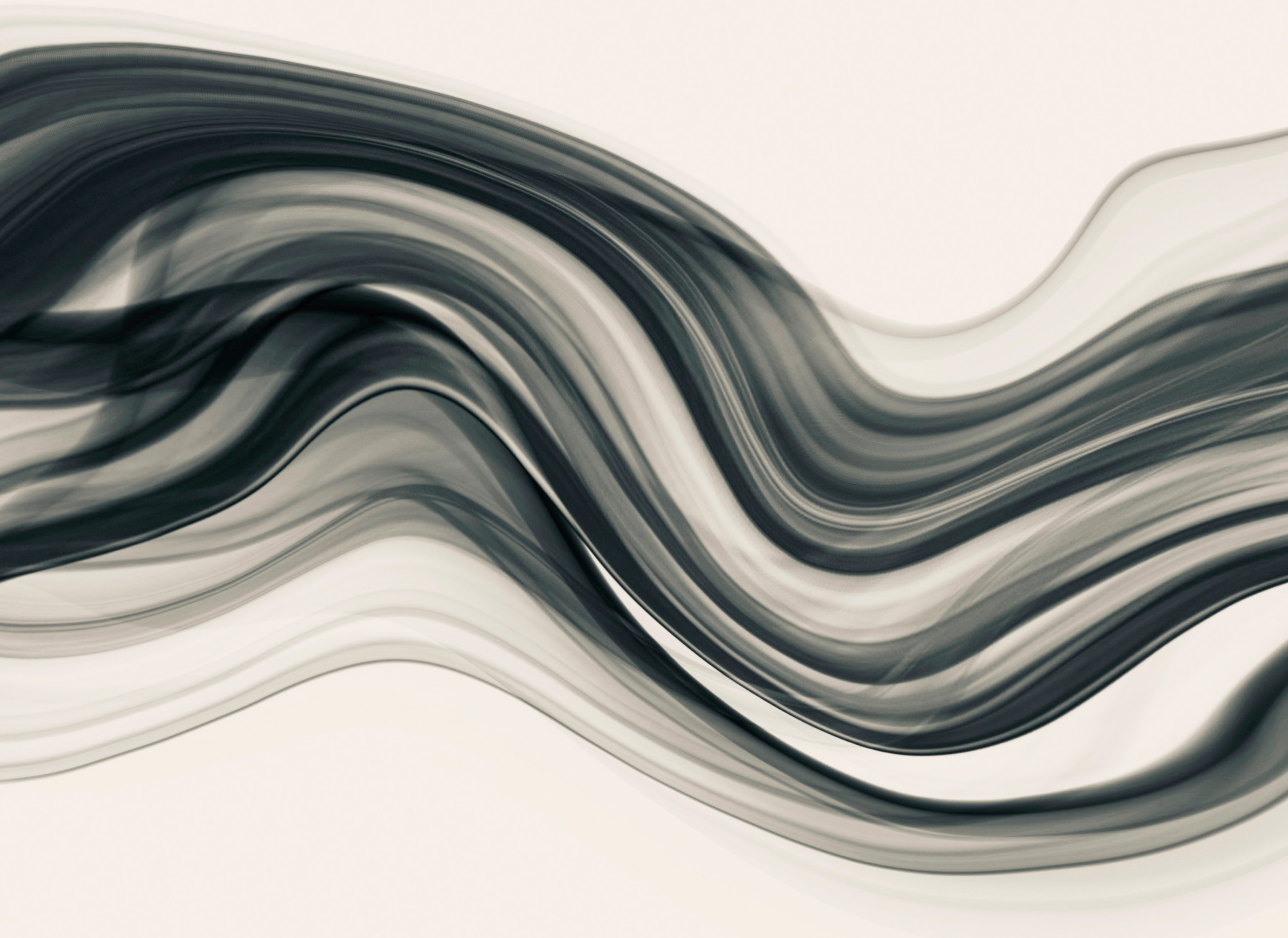
Keeping track of your gas flow

The future of cement production lies in gas flow. Whilst significant focus has previously been placed on mechanical issues such as the wear of parts, refractory lining, grinding elements as well as heat recovery in the grate cooler and burner technology, gas flow *per se* has not been a prime target. This becomes obvious when looking at modern plants today.

