluctuations in the quantities being mined.

It is demonstrated by the example of the Garzweiler opencast mine how the lignite upstream of temporary storage in the lignite stockpiles is sampled by means of such systems. The analytical results are considered in the stockpile balance that shows from what stockpile parts what lignite qualities can be taken to ensure optimum homogenisation.

The major operational advantages are that a more constant lignite quality will minimise breakdowns and wear in the power plants and that the output will be stepped up in boundary areas of the deposit.

References

(1) H.-J. Thiede, Einsatz kontinuierlich arbeitender Kohleanalysegerâte für die Betriebssteuerung im Tagebau Garzweiler, **BRAUNKOHLE 11/1991,** pp 27-33