It all comes down to the downcomer

Modern Cement plants all use a kiln pre-heater, which is connected to the tertiary air, the pre-calciner, the bypass and the rotary kiln. The hot oven gases which come out of the kiln inlet are subsequently used to heat up and pre-calcine the Raw Meal. In addition, fuel as well as tertiary air is added in the pre-calciner section in order to drive out the CO_2 from the limestone before it enters the kiln and is sintered into clinker. Any unwanted by-gases such as Chlorine are branched off through the bypass.

Figure 1: Typical Downcomer

Just this short description is enough to point out that the gas flow exiting the preheater into the downcomer is coming from one of the most essential and complex process steps of cement making.

It is not hard to see that controlling this gas flow is essential for several aspects of the cement production:

- The preheating of the raw meal,
- The correct calcination with as little NOx formation as possible,
- The prevention of larger agglomeration of material upstream of the kiln inlet,
- The correct gas flow through the kiln, reducing excess air to a minimum whilst preventing a reduced atmosphere.

By these different part process steps gas is subtracted from the main flow (bypass) or added to the main flow (tertiary air, leakage of the preheater cyclones). It is only possible to measure the total gas flow after it has all happened and that is in the Downcomer. The Downcomer carries all the gas from this process and is connected to an ID Fan. The ID fan operation has a major effect on the all the aforementioned parameters and is reaching up to the clinker cooler where the draft into the kiln head, which is caused by this ID fan, has a direct impact on the cooling behavior of the clinker cooler.

So how is the gas flow in the downcomer controlled? As mentioned before the most critical parameter in the kiln process is the O_2 content. The atmosphere in the kiln should not be reducing as this will damage the clinker. With this in mind an O_2 measurement upstream the kiln inlet where the gas comes out is essential. Only if a minimum excess O_2 can be guaranteed the clinkering process will be safe. Measuring the O_2 on the downcomer however has the disadvantage of measuring a lot of false air which is coming in by the tertiary air as well the leakages of the cyclones. The O_2 levels in the downcomer can be higher than 10 % when actually a 2 % margin is to be maintained on the kiln inlet.

In recent years more and more cement plants have installed sampling systems on the kiln inlet which run a water-cooled lance into the kiln and take a gas sample which is subsequently analyzed.

Figure 2: CEMTEC Kiln O_2-Measurement by courtesy of ENOTEC GmbH

The big advantage of this probe is that it will only measure the O_2 that is coming out of the kiln. So other leakages will not influence the measurement result which allows a far better control of the kiln.

However, the shortcoming of any extractive measurement method like this will be the time lag of the measurement as well as the limited representativeness especially over the short term. If a measurement like this is used solely to control the ID fan and hence the kiln process, there will be changes and fluctuations in the ID fan control which might not be original from the gas flow but far more from the O_2 distribution over the large cross-sectional area of the kiln inlet. This distribution will vary over time so that over long term an average O_2 value which is representative for the stoichiometry in the kiln, can be found. However short-term fluctuations measured by the O_2 sampler will not necessarily reflect a change in gas flow or fuel flow. They may not even reflect a short-term change of the overall stoichiometry in the kiln. Hence the control of the ID fan using just O_2 will have clear limitations in reducing process noise.

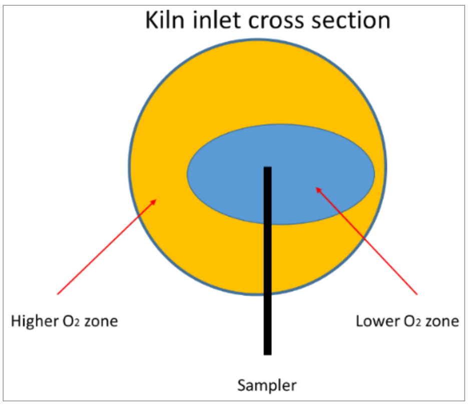

Figure 3: Kiln inlet cross section

As a consequence of a control purely based on O_2 the ID fan control will get noisier, the gas flow will change more than necessary, bringing all the other process parameters (bypass gas, stoichiometry of precalciner, neutral zone in the clinker cooler etc.) into a transient mode. The process will start to generate unnecessary process noise and will not as flat-lined as possible.

