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Optimisation of lignite beater wheel mills using modern gas flow measurements

A new digital time-of-flight-based cross-correlation technique, employing pairs of robust infrared sensors, enables hot recirculation gas flow into lignite beater wheel mills to be accurately measured, with significant potential benefits for mill control and optimisation

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Beater wheel mills, also called ventilation mills, as employed in lignite fuelled power plants, are large and complex pieces of equipment (see Figure 1). Even for modern beater wheel mills, gas flow measurements are not generally accurate enough for them to be controlled by total instantaneous mass and energy balances.

Besides the unreliable measurement of air flows into the mill, the main obstacle is the unknown amount of hot recirculation gas from the boiler, which is used to dry the lignite in the mill and at the same time keep the mill inert so that no explosion hazard can occur.

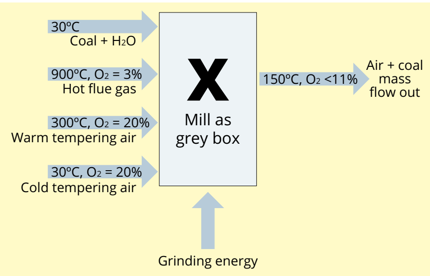
The control state space in which a beater wheel mill is operated, and which is defined mainly by the enthalpy flows in and out of the mill, can change rather quickly if individual parameters such as the water content of the lignite is changing rapidly. In this instance, mill gas inputs and outputs can undergo changes that are hard to control as the amount of heat into and out of the mill is not known.

The total flows into and out of the mill are shown in Figure 2.

The biggest challenge is to measure the hot flue gas flow into the beater wheel mill (see Figure 3). This recirculation gas is usually around 900°C and carries the bulk of the drying energy for the coal. On top of that this gas only contains 2% of O2 which makes it pivotal in keeping the mill inert.

Cross correlation technique

A new and 100% drift free digital technology for measuring hot and dusty gas flows that



Above: **Figure 2. Flows into and out of the mill. The control strategy targets: constant volume flow; coal mass flow; temperature; max O_2 limit**