In many cement plants, the number of points where gas flow is measured is very small. Whereas, in other processes of similar size and complexity there would be dozens of major gas-flow measurement points in order to monitor stoichiometry, enthalpy flow, or fan curves, in cement production one rarely finds any accurate gas flow measurement systems. Most operators are not aware of any major gas flow, especially inside the process. So, upstream of the bag houses and other gas cleaning devices there are normally no gas flow measurement points installed. As a result, not only is the absolute gas flow in major parts of the plant not being measured, but also the ratio between major gas streams and various branches is not measured and hence not directly controlled. The main way of managing the gas flow process is by means of measuring temperature and pressure in gas flows.

However, in many cases this cannot serve as a timely and accurate way to control gas flows.

Hans Georg Conrads, PROMECON GmbH, explains the importance of gas flow measurement as a key driver of cement plant optimisation in the future.



The typical cement plant offers many opportunities for measuring gas flows in order to optimise the process and hence optimise the ecological impact without impacting the bottom line.

The ecological Impact of gas flow

Gas flow constitutes a significant portion of the total cement plant's energy consumption.

Cement is a CO_2-intensive process which requires high levels of energy consumption.

Electrical energy: In the grinding section of a cement plant electricity consumption accounts for nearly half of the consumed power. So, energy itself is a big target when managing gas flow.

Dust emissions: the excessive use of process gas puts the whole gas cleaning system of the plant under stress. High gas flows mean lower dust separation from the gas flow in the bag house or electric precipitator. The consequence of this will be the increased pollution of the environment.

NOx emissions: The mixing of fuel and air always creates thermal NOx which is a hazardous gas and is regulated in most countries. The regulations on NOx have become stricter over the past years and will continue to act as a constraint when operating a plant. NOx abatement has become a cost driver in modern cement plants so that the primary NOx reduction, which is actually thermal NOx prevention, has become more and more important. But without an effective measurement of the combustion gas (which in the pre-calciner is mainly tertiary air) an effective stoichiometry control and hence a good NOx prevention becomes impossible.

CO_2 emissions: The energy consumption by itself is CO_2-intensive. In many countries the electrical energy used by the plant comes from fossil fired power plants. So, every MWh consumed means CO_2 emissions elsewhere.

CO_2 control: The cement industry will undergo a massive transition over the decades to come. The goal is to tackle the large amounts of CO_2, released by the firing of fuels as well as the calcining process itself. The process will be modified in order to recapture the process gas at the end and re-use it.

Measurement of raw gas flow.

Through this process nitrogen levels will fall and be replaced by CO_2, which can later be washed out and separated from the process so that it can finally be stored underground and removed from the biosphere. Obviously, in this new procedure the knowledge of process gas flows and their composition will be a key measurement parameter.

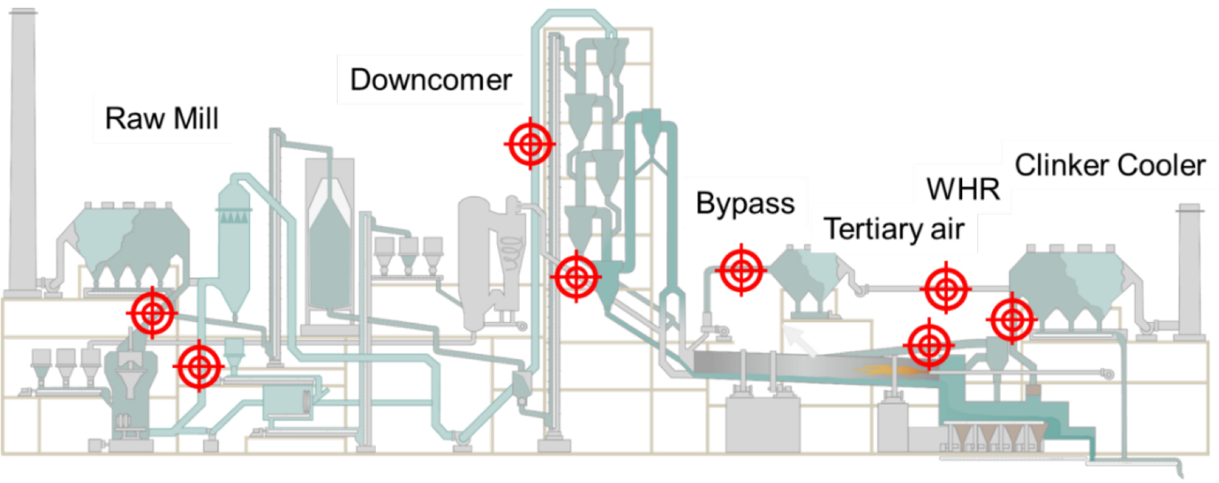
The impact of flow measurement on the plant

