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Continuous Emission Monitoring

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Continuous Emission Monitoring

Jose Tarodo, Dima Consultores, Spain, analyses the advantages and disadvantages of available emission monitoring systems, and discusses the installation of an Opsis cross stack DAOS monitoring system at the Cementos Alfa plant in Spain.

Introduction

Cementos Alfa S.A. is located in Mataporquera, in northern Spain. The cement plant is known for its environmental focus and for its commitment to high quality products. It is equipped with the latest technology, for example a totally automated laboratory. In October 2002, the plant installed a state-of-the-art continuous emissions monitoring system.

A number of environmental monitoring systems were investigated, and the monitoring equipment offered by Dima Consultores was considered to be the most appropriate. It consists of an Opsis system to monitor NO, NO_2, SO_2, CO, CO_2, H_2O, HCl, HF, Hg^0, particles, flow velocity, etc. This Swedish technology provides Cementos Alfa with high quality data and fulfils the requirements set by the authorities. Furthermore, since it is a non-contact and non-extractive monitoring system, it requires extremely low maintenance. Another advantage is that the system can be easily upgraded to measure additional compounds.

CEM technologies

At present, there are many accurate emission monitoring systems on the market, each of which has its own advantages and disadvantages. Therefore, it is necessary to choose a monitoring system that fulfils an individual plant's requirements and objectives.

The main CEM technologies available are as follows:

Extractive systems

Extractive CEM systems are based on taking (extracting) a sample of the flue gas and transporting it to the analysis instrument.

To ensure measurement accuracy, it is important to guarantee that the sample is representative of the actual gas. Therefore, it is important that the extraction point really represents the emission gas.

Sample transportation must be designed carefully to avoid gas reactions or condensations.

A brief overview of the most common extractive CEM systems is presented below.

Dilution systems

The sample is diluted with a dry and contaminant free dilution air. Absolute H_2O does not change after the dilution, but relative humidity values get much lower. The dilution rate must be chosen so that the diluted sample gas dew point is below the coldest ambient temperature. Then the diluted sample is sent to the analysers with no contaminants condensating from the sample. The diluted sample reaching the analysers is equivalent (with the dilution factor) to the one taken from the flue gas.

Dilution system benefits:

- Economical system.

Dilution system disadvantages:

- High maintenance, unless a heated dilution system with two critical orifices and zero velocity filter is chosen.
- The need to compromise between the dilution rate and the range of the analysers. As the dilution rate is increased to avoid sample condensation, the contaminant range gets lower. Therefore, the analysers must have a lower range. Various gases (HF, HCl, etc.), are hard to measure after dilution.
- Delay between the flue gas and the measurement value (the sample must be conditioned and transported to the analyser).
- Upgrade difficulties: if more gases are to be measured in the future, flow rate, tubing diameter, permeation tube capability etc., have to be studied and modified in line with the new configuration.

Permeation systems

The sample is dried when forced through a permeation tube. The permeation tube lets the vapour H_2O escape, leaving most of the contaminants. Absolute H_2O is reduced after the permeation. The permeation tubes must be chosen so that the conditioned sample gas dew point is below the coldest ambient temperature. Then the sample is sent to the analysers with no contaminants condensating from the sample. The conditioned sample reaching the analysers is directly equivalent to the one taken from the flue gas.

Permeation system benefits include:

- Allows measurement of several gases, including HCl and HF.

Opsis UV and IR DOAS analysers.

Permeation system disadvantages include:

- Very high maintenance: the permeation tube is made with many thin tubes. Particles must never reach the tubes, therefore the probe must have a blow back system and a particle filter. Also, before the permeation tubes, there need to be a coalescent filter. The maintenance interval depends on the flue conditions. In some situations, the filters must be manually cleaned once a day.
- A number of compounds (NH_3, THF, etc) react with the permeation tube. A permeation based CEM cannot measure NH_3, THF etc, and it is important to know the concentration of these compounds in order to estimate how long the permeation tube will last.
- The permeation tube does not dry liquid water, only water vapour. If there is any condensation before or inside the permeation tube, the sample will not be dried and various compounds will condense.
- Delay between the flue gas and the measurement value (the sample must be conditioned and transported to the analyser).
- Upgrade difficulties: if more gases are to be measured in the future, flow rate, tubing diameter, permeation tube capability, dry gas flow rate, etc., have to be studied and modified in line with the new configuration.

HW systems

The sample is transported through a heated line to the analysers.

HW system benefits include:

- Allows measurement of several gases, including HCl and H_2O.

HW system disadvantages:

- High maintenance: The sample attacks valves, analysers, pumps, etc., and many parts must be periodically changed.
- HF cannot be measured.
- HCl is hard to measure to the desired accuracy.
- Delay between the flue gas and the measurement value (the sample must be conditioned and trans-

The Opsis EnviMan software handles the data collection, presentation and surveillance from the CEM system. The software is also capable of generating reports.

ported to the analyser).