It is much better to use a direct gas flow measurement in the downcomer as a short-term control signal which is cascaded by the O_2 measurement of the lance in the long term. By this the gas flow can be kept far flatter lined, process noise be reduced whilst making sure that the O_2 corridor of the kiln exhaust gas is not left.

The reason why this has not been done over the years is the unavailability of a reliable and drift free gas flow measurement that can survive under the harsh and dusty conditions of the cement making process.

With PROMECON McON air system utilizing the tribo-electric measuring method, a precise flow measurement can be made directly behind the last cyclone stage and directly at the scene of the gas analysis. Based on independent expert's estimation, a more stable operation of the rotary kiln can save up to 5 % of fuel energy. PROMECON McON air has a maximum measurement error of 2 % in volumetric mass flow, such precise instrument provides the necessary energy saving control of the kiln ID fan to stabilize the complete pyro process.

Measurement Technology

The airflow measurement system uses a cross correlation technique to measure the velocity of particles flowing in a gas stream. A measurement point requires the installation of a pair of sensors aligned parallel to the longitudinal axis of the pipe. Each sensor is simply a metal rod electrically isolated from the duct, extending across the gas flow stream. Electrical signals, created by particle clouds passing over the sensors, are analysed 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.

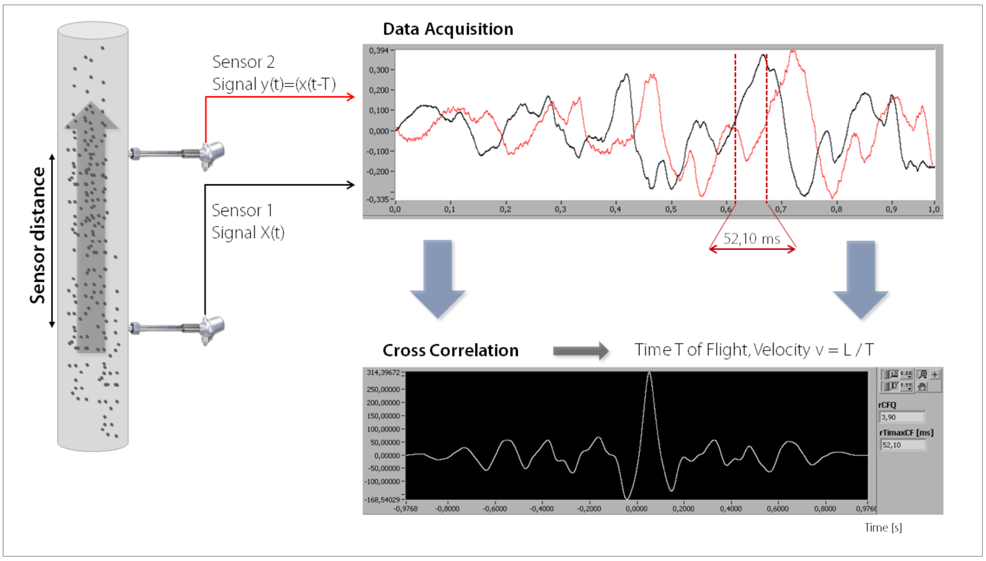

Figure 4: Measurement principle of McON Air

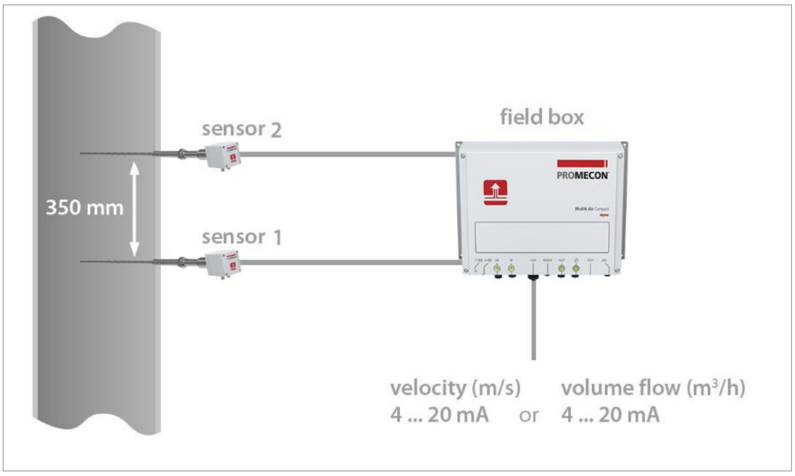

Figure 5: Measurement principle of McON Air (2)

Implementation

The McON air system can be installed on the downcomer duct to measure the volumetric mass flow directly. This flow measurement signal can be used to regulate the ID fan variable speed motor to achieve the optimal electricity usage. The total flow will also be controlled by the O_2 values but only in longer term. The short-term control will be done via the direct gas flow measurement.

