Modern mill and fan instrumentation for cement plants

The article describes the task of accurately measuring gas flow through a large pulverizer such as a raw mill. Besides the pure mechanical layout of a pulverizer special attention has been given in recent years on the material and gas flow management through a large scale mill. The main aspects for this motivation are the product quality itself but beyond that also the flat lined operation of the pulverizer.

I) Optimised Grinding:

The largest concern with grinding certainly is the quality of the processed product i.e. its fineness distribution as well as the nominal maximum throughput of a pulverizer at which it can keep the guaranteed fineness values.
A mill has three basic processes which act together in order to achieve the final grinding result:

The mechanical grinding part:

This process is connected to the grinding elements of the mill, the tires, the bowl (on a vertical spindle mill) or the grinding media in a tube mill. Especially in a vertical spindle mill the roller pressure will not only have an impact on the fineness of material in conjunction with classifier speed but also on the bed depth of the material on the roller table. A dynamic change of roller pressure will hence impact the short term output of the mill.

The thermal part for achieving a targeted moisture of the product on the outlet of the mill:

This part is usually quite important for coal mills where the raw material has to be dried down from a moisture of say 10%-20% to only a few percent on the classifier. This process is connected to the enthalpy flow through the mill, which is defined by the gas flow, the material throughput and the temperature drop over the mill.

The pneumatic transport and classification part of the mill:

This process is mainly connected to the material and airflow through the pulverizer.
It is obvious that all three parts are linked to each other. For example a short term increase in roller pressure will increase the material output. The same will happen with increased air flow or temperature differential over the mill. That also means that a short term change in material flow can have several causes. Mill pulsations, instabilities of the grinding process and operational limits are usually tied to these crucial values. In order to keep these variables within their specified range the most important thing for pulverizer control is the accurate measurement of the base values of these processes. These values are:

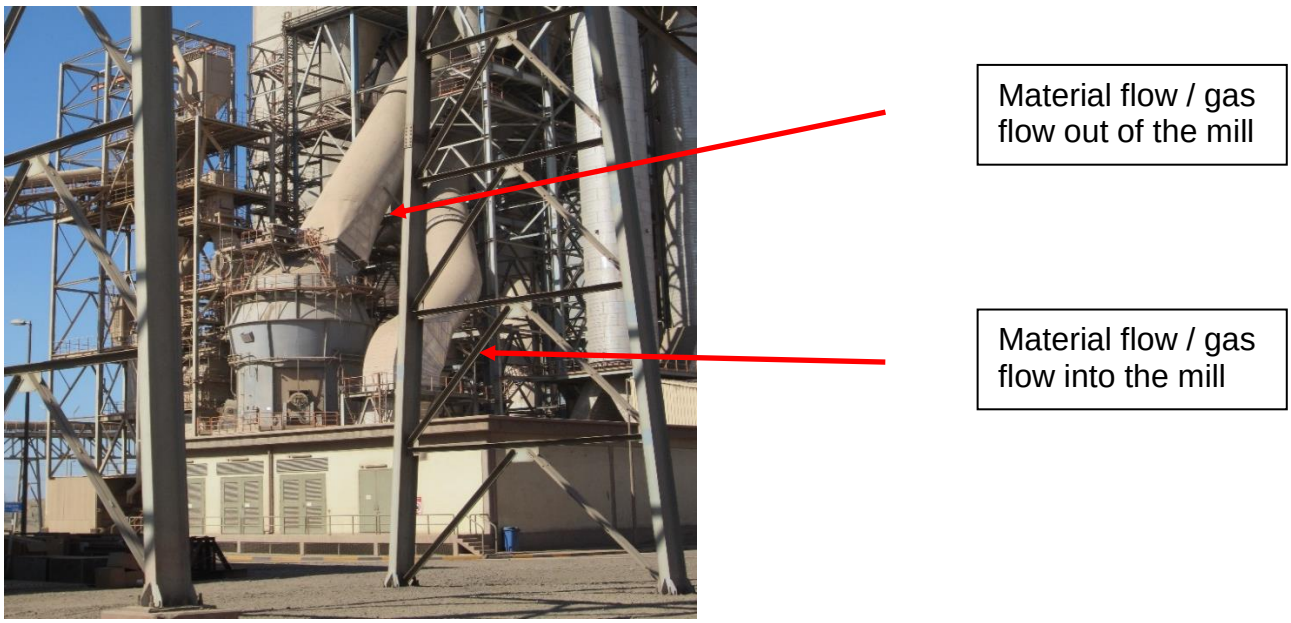
- Gas flow through the mill
- Material flow into the mill
- Material flow out of the mill

- Delta pressure over the mill
- Delta T over the mill

Even in modern Cement plants these five essential values are not all measured or in many cases not measured accurately.

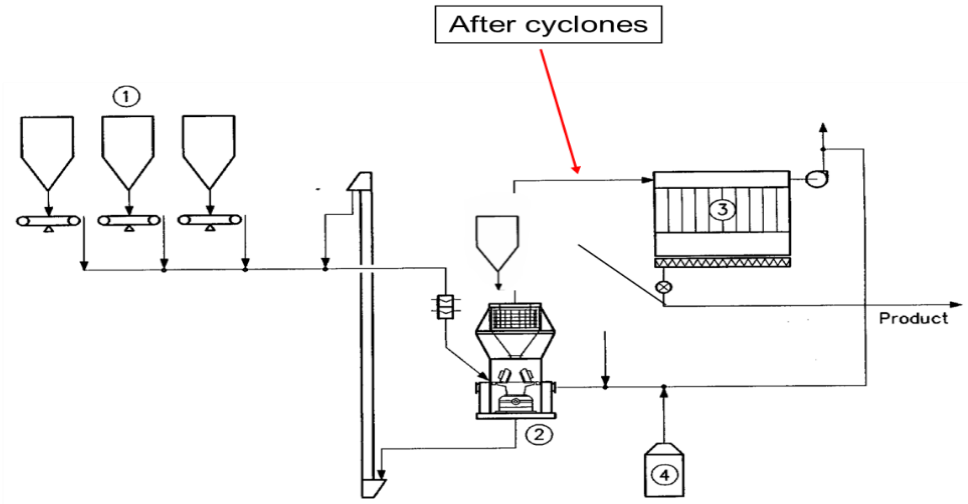
In this article we would like to focus on the two following measurement parameters which are usually a hard to measure accurately.
First of all gas flow through the mill: the nature of the gas flow through a raw or cement mill is that the gases are contaminated with dust. A measurement of gas output from a mill or raw recirculated gas hence is impossible. But even in clean gas measurement situations, when the flow is measured downstream of a bag house filter over time the used delta P measurements are prone to drift.

The second measurement parameter is the material flow out of the mill. This parameter is usually not measured at all. However in conjunction with the material flow into the mill the amount of material in the mill can be monitored. This is usually done via the delta pressure over the mill. However pulsations of material output often go undetected so that the stability of the grinding process is lacking this essential parameter.



Raw mill

There are many examples of how the grinding process could be optimized by integrating these two parameters into the mill control loops.
One of the earliest has been described by HOLCIM technical managers Syed Suhail Akhtar and Roland Bachmann at an IEEE conference in 2006. The measurement of airflow after the first raw meal cyclone on the mill fan.



Gas flow measurement with McON Air on outlet of raw mill

The findings on savings of HOLCIM were 0.5 - 1 KWh/t of raw meal. At an electricity price of 0.08 €/KWh and 3000 full load hours with a 1 MW fan this would equal 120 000€ - 240 000 € per year in savings.
So a modern mill control strategy will be using gas mass flow out of the mill on the one hand and dust concentration out of the mill on the other hand.

The PROMECON technology on gas flow

The system utilizes the triboelectric principle. Electrical signals created by (dust) particle clouds passing each of the upstream/downstream sensors are cross correlated and referenced by their time shift. The digital system requires no calibration, imparts no pressure drop to the system, and does not drift over time. Various applications at different cement plants will be discussed and will illustrate how the direct measurement of dust carrying gas flows has opened new ways to monitor, control, and optimize the cement making process. A measurement point requires the installation of a pair of sensors aligned parallel to the longitudinal axis of the pipe. Electrical signals, created by particle clouds passing over the sensors, are analyzed by the instrument. Charge patterns detected by the first sensor are cross correlated with patterns detected by the second sensor. Knowing the time shift of the signals and the distance between the sensors, the velocity can be very accurately determined. Using the cross sectional area of the pipe, as well as the pressure and temperature of the stream, the volume and mass flow can be calculated. Note that the only real measurement is time and that the measurement itself is not affected by temperature or pressure conditions of the stream. The electrical signals from the two air flow sensors are processed in the McON Air Box shown in Figure 1. A new flow measurement is calculated every second. A larger multi-channel McON Air Box is also available for several applications that are located within 40 m.

