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SUMMARY

The contribution describes the task of accurately measuring gas flow through a large grinding mill such as a vertical roller mill for the production of raw meal. Besides the pure mechanical layout of the mill special attention has been given in recent years to the material and gas flow management through the mill. The main aspects for this motivation are the product quality itself but beyond that also the flat lined operation of the mill. A stable process of the mill will allow for the reduction of gas amount that is flowing through the mill. This is especially important as conveying the process gas through a vertical roller mill constitutes about half of the electric energy consumption of the mill. This article describes a novel technology for measuring the gas flows through the mill directly. In addition dust emissions from the mill at the bag house outlet can be measured.

ZUSAMMENFASSUNG

Der Beitrag befasst sich mit der genauen Messung des Gasvolumenstroms durch eine große Mühle, wie z.B. einer Vertikal-Rollenmühle für die Rohmehlerzeugung. In den letzten Jahren ist neben der rein mechanischen Auslegung einer großen Mahlanlage das Interesse an einem immer besser kontrollierbaren Material- und Gasdurchsatz gestiegen. Wesentliche Gründe für dieses Interesse sind nicht nur die Forderungen der Betreiber nach Gewährleistung der Produktqualität, sondern auch die Steigerung der Prozessgüte beim Betrieb der Mahlanlage. Die Verbesserung der Prozessgüte ermöglicht eine Absenkung des Gasdurchsatzes, den die nach dem Luftstromprinzip betriebene Vertikal-Rollenmühle zum stabilen Betrieb benötigt. Das hat für die Effizienz der Mahlanlage eine große Bedeutung, da nahezu die Hälfte des gesamten elektrischen Energieaufwands zur Aufrechterhaltung des Mahlprozesses auf das Prozessgebläse entfällt. Dieser Beitrag beschreibt, wie die Gasmenge, mit der die Mühle beaufschlagt wird, direkt gemessen werden kann. Darüber hinaus wird auch die Messung der Staubkonzentrationen in den Prozessgasen hinter dem nachgeschalteten Gewebeabscheider kurz diskutiert.

(English text supplied by the author)

Modern mill and fan instrumentation for cement plants

Moderne Instrumentierung von Mühle und Gebläse in Zementwerken

1 Optimized grinding process

The largest concern with grinding certainly is the quality of the processed product i.e. its fineness at the nominal maximum throughput of the mill.

A vertical roller mill has to fulfill three basic processes which act together for achieving the best final grinding results:

1. The mechanical grinding part is connected to the grinding elements of the mill, the rollers and the table of a vertical roller mill or the grinding media in a tube mill. Especially in a vertical roller mill the roller pressure will not only have an impact on the fineness of the material in conjunction with the classifier 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.

2. The thermal part of the mill is responsible 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 10 to 20 % to only a few percent. 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.

3. The pneumatic transport and classification part of a vertical roller mill is mainly connected to the material and airflow through the mill.

It is obvious that all three process 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. In order to keep these variables within their specified range it is most important to control 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 and
- Delta temperature 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 contribution the focus is on the measurement of two parameters. First of all there is the measurement of the gas flow through the mill. The nature of the gas flow through a vertical roller mill (▸ Fig. 1) is that the gases are contaminated with dust. A measurement of the gas output from a mill or of the raw recirculated gas is therefore impossible. But even in clean gas measurement situations, when the flow is measured downstream of a bag house filter over time the delta pressure measurements used 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 by measuring 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.