- Upgrade difficulties: multiparametric analysers can only measure a limited number of gases. If more parameters are to be measured, another complete multiparametric analyser must be installed, which will double the price.

Non-extractive systems

Many of the extractive systems disadvantages, can be avoided by using in-situ CEM systems.

In-situ systems

Multiparametric optical based analysers are installed directly in the exhaust gas ducts. Since no sample is required, the need to maintain the system is significantly reduced.

In-situ system benefits include:

- Continuous, direct and rapid measurements.
- Lower maintenance than extractive systems.

In-situ system disadvantages include:

- Each analyser can only measure a limited number of parameters (3, 5, etc., depending on the manufacturer). If more parameters are to be evaluated, additional systems must be installed and the cost will increase.
- HF and HCl cannot be measured accurately.
- Sensitive components are located in the exhaust gas ducts. Vibration and environmental conditions may affect the analyser.

Cross stack laser head systems

State-of-the-art analysers which operate with very low maintenance, very high accuracy, and with very fast response times.

An emitter projects a laser signal, which is sent across the stack to a receiver. The receiver sends the modified laser signal to the analyser, which determines the gas concentration.

Each analyser can be equipped with as many as four laser heads, allowing one analyser to measure several gases.

There is no contact between the analyser and the flue gas and there is also no probe inside the flue gas, therefore maintenance is very low.

Laser head system benefits include:

- Continuous, direct and ultra rapid measurements.
- Lower maintenance than extractive and in-situ systems.
- Very high accuracy for NH_3, HF, H_2O, HCl, CO, CO_2, O_2, CH_4 and temperature.

Laser head system disadvantages include:

- Each analyser can be equipped with up to four laser heads. If more gases are to be evaluated, additional systems must be installed.
- Cross stack technologies require a receiver and an emitter to be installed in opposite sides of the duct or stack.
- SO_2, NOx, and other common gases are not evaluated.

Cross stack DOAS systems

State-of-the-art analysers which measure gases with very low maintenance and very high accuracy.

An emitter projects a beam of polychromatic light through the flue gas to a receiver. The light is transferred to the analyser through a fibre optic cable.

The DOAS system can evaluate several parameters and it can be easily upgraded to measure additional parameters.

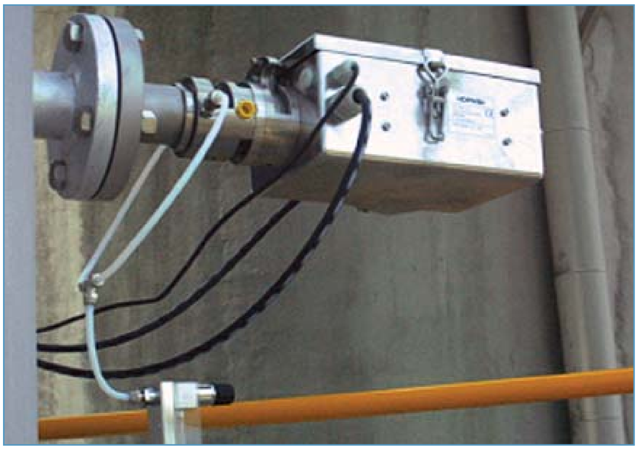
There is no contact between the analyser and the flue gas and there is also no probe inside the flue gas, therefore maintenance is very low.

Cross stack DOAS system benefits include:

- Continuous, direct and rapid measurements.
- Allows monitoring of several gases, including HCl, H_2O, HF, benzene, phenol, formaldehyde, toluene, HBr, etc.

The stack with the Opsis receiver.

The Opsis emitter including the light source, installed on the stack.



The Opsis receiver installed on the stack. The optical fibres transfer the light to the analysers for detection of gaseous compounds.

- A DOAS system can be easily upgraded to measure additional gases without new installations or hardware modifications.
- Significantly lower maintenance than extractive and in-situ systems.
- Very high accuracy, including monitoring of HF, HCl, etc.
- Cross stack systems can be installed anywhere in the exhaust gas ducts.

Cross stack DOAS disadvantages include:

- The optical line length is limited depending on the gases that are measured. For NO, the distance between the receiver in the gas duct and the analyser should not be more than 10 m.
- Cross stack technologies require a receiver and an emitter to be installed in opposite sides of the duct or stack.
- The DOAS technology is very expensive when only one or two gases are measured.

Focusing on the solution

Dima Consultores, a company dedicated to designing and supplying AQM (air quality monitoring) and CEM (continuous emissions monitoring) systems, studied Cementos Alfa's needs and evaluated the existing technical solutions.

The requirements from the engineers at Cementos Alfa included:

- First line products with high levels of accuracy and reliability.
- Monitoring equipment capable of measuring SO_2, NO, NO_2, CO, CO_2, etc.
- Monitoring equipment which can be upgraded to measure additional compounds in the future. At least NH_3, H_2O, HCl, HF, etc.
- Low maintenance.