Figure 1. Beater wheel mill in typical lignite fuelled power plant

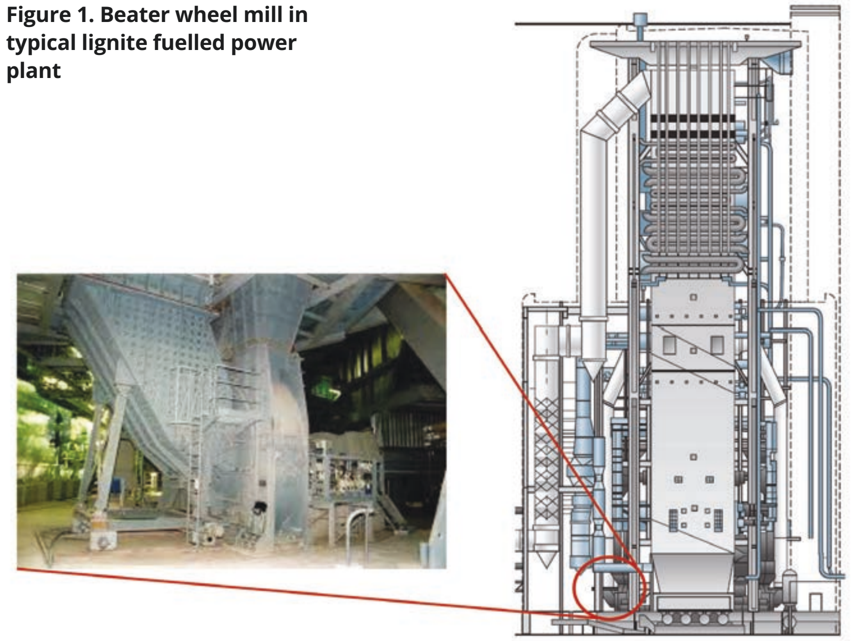
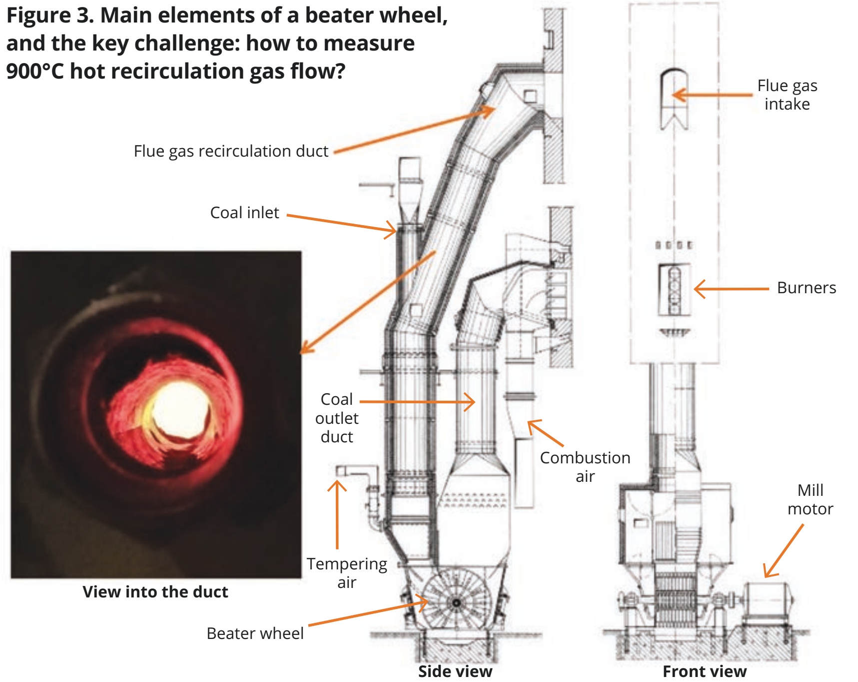
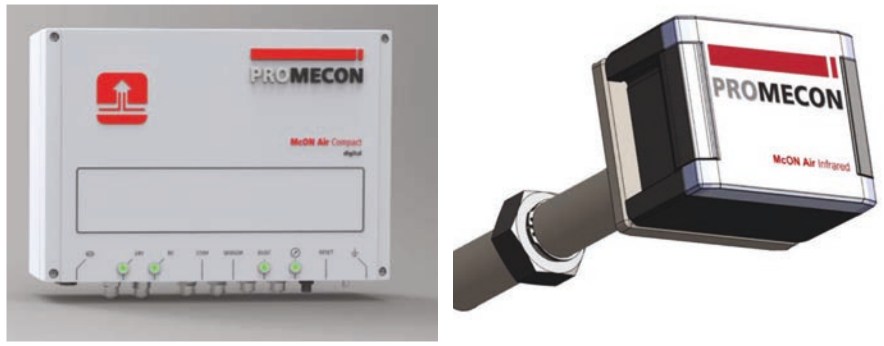


Figure 3. Main elements of a beater wheel, and the key challenge: how to measure 900°C hot recirculation gas flow?





Above: **Figure 4. Electronics box and new IR sensor**
Right: **Figure 5. IR sensor installed**

has emerged in the past ten years in modern power stations is the cross correlation technique using sensors that record the succession of electrostatic charges passing through the gas duct. This electric charge imparts a current to the sensor which mirrors the random succession of charged clouds of particles passing through the duct. As the dust in the gas flows carries the electric charge it turns from being the obstacle it presents for traditional measurement methods, such as dP or hotwire anemometers, into being a perfect tracer for the flow velocity of the gas. Cross correlation measurement systems have become the first choice for the new generation of coal fired boilers in Europe, especially for measuring preheated air flows such as primary, secondary and overfire air.

These digital measurements, which are solely based on the time of flight principle applied to the electric charge, are also suitable for measuring the preheated air flows to the beater wheel mills of lignite power plants. The measurement systems are 100% drift free, and can also be delivered as SIL2 approved sensors. The specific problem, however, is that their sensors, which protrude into the duct, are only as durable against temperature as their material properties allow. Usually temperatures above 800 °C will start to become challenging especially when abrasive ash is present in the process gas.