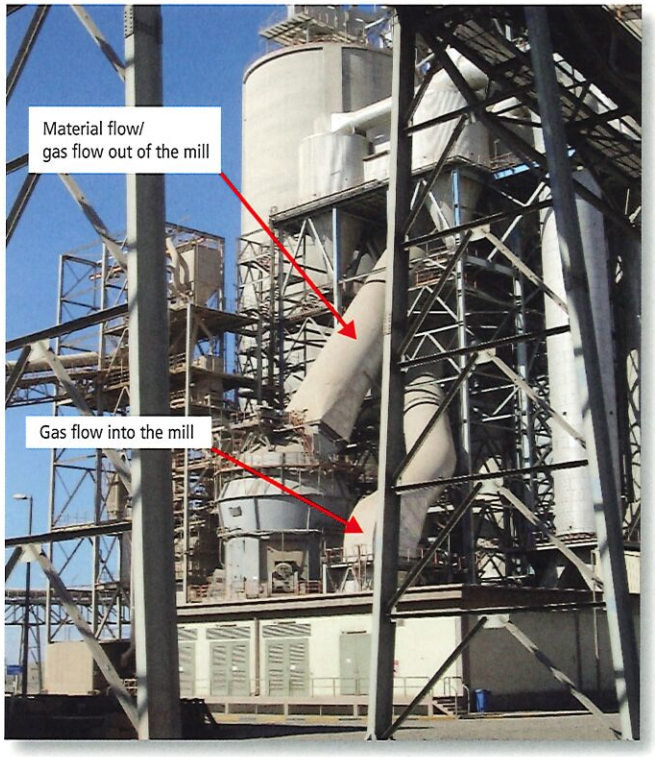

Figure 1: View of a vertical roller mill for raw material grinding

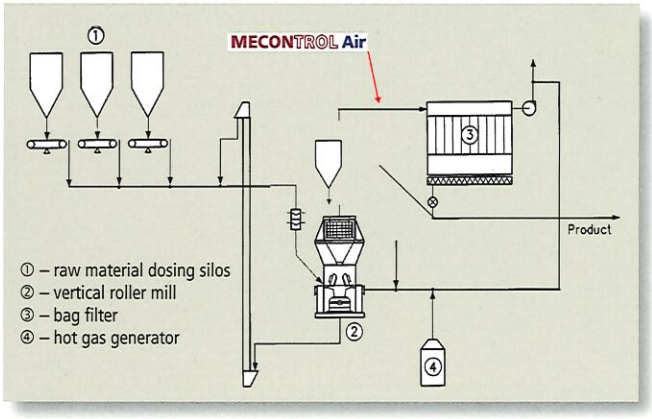

Figure 2: Gas flow measurement with the McON Air system on the outlet of a vertical roller mill for raw material grinding

PROCESSING

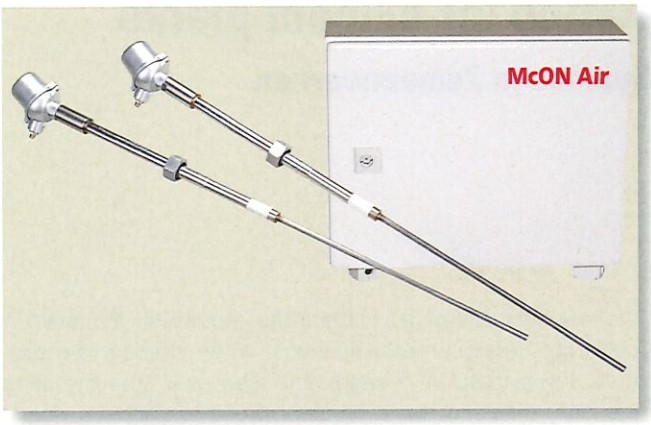

Figure 3: McON Air measurement system

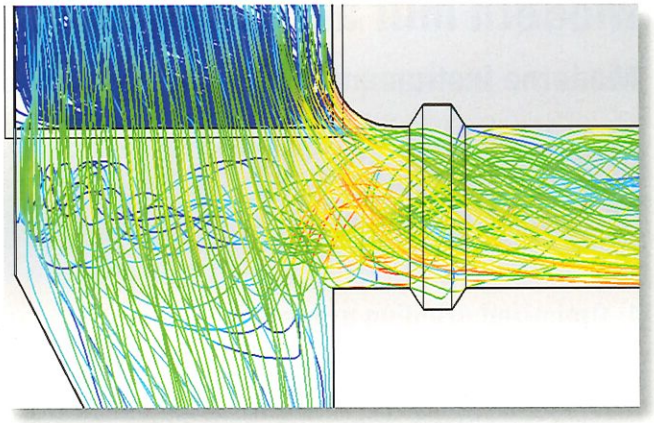

Figure 5: CFD example of swirled flow, which can be measured correctly with correlation measurement systems

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 the airflow is done after the cyclones before the bag filter. ❯ Fig. 2 shows the flow sheet of a vertical roller mill for raw material grinding

The findings on savings by Holcim managers were 0.5 to 1.0 kWh/t of raw meal. At an electricity price of 0.08 €/kWh and 3000 h/a and with a installed fan power of 1 MW the savings per year can reach between 120000 to 240000 €. A modern mill control strategy should use a gas mass flow and dust concentration out of the mill.

Figure 4: Combination of the process fan and de-dusting filter

2 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 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. The only real measurement is time and 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 ❯ Fig. 3. 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 a distance of 40 m.

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 can be adjusted.

3 Fans and bag filters

One crucial part of the grinding process is the fan/filter combination (❯ Fig. 4) at the outlet of the mill. In terms of energy the fan power needed for a vertical roller mill for raw material grinding is mostly the same as the power demand for driving the grinding table. Therefore energy savings or optimization of flow will primarily go along with the drive power of the fan.

The true flow through a fan can be measured by Promecon's modern correlation technique (❯ Fig. 5). With these systems special attention is given to the fact that the flow into and out of a fan will not be uniform in profile. Especially the