Correct mill set points: the grinding section requires accurate gas flow measurement, not only in the main outlet of a raw mill or a finished product mill but also in the sections where recirculated gases flow back into the mill. Even in modern plants it is a common problem that mills are over drafted because of unknown gas flows. The result is a different particle size spectrum than desired and increased energy consumption of the mill. A gas flow that is lower than specified can lead to tripping the mill which, for a large raw mill, creates a production outage as it is cleaned out and restarted.

Correct O_2 set points on the kiln inlet: The amount of gas going through the rotary kiln cannot be measured directly. So, at the end of the kiln and in the downcomer, CO_2 measurements are used to control the excess air levels. It is obvious that the leakage in the kiln preheater as well as the long measurement intervals are not suited for a timely and smooth control of the ID fan at the end of the process. The levels of air flow are fluctuating, and the process is far from flat-lined.

Correct bypass air flows: The quantity of bypass gas is essential for process control. However, bypass gas flows are not normally measured, meaning that the ratio of gas pulled out of the process is unknown to the operators.

Waste heat recovery (WHR): In many plants, waste heat is used to save energy or even to convert the flue gas enthalpy into other forms of energy. While the temperature of the gas can be measured without any problems the flow as the other constituent of the



Plant overview with typical gas flow measurement points.

enthalpy flow is unknown and can only be calculated out of a mass energy balance of the heat exchanger.

Gas flow problems are fan control problems

In modern cement plants, fans are frequency controlled so that fan power consumption will rise to the third order with gas flow.

A reliable gas flow measurement system can lower the energy consumption of the plant significantly and helps to optimise the aforementioned processes. Most plants have expert systems or optimisers which can easily integrate the flow values in order to optimise the whole plant process.

Obstacles in measuring gas flow in dusty processes

The question stands: why is the gas flow not measured even in modern plants?

The answer lies in the specific difficulty of measuring hot and dusty flows.

Measurement of downcomer flow.

Measurement of bypass flow.

There are several conventional methods used to measure gas flow, which have been used for a long time. Most of them are very hard to use in dusty flow processes. These methods are:

dP measurement

Conventional differential pressure based airflow measurement approaches have always been difficult to apply to hot, dusty process streams. In this analogue measurement the particulate causes errors in the measurement due to influences on measurement probes that are inserted into the process stream itself. In addition, the erosion of those devices, as well as the plugging of sensing lines, cause's a continual drift of the measurement and requires significant maintenance resources to keep the instrument operating in an acceptable fashion. Potentially even worse than not operating at all, most of the time this instrumentation is providing erroneous information on which operators base their process control decisions. Additional challenges include the location of probes in an acceptable duct location, maintenance accessibility and safety, temperature and pressure limitations, and response to rapid fluctuations in flow rate.

Thermal dispersion measurement

Another analogue method is the measurement of thermal dispersion. A heated wire element is cooled by the gas flowing by. By monitoring the cooling, the gas flow can be calculated. This method is an analogue measurement, which needs cleaning and recalibration over time. Even though it does not have a problem with clogging impulse lines it still is not reliable over long term. Dust and dirt on the heating element, for example, can lead to a loss in repeatability over time.

Ultrasonic measurement

Ultrasonic measurement methods have also been successful in many applications. However, they struggle with signal loss in hot and dusty conditions. In larger ducts and at higher gas speeds the signal sometimes does not properly reach the receiver on the other side of the duct.

Ultrasonic measurement is especially well-suited to dense media with a low attenuation such as liquids, steam or cold gases. Hot and dusty gases are far more challenging for this measurement principle.

Another implementation obstacle is the fact that ultrasonic devices need a flow path across the duct so that they always have to be mounted from both sides of the duct.