Existing dilution systems do not fulfil these particular requirements, because the systems cannot be easily upgraded to measure HCl, HF, H_2O etc. Upgrading for these parameters will call for new and different technologies and also require a new installation.

Permeation was not suitable either, because cement plants may generate NH_3 emissions. Besides this, maintenance would be higher than desirable.

HW systems were seen as one possibility. Maintenance would be a bit higher than specified, but the system measures with a high level of accuracy. However, upgrading to gases such as HF would not be possible. Cementos Alfa was interested in evaluating quite a few parameters. This means that the HW system would measure the maximum amount of gases possible, and upgrading the system for additional compounds would call for another complete system installation.

Laser head systems were not an option since Cementos Alfa wanted to measure SO_2, NOx, etc., and commercial laser systems cannot measure those gases.

Laser systems are, however, a great solution for those plants that are already measuring a number of gases and want to upgrade their system to measure additional gases. Especially if their existing CEM system has poor upgrade capabilities.

The cross stack DOAS system fulfilled all requirements and was the only solution capable of measuring HCl, HF, H_2O, etc., with high reliability and accuracy.

Cross stack DOAS systems were therefore selected by Dima Consultores and Cementos Alfa. The distance limits between the receiver and the analyser were not a problem in the Cementos Alfa installation.

The monitoring system

Cementos Alfa decided to install a system manufactured by Opsis. The system was configured to measure SO_2, NO, NO_2, CO, CO_2, H_2O, HCl, HF and Hg0.

In this cross stack DOAS system, a high-pressure xenon lamp projects a white beam of light through the gas. A receptor unit, mounted on the opposite side of the duct or stack, receives the light and transfers it through a fibre optic cable to the analyser. Each parameter leaves a spectral fingerprint, which is analysed spectroscopically.

Although both the emitter and the receiver are installed in the stack, they do not come into contact with the flue gas. A small clean airflow is injected at the end of the emitter/receiver. The airflow keeps particles away from the emitter and receiver.

An optical lens located between the emitter and the stack protects the emitter in case any particles or corrosive gases reach it. The lens can be easily removed for cleaning, which only takes a few seconds.

If the lens gets dirty, the amount of light will decrease. Particles do not absorb light, therefore this will not affect the reliability or accuracy of the measurement. However, if the light level decreases too much, the system will not measure accurately.

Since light is an important parameter for optical analysers, Opsis DOAS will always keep track of the light levels for the different parameters.

In situations where the light level is too low, the amount of clean air injected in the emitter and receiver is simply increased to take care of the problem.

The Cementos Alfa system includes an UV and IR DOAS analyser. The UV DOAS analyser evaluates the ultraviolet light spectrum for determination of NO, NO_2, SO_2, Hg0, etc. The analyser contains a spectrometer that divides the light in narrow spectral ranges by means of an optical grid.

The second analyser, the IR DOAS, evaluates the infrared light which determines HCl, HF, CO, CO_2, H_2O, etc. This analyser contains an interferometer that sections the light towards two movable mirrors. Continuous varying of the position of the mirrors produces an interference pattern.

The analysers are protected by an air-conditioned rack. Furthermore, Cementos Alfa built a cabinet to shelter the rack from rain.

Although the system consists of two analysers, only one emitter and receiver unit is needed.

In addition, the installation is equipped with instruments to monitor oxygen levels, stack temperature, particle concentration, flow gas velocity etc.

The measured parameters are transmitted to a computer located in the control room. The computer runs the Opsis EnviMan software, a powerful tool for environmental management. The software meets all of the requirements stated by Cementos Alfa.

The EnviMan software transfers the CEM data to Cementos Alfa's local network. This makes it possible for the plant staff to view the emission levels on their computers.

The system includes a modem connection, which makes it possible for Cementos Alfa to receive on-line support and maintenance, as well as system checks from the Dima or Opsis facilities.

Installation difficulties

Installation and start up was easy without any technical problems. The greatest problem was caused by the good thermal insulation of the customer's cabinet.

As mentioned before, the analysers were kept cool by an air-conditioned rack. The analyser rack was located inside a very well thermal insulated cabinet. Due to the insulated cabinet, the heat generated by the air-conditioned rack could not evacuate from the cabinet, causing a too high temperature. Finally, the EnviMan software alerted the staff that the temperature was to high inside the analyser rack.

When using the Opsis AC 181 air-conditioned rack, the analysers can be protected in a cabinet, but it must be well ventilated or have a low thermal insulation.

Conclusion

The Opsis system has been in operation without any problems since October 2002. No maintenance has so far been needed.

A complete calibration check was carried out in May 2003, according to Opsis' QAQC recommendations, and the results were correlated with reference lab measurements.

Zero and span drifts were so small that no adjustments were needed for any of the instruments.

The correlation between the reference lab measurements and the Opsis measurements showed a high linearity and a R2 factor greater than 0.99.

Enquiry no: