ecra

european cement research academy

3 / 2016

NEWSLETTER

Contents

Next ECRA events:

- Techniques for Accurate Weighing and Dosing
  5–6 October 2016
- Alternative Fuel Combustion in the Calciner:
  Precombustion Chambers and Gasifiers
  15–16 November 2016

Weighing and dosing systems in the cement industry

Maintenance and control for product quality assurance and reporting

Weighing and dosing systems in the cement industry are used for measuring, controlling and dosing mass flows of solid materials with very different properties. They are especially important for managing the supply of material to a downstream process and the stocks of material in the cement plant. Regular maintenance and control of weighing and dosing systems is essential for achieving the exact composition of materials, efficient processes and high cement product quality. In addition, accurate weighing and dosing is also important for the internal and external monitoring and reporting of production processes.

One example for the requirement of low measurement uncertainty is the annual report for the European Emission Trading System (EU-ETS). The monitoring and reporting processes for greenhouse gas emissions in the EU-ETS has to be carried out in accordance with the rules of the Monitoring and Reporting Regulation (MRR) of 2012. It specifies maximum uncertainty thresholds for determining mass flows of raw materials, products and fuels used in the production process. Accordingly, all cement plant operators have to comply with the MRR when monitoring and reporting their CO_2-emissions.

Materials with different properties

In cement manufacturing, raw materials and fuels with very different properties are used. The material properties are relevant for the selection of suitable weighing and dosing equipment. The following types of equipment are often installed in cement plants for measuring the continuous supply of solid material:

- Belt weighers measure the mass transported on a belt which is continuously running. They are especially used for coarse raw materials or clinker going to the clinker stock. The accuracy of belt weighers depends on the conveyor belt's physical properties, the belt tension, speed, the uniformity of loading, and the cleanliness of the belt and scale system.
- A belt weighfeeder (**Fig. 1**) can weigh and dose materials simultaneously. It can be used for materials which are very coarse or easy-flowing. It is also suitable for dusty materials like raw meal, fly ash or filter dust. The choice of construction depends on the materials' properties and the flow-rate.
- A rotor weighfeeder consists of a slow-turning rotary valve. It can be used for dusty material, fine-grained mineral products and also coarse materials. Its application encompasses the dosing of materials in pneumatic conveying systems, air slides or screw conveyors.
- Coriolis metering devices can be used for all powder materials (e.g. ground coal, fly ash, etc.) which do not tend to adhere. Its measuring principle for determining the mass flow is based on the Coriolis Effect.

Regular checks and maintenance

The measurement results of weighing and dosing systems can be affected by abrasion of the mechanical components, damage to a component part, dirt, and the presence of adherent materials in the system. In particular, the cement product quality depends on the exact dosing of the cement components. It could become compromised if the metering equipment does not work properly. In order to avoid or reduce measurement errors and to achieve a sufficient accuracy in weighing and dosing, checks, cleaning and regular maintenance are necessary. Good practical experience is required to detect the sources of errors and to correct them. A regular monitoring of the equipment performance should be implemented to prevent errors in the metering devices and scales. The detected errors should be documented in a protocol and assessed with regard to the metering accuracy.

However, regular scale checks are not the only method for identifying errors in the metering of weighing and dosing systems. Frequent controls of the clinker and cement product composition in the cement plant laboratory often allow a very fast identification of errors. Monthly inventories and analysis of mass balances in the cement plant are good indicators for the long-term accuracy of metering equipment. Systematic errors in mass flow metering would result in significant deviations between the calculated stocks and the actual stock as recorded in the inventory.

For a comprehensive assessment of the measurement uncertainty of weighing and dosing systems, the current measurement error should be recorded before any adjustment or calibration takes place. It should reflect systematic and random error

Figure 1: Belt weighfeeder for continuous weighing of alternative fuels

components as they apply to the measurement in practice. The uncertainty assessment relies on multiple records of the measurement error from regular scale checks.

Uncertainty in the EU-ETS

The uncertainty assessment is needed as proof for the annual reporting of the mass flows of fuels and materials as activity data in the EU-ETS.

The MRR requires certain maximum uncertainties in the reporting of activity data of the clinker production process. For example, the allowed maximum total uncertainty for clinker production is 2.5 %. This total uncertainty should comprise the combined uncertainty of all weighing and dosing systems which are relevant to calculating the clinker production. For the so called "Output Method" the total uncertainty includes the uncertainty of the clinker and cement dispatch scales, the uncertainty of all scales used for the cement components, and the uncertainty of the clinker and cement stock inventories. Alternatively, a clinker belt scale with low uncertainty can be used for reporting. **Fig. 2** shows relative errors from regular scale checks of a belt weigher for metering clinker production. Additionally, the expanded measurement uncertainty for the recorded annual clinker production is indicated. This uncertainty assessment is based on the 95 % confidence interval. The uncertainty (1.2 %) results from the maximum absolute value of both limits. This record can therefore serve as proof for the required uncertainty of 2.5 %.