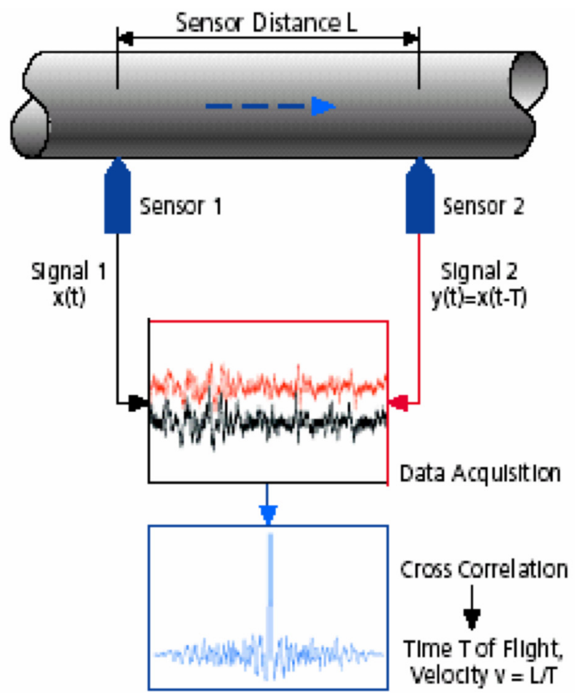
The game changer: New digital measurement of gas flow

PROMECON's base innovation for air flow using electrostatic cross correlation has been applied world-wide to the field of process flow measurement. It utilises the dust particles in the stream as the basis of the measurement. It offers a long awaited solution to the age-old problem of making accurate, reliable measurements of the flow of hot, dirty process streams.

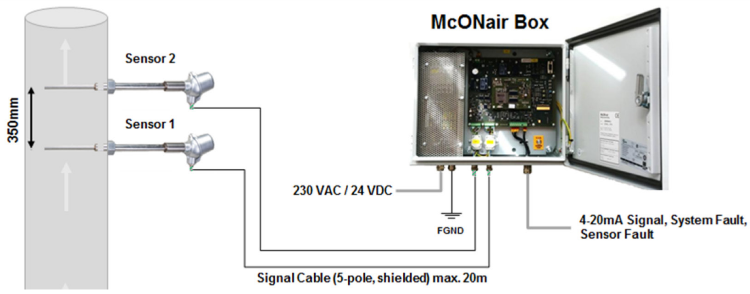
The McON Air measurement system has the following characteristics which have made it attractive to the cement industry:

- It is digital.
- It does not drift over its whole lifetime.
- It has been installed for 20 years in more and more plants showing that it is not affected by dust and heat.
- It has become first choice with some world leading cement producers.

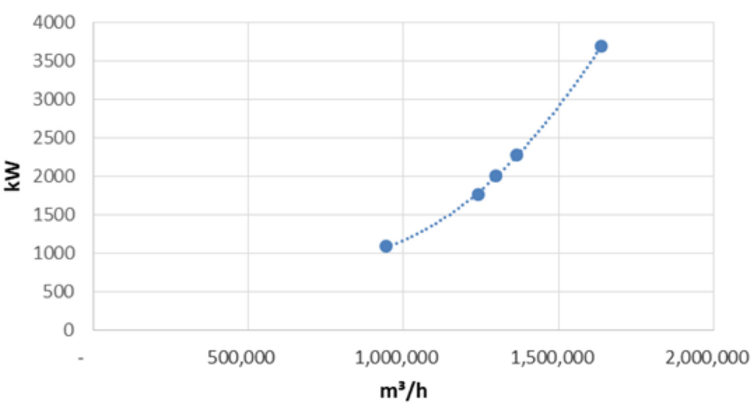
A more accurate measurement will allow operators to adjust fans more precisely and achieve an overall reduction of process noise, which will keep the process steadier and reduce auxiliary power consumption as well as dust emissions.



Measurement principle of MECONTROL Air.



Installation of a PROMECON McON air system.



Fan power consumption versus gas flow.

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 then 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.

Summary

The PROMECON McON air system has been used in cement plants worldwide in order to optimise the plant and make it more efficient. To overcome future obstacles, such as NOx and CO_2 reduction, reliable air flow measurement will be a key component. ■

About the author

Hans Georg Conrads holds an Electrical Engineering and Signal Processing degree from the RWTH University of Aachen, Germany.

Hans has over 25 years of experience in the power industry as an entrepreneur and inventor of novel measurement systems to optimise the combustion of large steam generators. He also has multiple international patents and innovation awards and is the owner and CEO of PROMECON GmbH in Germany.