Using infrared

A new technique developed by PROMECON, building on its extensive experience with cross correlation measurement systems, enables this hot gas flow to be measured reliably. By cross correlation of optical (IR) signals the newly developed non-intrusive measurement sensor on the flue-gas recirculation duct can measure the gas flow accurately and hence provide the most important missing bit of information in order to control the state space of the mill. The main novelty of this setup is the front-end sensor, which detects the infrared light emitted by the gas itself at two locations aligned in the flow direction.

The electronic measurement box used is identical with the ones that have been successfully working in many power stations, only with new parameters suited to the optical signal detection.

Figure 4 shows the box and optical sensor for gas temperatures of up to 2000°C. Figure 5 shows the sensor installed.

Figure 6 provides live measurement data for a 800 MW lignite fired plant in Germany, showing gas flow into one beater wheel mill. The upper plot shows the velocity of the hot gas through the recirculation duct. Several cross checks with water-cooled testing lances proved the high accuracy of the measurement.

The lower plot is a measure of the correlation quality of the two raw signals. It proved to be very constant and stable throughout the whole testing time of over 6 months. The system proved to be 100% drift stable (which was checked at the beginning and the end of the testing period). This is not a surprise as the measurement is solely relying on digitally clocked out time, which makes it fully digital.

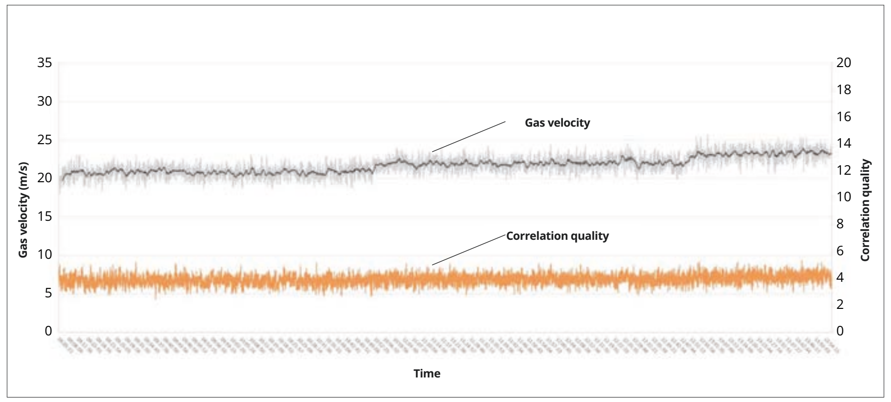
With the hot flue gas measurement technique described here the missing component of the mass/energy balances can be established (Figure 7) and the classical control parameters for the mill, such as air dampers and wheel speed control, can be used to keep the mill at its optimum set point.

The measurement allows the detection of abrupt changes in operating conditions such as a sudden surge of water due to an increase in fuel moisture content, which will upset the beater wheel controls and often leads to mill trips.

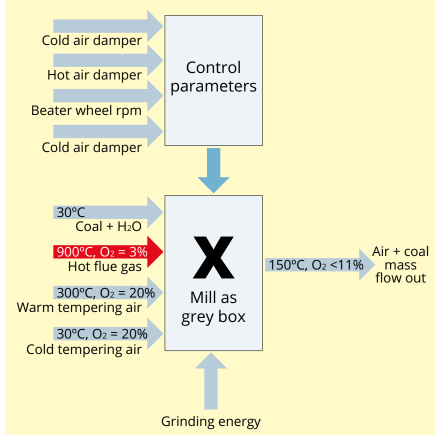
O_2 levels can be controlled by a feed forward loop as the composition of all gas flows into the mill is known at all times. Also, beater wheel characteristics such as wheel wear over time can be monitored and used for predictive maintenance.

Future outlook

The full impact of being able to measure hot gas flows through the mill and its optimisation has yet to be explored. Several power companies are showing interest in this measurement that is so pivotal to the basic operation of this type of mill. ■



Above: **Figure 6. Live data from 800 MW German lignite plant**



Above: **Figure 7. The hot flue gas measurement provides the missing data needed to determine the mass/energy balance**

More details can be found in the proceedings of the 2019 ICCI conference in Istanbul, Turkey.