In conclusion, accurate weighing and exact dosing are highly significant for clinker and cement quality. Comprehensive and regular scale checks lead to better process control and consistent product quality. Furthermore, accurate weighing and exact dosing have a significant influence on determining mass flows with low uncertainty and on compliance with the EU-ETS regulations.

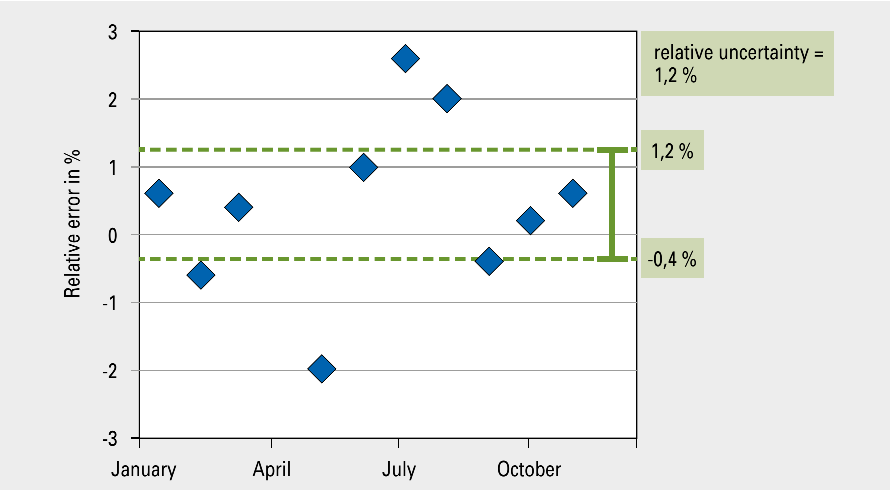

Figure 2: Example of relative errors (blue) from regular scale checks of a belt weigher for metering clinker production and uncertainty assessment for the recorded annual clinker production (green dashed lines)

Alternative fuel combustion in precalciner kilns

Thermal pretreatment of fuels and the optimisation of calciner operation by CFD modelling

Today, precalcining technology is included in the design of virtually all new kiln installations in the cement industry worldwide and in major upgrades. Precalciners provide particular flexibility as alternative fuels can be fed at several firing places at different temperature levels. In addition to economic criteria, physical (e.g. particle size) and chemical (e.g. chlorine, sulphur, alkali and phosphate content) criteria play a decisive role in the selection of alternative fuels, as they may have an impact on the kiln operation or emissions.

Alternative fuels are usually fed directly into the calciner. In principle, all firing units at which standard fuels are fed are also suitable for the input of alternative fuels. Depending on the type of fuel to be used, fuel metering can be rather complicated. It may therefore be reasonable in individual cases to subject alternative fuels to thermal pre-treatment in a separate device first. This is especially useful for coarse fuels or fuels with a low ignition behaviour.

Alternative fuels in calciners

Basically, two types of plants must be distinguished: in gasifiers the fuel is pyrolysed under extremely low-oxygen conditions, and the lean gas thus produced is subsequently fed to the calciner as fuel. The energy required in this process is either supplied externally or released in a partial combustion process. In precombustion chambers, by contrast, a considerably higher proportion of fuel is converted at over-stoichiometric or slightly under-stoichiometric conditions. Similar to the gasifier, the energy is used to decarbonate the kiln feed. The unburnt part of the fuel (residual coke) can also subsequently be fed to the calciner.

Thermal pretreatment

The devices for thermal pretreatment currently existing in Europe are gasifiers, such as the circulating fluidised bed from Envirotherm, and precombustion chambers from A TEC, KHD, FLS (Hot Disc) and Thyssen Krupp Industrial Solutions (PREPOL_SC; step combustor).
The circulating fluidised bed is suited to the intake of fairly fine-grained fuels only, while some precombustion chambers like the Hot Disc and the PREPOL-SC are rather designed for coarse fuels, but fine-grained fuels can also be treated with these designs.

The operating experience gained shows that all methods work reliably. Variations that can occur in the operation of the gasifier or combustion chamber can be balanced by the burners in the calciner. Most of these devices can be uncoupled from the kiln system by means of slides, thus allowing the kiln to still be run on conventional fossil fuels only.

The choice of the most suitable system is influenced mostly by investment and operating costs, but also by fuel processing costs, the availability of the waste fuels, the removal of contaminants and substances forming cycles in the system, and safety concepts that might be required. Plant designers are currently making increasing efforts to further optimise existing plants, and to develop and test new concepts. As gasifiers and combustion chambers permit a high degree of flexibility in terms of the type, composition and nature of the fuels utilised, the number of such plants in the cement industry can be expected to grow in the long term.