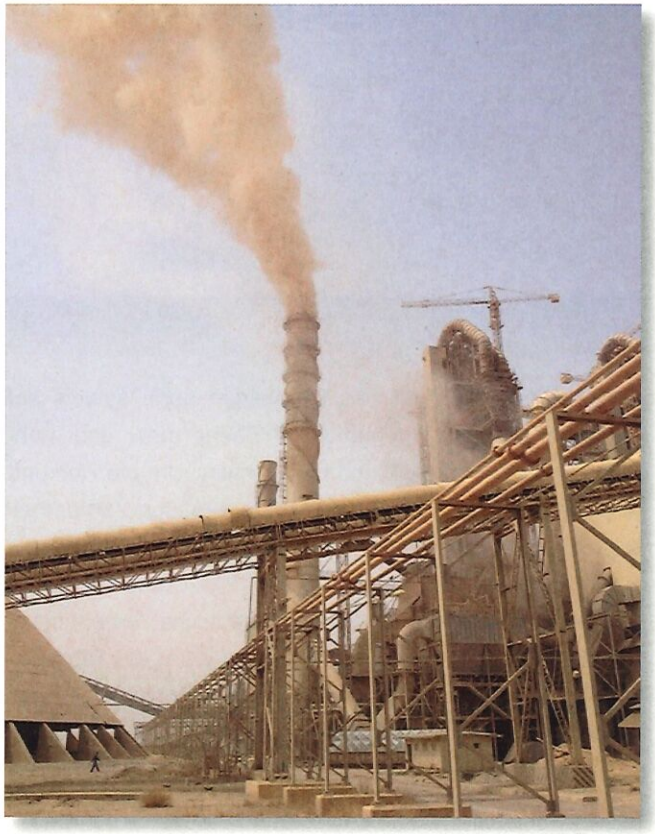

Figure 6: Broken bag filter, which can be monitored and recorded

spin of the air flow poses a great challenge to conventional measurement technologies.

Here the measurement of velocity as a vector has become one of the most important aspects of modern measurement systems (▶ Fig. 6). The correlation technology of Promecon ensures the correct measurement of velocity in a defined direction (i.e. in the direction along the duct).

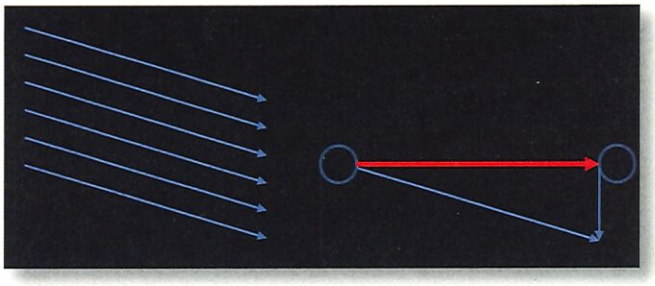

Figure 7: Correlation measurements are vector measurements; V measured is the distance (Vector) divided by time

4 Dust or no dust?

Any system used in this configuration must be capable of measuring the gas flow with or without dust contaminations. 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 the dust content behind the bag filter exceed a certain limit then there can be an alarm for detection of a filter problem (▶ Fig. 7).

5 Final remarks

In the cement industry the instrumentation levels on gas flows have historically been low as the flow is complicated 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 vertical roller 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 regarding filter problems. ◀

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SUMMARY

As a harmful environmental toxin, mercury is coming increasingly under the political and social spotlight at both the national and international levels. The VDZ (German Cement Works Association) with wide support from its member plants has drawn up a mercury balance for the entire German cement industry to clarify the origin and location of mercury in cement production. It is based on more than 5300 data analyses on solids from the incoming and outgoing raw materials, fuels and products as well as data on the emissions to the air, from which material-specific mercury mass flows have been calculated. The result of the balance shows that it is substantially closed, with an output-side balance remainder of about 10 %. There is a fairly large level of uncertainty, mainly because of some very large mass flows, like limestone/marl/chalk and granulated blastfurnace slag, which have exceptionally low mercury concentrations with numerous analytical values below the limit of quantification. Long-term investigations at several cement mills have shown that the mercury concentration in the exhaust air lies at a negligibly low level.

ZUSAMMENFASSUNG

Quecksilber als schädliches Umweltgift gerät sowohl auf nationaler als auch internationaler Ebene mehr und mehr in den Fokus von Politik und Gesellschaft. Um die Herkunft und den Verbleib des Quecksilbers bei der Zementherstellung zu klären, hat der Verein Deutscher Zementwerke (VDZ) mit breiter Unterstützung seiner Mitgliedswerke eine Quecksilberbilanz über die gesamte deutsche Zementindustrie erstellt. Grundlage dafür sind mehr als 5300 Feststoff-Analysendaten der ein- und ausgehenden Rohstoffe, Brennstoffe und Produkte sowie Daten zur Emission in die Luft, aus denen materialspezifische Quecksilbermassenströme berechnet wurden. Das Ergebnis der Bilanzierung zeigt, dass diese mit einem austragsseitigen Bilanzrest von etwa 10 % weitgehend geschlossen ist. Größere Unsicherheiten bestehen vor allem aufgrund einiger sehr großer Massenströme wie Kalkstein/Mergel/Kreide und Hüttensand, die äußerst geringe Quecksilberkonzentrationen mit zahlreichen Analysenwerten unterhalb der Bestimmungsgrenzen aufweisen. Langzeituntersuchungen an mehreren Zementmühlen haben gezeigt, dass die Quecksilberkonzentration in deren Abluft auf einem vernachlässigbar niedrigen Niveau liegt.

(Translation by Robin B.C. Baker)