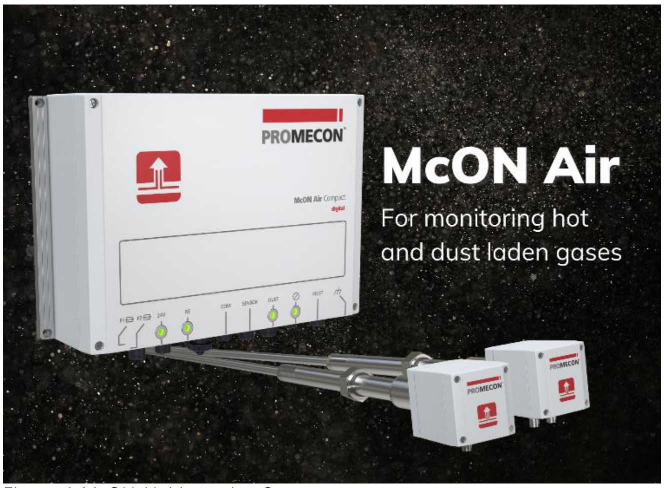

Figure 6: McON Air Measuring System

Result

Measuring the actual exhaust gas flow from the kiln opens new possibilities for controlling the overall draft through the system. This will result in a flatter lined kiln operation as compared to conventional O_2 control.

Application example

The screenshot of a plant with the PROMECON volume flow measurement installed in the kiln exhaust gas system with a cascaded controller already set up in the kiln-master system.

The thermal energy of about 120 kg of high-quality coal is required for the production of a ton of clinker. For a 3,000 tons per day rotary kiln installation this means:

With a clinker production of 3,000 t per day a consumption of 360 t per day can be expected. With an optimized kiln operation up to 18 t per day can be saved this way. With a current market-price of 120 €/t (costs at the burner tip) this amounts to a saving of approximately 2,200 EUR per day.

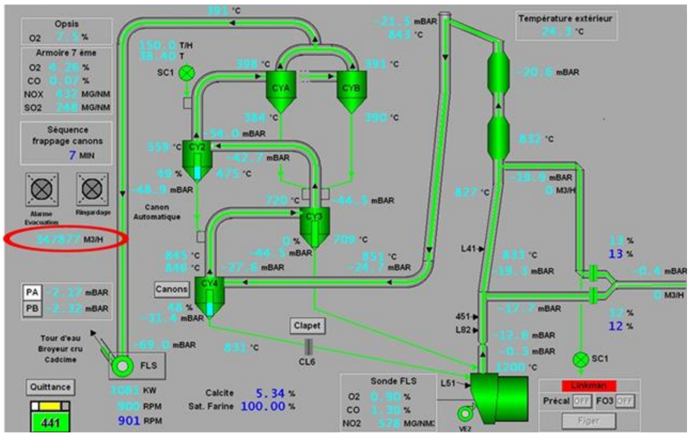

Figure 7: Screenshot of a Plant with a McOn Air Measurement

If, in this cement plant, 70 % of high-quality coal is replaced by alternative fuel, that means only 30 % of the costs account for this coal type (or comparable primary combustibles), one can still plan with a saving of up to 20,000 EUR per month.

Advantages & Benefits

- Temperature range up to 1,000°C/ 1,800°F
- Drift free - no calibration, no purging
- Virtually no maintenance
- Turn down ratio up to 25
- No K-Factors - direct time of flight measurement
- Outputs: 4 - 20 mA
- Hot tapping solution for full plant availability

The PROMECON correlation-based downcomer measurement has been implemented in many cement plants around the world. In conjunction with a modern O_2 measurement it helps to optimize the cement making process, saving fan power, and making the process flatter lined, by reducing process noise. The PROMECON measurement system has been directly connected to plant optimizers and control systems such as the kiln-master.

The system is easy to retrofit and has been implemented in new builds as well as in existing plants.