Application of measuring gas flow in the downcomer.

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Introduction

For the proper operation of equipment in a cement plant, knowing the flow rate is essential. In the past, high temperature and particulate in the gas stream have prevented online gas flow measurement. But the PROMECON Air Flow System utilizes the particulate to measure the velocity of the gas stream. Since the first installation at a cement plant in 2001, the system has been installed in more than 75 plants worldwide. The direct measurement of dust-carrying gas flows has opened new ways to monitor, control, and optimize the cement making process.

Measurement Technology

The system applies the triboelectric principle. Electrical signals created by the dust particle clouds passing each of the upstream/downstream sensors are cross correlated and referenced by their time shift. With the time of flight between the two sensors and a fixed distance (usually 350 mm), the actual particle velocity is known. For small particles, zero particle slip is assumed. The digital system requires no calibration, imparts no pressure drop, and does not drift over time.

A measurement point requires the installation of a pair of sensors aligned parallel to the longitudinal axis of the pipe. 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 (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.
The flow sensors require a very small minimum of particulate, but with the addition of an optional Range Extender System the flow sensors will operate with no particulate. An emitter rod is installed upstream of the flow sensors that injects an electrical charge that is detected by the flow sensors.

Application Details

Most applications are unique. Information that must be obtained and evaluated are:

- Range of particulate loading
- Minimum and maximum temperature
- Minimum velocity
- Straight run of ductwork before and after flow sensors
- Platform access for flow sensors

By analyzing the available information and applying experience from past installations the location and quantity of flow sensors is determined. Flow stratification at the sensor location must be considered and in the worst conditions computational fluid dynamic software is utilized.
Some of the most difficult ductwork has been on large raw VRM’s with two ducts coming from the cyclones merging together for one straight diameter and then splitting again to the fan inlets. For these 4-5 meter diameter ducts, multiple pairs of flow sensors were installed and averaged in the DCS. The technology can be applied to congested ductwork where differential pressure could not be considered.

Downcomer

One of the popular applications in a cement plant is the downcomer duct from the top of the preheater tower. After reaching the top of the preheater tower the gas is in the 400-600 C range. The gas stream is after a series of cyclones so there is a lot of particulate present. The particulate level is rarely known, but can be calculated by guessing the efficiency of the last cyclone. The actual amount is not important, as it is always changing, but it stays in a range where the flow sensors can detect a strong electrical signal. The printed circuit board on the flow sensor has adjustable dip switches to control the signal strength for each specific application. If the downcomer has water spray nozzles, then the air flow sensors are located just upstream of the water spray.
The gas flow measurement in the downcomer can be utilized by a “high level” control system to stabilize the kiln operation and save fuel costs. A previous control strategy was to control the kiln ID with the oxygen measured with a gas analyzer. The oxygen content should confirm the complete consumption of the fuel inside the calciner, but the oxygen value can fluctuate, due to the changing heating value of the fuel. This fluctuating value is difficult to control and often requires smoothing. Also the dead time of the oxygen sampling system and analyses has to be considered. The gas flow measurement of the Promecon system is nearly real time. As a result, controlling the kiln ID fan with the gas flow measurement and monitoring the oxygen content provides a more stable kiln operation. The gas analysis equipment requires maintenance, so using the gas flow measurement also avoids the blind kiln operation during these maintenance periods. Independent and experienced process experts have confirmed that a more stable kiln operation can reduce the energy consumption up to 5%. If only 1% reduction is achieved, then the return on investment is less than 3 months.

Figure 1 is a downcomer installation in Florida. Initially the plant was concerned with the movement of the flow signal. Promecon evaluated the information that can be obtained by connecting a laptop and did not find any issues. Later the plant attributed the movement to an uneven feed of fuel into the precalciner.

Other Plant Applications

Raw Mill The raw mill is usually a large vertical roller mill that is designed to grind with a specific material-to-air ratio. The large power requirement of the grinding process results in a short payback. The first installation in North America in 2004 resulted in an energy savings (determined by the plant) of 0.5-1 kWh/t of raw meal. Sensor location is usually after the cyclones.

Tertiary Air (TAD) The TAD is one of the most difficult applications in a cement plant. The actual flow measurement of the TAD provides process knowledge and is more effective for closed-loop control. The TAD flow measurement signal is used to regulate the load on the precalciner to achieve the optimal energy distribution and stabilize the process. There is usually a long straight run of duct, but the issue can be access to the TAD. The hole through the refractory must be kept clean with ambient draft or purge air.

Cement mill If the cement mill is a VRM, then the application is the same as the raw mill. If the cement mill is a ball mill, then the applications can be to measure the air flow to the mill sweeps and the flow to/from the separator in order to stabilize the operation, resulting in a more consistent grind.

Coal mill The coal mill is usually a VRM so it is important to control the air flow accurately. The flow can be measured to the mill or at the outlet pipe from the mill.

Clinker cooler For control and process knowledge, the off gas from the cooler can be measured. With this, a complete air flow balance through the clinker cooler can be established. The secondary air going into the kiln can be calculated online out of this clinker cooler balance.

Conclusion

The cement industry has learned to operate without flow measurement for many difficult applications. But with the success of triboelectric cross-correlation technology, accurate and repeatable flow measurement is now possible in very dirty gas streams at temperatures up to 1100 C (2000 F). Properly integrated into the plant control system, this technology will increase the efficiency and profitability of the processes where it is utilized.

More than 75 plants worldwide have proven that the technology is reliable and requires virtually no maintenance. The air sensors can be installed online in most duct applications and there is no calibration required. A major advantage of this technology for process flow applications is that it is not affected by particulates present in the air stream. These advantages make the system attractive for measuring a very diverse range of process streams.