CFD Simulation of combustion

For the use of alternative fuels in a calciner it is crucial to consider the properties of the substitution fuel, such as the particle size, volatility and heating performance, as these have an effect on heat release and therefore on the calcining process and emissions.

Usually, experimental tests in precalciner plants are necessary to predict the effects of the use of alternative fuels. Optimisation of the calciner operation is also generally carried out by testing. An alternative approach is the numerical modelling (CFD simulation) of the combustion process inside the calciner.

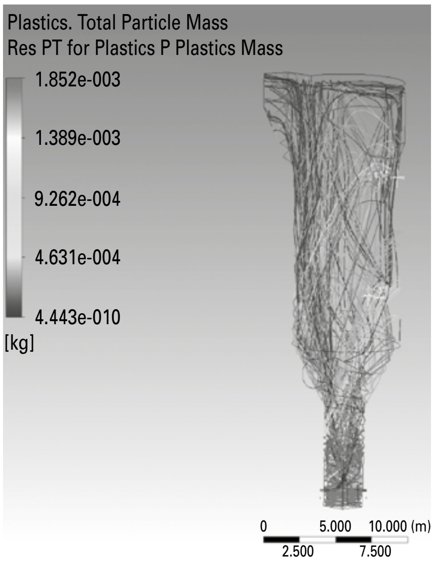

Figure 1: Particle tracks of plastic materials from alternative fuels

The option of simulating the processes taking place in the calciner simplifies operational optimisation and can thus reduce the number of costly and time-consuming experiments conducted at kiln plants during operation. Moreover, it becomes easier to make substantiated statements on the technical feasibility of installed precalciners in existing plants to reduce emissions of NO_x by staged combustion or by the SNCR process.

Within several years the development and the validation of appropriate modelling tools have made huge progress. New developments and the adaption of key sub-models to existing models to describe the process have taken place. Individual sub-models have been verified by laboratory tests und unified under a single methodological concept. The results of the simulations were compared with actual results based on extensive operational measurements at an industrial plant (**Fig. 1**).

Nowadays, CFD simulations are increasingly being applied to tackle problems. Possible starting points for optimisations with the aid of CFD simulations are:

- Calculation of the optimal degree of preparation (fineness) of the fuels with regard to the rate of descent and flight properties (**Fig. 2**).
- Determination of the optimal feed location for various fuels with regard to retention time and burnout.
- Optimisation of the constructive design of calciners with regard to formation of layers and improved mixing.

Given the fluctuating raw material and fuel properties and the various designs and modes of operation of kiln plants, individual testing by plant operators will always be necessary, but CFD simulation can help save time and money. Overall, it is evident that the combination of measuring and simulation enables a more detailed and further-reaching analysis of the processes in the calciner under realistic conditions than would be the case by measuring alone.

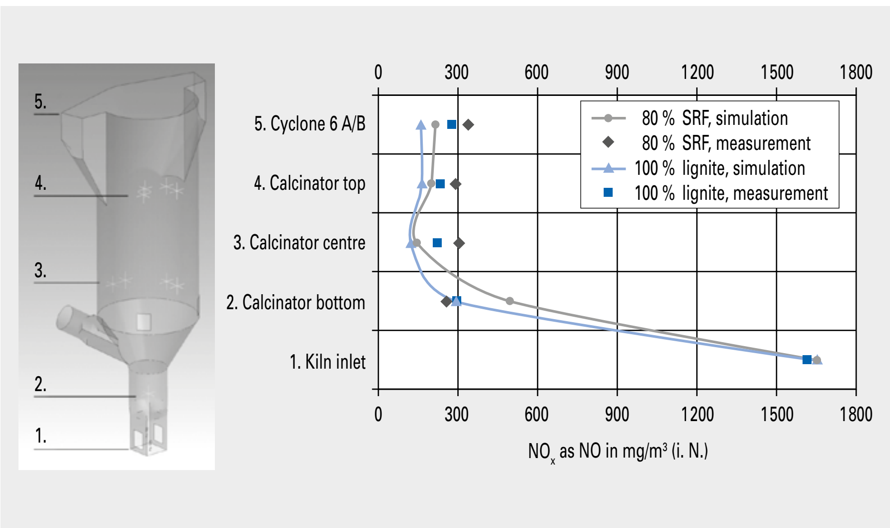

Figure 2: Comparison of the measured and simulated NO_x concentrations for 100 % lignite and 80 % AF utilization

ecra
european cement research academy

European Cement Research Academy

Tannenstr. 2 · 40476 Duesseldorf
P.O. Box 30 03 32 · 40403 Duesseldorf
Germany

Phone: +49 (0)211 2 39 83 8-0
Fax: +49 (0)211 2 39 83 8-500

info@ecra-online.org
www.ecra-online.org