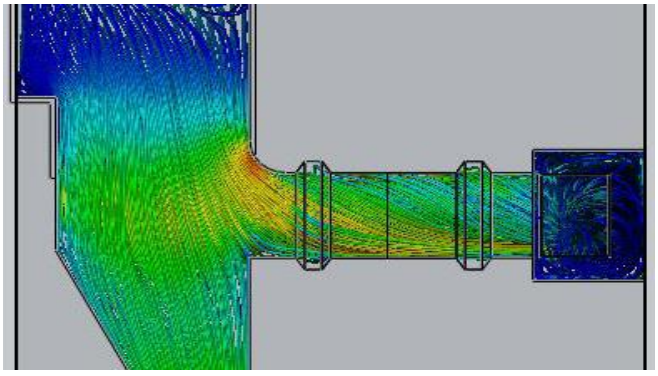
McON Air Measurement System

A new feature of the PROMECON technology is the ability to detect changes in the dust loading of the gas flow out of a mill. By this, pulsations of material output can be detected and operation parameters for the mill control be adjusted.

II) Fans and Filters

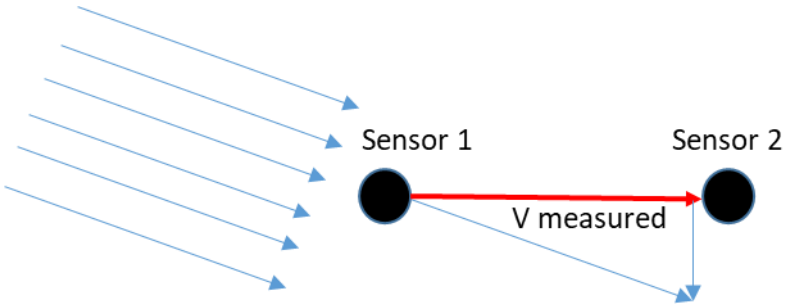
One crucial part of the grinding process is the fan/filter combination that is situated at the outlet of a mill. In terms of energy the fan power needed for a mill is of the same order of magnitude as the grinding power. So energy savings or optimization of flow will primarily go along with fan power.

The true flow through a fan can be measured by PROMECON´s modern correlation technique. With these systems special attention is given to the fact that the flow into and out of a fan will not be uniform on profile. Especially the spin of the air flow poses a great challenge to conventional measurement technologies.



CFD example of swirled flow, which can be measured correctly with correlation measurement systems

Here the measurement of velocity as a vector has become one of the most important aspects of modern measurement systems. The correlation technology of PROMECON ensures the correct measurement of velocity in a defined direction (i.e. the direction along the duct).



Correlation measurements are vector measurements: V measured is the distance (Vector) divided by time.

Dust or no Dust?

Any system used in this configuration must be capable of measuring with as well as without dust contamination. This property is ensured by the McON air Range Extender technology, which allows the correlation system to be used in clean gas as well as in dust contaminated flows.
An additional feature to be used with the PROMECON fan measurement is the detection of dust on the outlet of the bag house filter. Should the values of dust behind the bag filter exceed a certain limit then there can be an alarm for the detection of the filter problems.

Broken bag filter, which can be monitored and recorded.

Conclusion:

In the Cement industry the instrumentation levels on gas flows have historically been low as the flow is hard to measure. Today it is possible to accurately measure gas flows with and without dust contamination regardless of swirl components in the flow. This allows large mills to be outfitted with much better instrumentation on gas flow and material output. Also this allows for a much more accurate measurement on large scale fan inlets as well as outlets. Behind bag filters on the clean gas side alarms can be given on bag house problems.