Measuring the coal dust flow in burner pipes

H. Bräuer, M. Tappen

Abstract The results presented give an insight into the coal dust volume measuring system used at the Wilhelmshaven power plant. Two new measuring systems for measuring coal dust volumes and coal dust distributions have been investigated as part of a test. The comparison with a recognised isokinetic process of E.ON Engineering has shown that both measuring systems can measure coal dust volumes in states of inertia. However, the relative evaluation gives a better correspondence of the measured values, because cross-influences (not known to some extent) are not included in the measurement in the first approximation. The analysis of the load following behaviour shows that each measuring system supplies plausible values for itself. However, a comparison of the two shows that there can be considerable differences in individual burner pipes which cannot always be adequately explained at the end of the day. The plausibility check is if critical importance in individual cases. In view of the generally positive experience with the coal dust volume measurements, the Wilhelmshaven power plant is in the process of equipping the complete unit with a measuring system of this type.

1 Introduction
Efficient, safe and environmentally acceptable power generation has always been the primary objective of power plant operators. And against the backdrop of the liberalised power market, is it now more important than ever to identify and develop economic improvement potential. New approaches to firing control will help to improve the efficiency of the coal combustion process. One of relevant parameters relates to the use of coal dust measurements, which are used for continuously recording coal dust quantities and coal dust distribution in the burner pipes. This report compares two processes and gives a breakdown of the measuring results of the tests at the Wilhelmshaven power plant.

2 The Wilhelmshaven power plant
The Wilhelmshaven power plant which belongs to the E.ON Kraftwerke GmbH, formerly PreussenElektra Kraftwerke GmbH, is an imported coal fired unit with an net generated output of 747 MW. The coal is processed by four roller bowl mills of the Babcock MPS type. Each mill supplies 8 burners giving a total of 32 burners. The burners are arranged in a meshed opposed arrangement at four levels. The combustion air is transported by two fresh air fans to the individual burners, where it is divides into primary air (carrier air), secondary air, top air and bottom air. The secondary air is divided into core, envelope and stage air via a valve control system. The core and the envelope air are controlled individually for each burner, while a stage air can be controlled for four burners at a level. A part flow is taken from the secondary air upstream and downstream of the air preheater, mixed and supplied to the four mill air fans (Carrier air). A three stage fan-type forced distributor distributes the coal dust to the burner lines.

3 Use of coal dust volume measurements
The Wilhelmshaven power plant has been making coal dust distribution measurements since as early as the beginning of the eighties. It was found that owing to unfavourable flow conditions upstream of the first forced distribution stage the distribution of the coal dust to the individual burners varies considerably in some instances. The variation in the amount of coal dust introduced into the boiler creates problems when the individual burners are ignited. The increased risk of CO formation at the boiler wall and temperature differences in the combustion chamber may be the consequence of the coal dust distribution. The knowledge gained from the tests has been implemented by installing baffles in the pipe to the first fan-type forced distributor stage, which make sure that this stage receives a uniform flow. The coal dust distribution improved for a time, but then deteriorated as a result of wearing of the forced distributor stages.

The coal dust throughput was measured by isokinetic extraction, a time and labour intensive process, which is still the normal measuring method used when adjusting the firing system. This system can only work with static states; no conclusive information can be derived about the dynamic states in the normal mode of the coal mill.

Figure 1 illustrates the current results of a coal dust distribution measurement which was made with the isokinetic AKOMA system of E.ON Engineering. It can be seen that there is a considerable discrepancy in the coal dust distribution in the burner pipes of a mill, which manifests itself in overcharging or inadequate charging of
the burner pipes of up to around 35% (burner NL 44) compared with the average coal dust throughput. It was found that the dust distributed to a burner pipe is a function of the load state of the mill, when the dust distribution tendency usually remains the same. Even with a constant mill load (inertia stage), differences were measured in the coal dust distribution to the burners of up to 10% compared with the average throughput of the burner concerned.

The uncertainty in terms of the coal dust distribution means that technical firing systems are operated with excess air. The firing system at the WilhelmsHAVen power plant is operated at the full load point with an excess air of 25% ($\square = 1.25$). The combustion air is measured and distributed uniformly to the burners. Therefore, at overcharged pipes, the calulatory excess air value is well below the set value, so that the oxygen supply is so small at individual burners that there is a risk of increased CO formation. In the case of the inadequately charged pipes, there is an oversupply of combustion air, which promotes the formation of $\text{NO}_x$.

If precise information is available about the dust distribution to the burner pipes, the combustion process can be made uniform. On the one hand, making the combustion process uniform means the equal distribution of the coal dust to the burner pipes and on the other, the adjustment of the combustion air (secondary air) according to the measured coal dust distribution to a burner. The adjustment of secondary air to the measured pulverized coal flow results in the ideal case in a uniform fuel/air ratio corresponding to the projected values at the burners.

By integrating a coal dust volume measurement, the WilhelmsHAVen power plant expects to make the following improvements and savings:

- increased operating reliability, more uniform combustion,
- reduction of the excess air, reduction of the waste gas loss,
- reduction of NO, and saving of $\text{NH}_3$,
- reduction of auxiliary power (fresh air fans, suction passes).

The list of possible improvements and potential savings varies from one power plant to the next and is certainly not exhaustive.

After various vain attempts, measuring methods were finally developed in 1997 for determining the coal dust mass flow which, in terms of method and handling, are suitable for use in a power plant. The measuring systems differ in terms of measuring process and measuring principle. Depending on the measuring process, a distinction is made between systems that work continuously and those that work discontinuously. The systems that work continuously update the results of the coal dust distribution in the burner pipes more or less in real time, so that precise information can be obtained at any time on the coal dust charge in a burner pipe. Depending on the measuring results, the operator is able to balance the firing system accordingly. The discontinuous measurement works on the basis of a mechanical sampling process, when the coal dust samples are taken from a burner and pipe over a certain period by scanning representative cross-sections and the coal dust mass throughput is calculated from this information. A dynamic behaviour of the coal dust charge, as occurs in the case of load changes, cannot be picked up with this process, so that the fuel/air ratio cannot be adjusted continuously. However, the operator is able to investigate the sample taken in order to obtain information about the moisture or grinding fineness of the coal. The tried and tested pendulum sensor process of E.ON Engineering was used for the discontinuous measurement. It served as a reference measurement in the first instance and was later used for the comparison with the other continuous systems.

High demands are made of the measuring equipment. The continuous measurement of the coal dust throughput, high reliability in operation and wear resistance and a good measuring accuracy are just a few examples. The systems available in 1997 were new developments that had not yet put their fitness for practical application to the test. Therefore, the WilhelmsHAVen power plant decided to compare the measuring systems with each other directly as part of a test.

4 Test arrangement

The tests were carried out at the eight burner lines on one mill. Considerable importance was attached to choosing the place where the measuring systems were to be installed. (Fig. 2). The measuring systems were installed one above the other, seven metres apart, so that they would not influence each other. Adequately dimensioned inlet and outlet sections and also the vertical installation offer almost ideal measuring conditions. The arrangement of the measuring points allows the fuel throughput through eight mill pipes to be recorded simultaneously. Therefore, it is possible to compare the results of the individual measuring systems and draw conclusions about the accuracy.

Because of the competition between the individual companies, we are not giving any names here. The measuring systems are designated as “A” and “B”, respectively.