At-line particle measurement

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A recent upgrade at the Obourg (Belgium) facility of Holcim has seen the production plant move to an automated laboratory for the routine analysis of cement composition and particle size. The system of choice for particle characterisation is the Insitec ALISS from Malvern Instruments. This article reports on challenges faced at Holcim Obourg and the role of Malvern's process systems in improving analytical efficiency and process control.

The establishment of automated laboratories is a growing trend as cement producers seek to minimise the costs associated with routine operation. Full automation allows the analytical process to be integrated more closely with day-to-day operation, increasing responsiveness to operational demands. Furthermore, analysis becomes an integral part of the production process rather than a service facility, often moving physically closer to the line.

Automated laboratory design demands suitable analysers able to fulfil the requirement for continuous operation, with minimal maintenance. One such system is the Insitec ALISS from Malvern Instruments, a robust at-line particle size analyser designed for routine use within the process environment.

At-line particle size measurement at Holcim's Obourg plant. The two kilns at the plant, used in parallel to produce clinker at the plant, are some of the largest in Europe

Cement production at Obourg

The Obourg site in Belgium produces around 1.6Mta of cement, in 10 different grades. As cement quality is defined primarily on the basis of chemical composition and fineness, elemental analysis and particle size measurement are regular features of day-to-day operation.

Different grades of cement are manufactured at Obourg by milling a blend of clinker, gypsum, anhydrous calcium sulphate, fly ash and blast furnace slag, to the correct particle size. Particle size is important because it controls the reactivity of cement during hydration in the field, thereby impacting directly on compressive strength, a parameter of key interest to cement users.

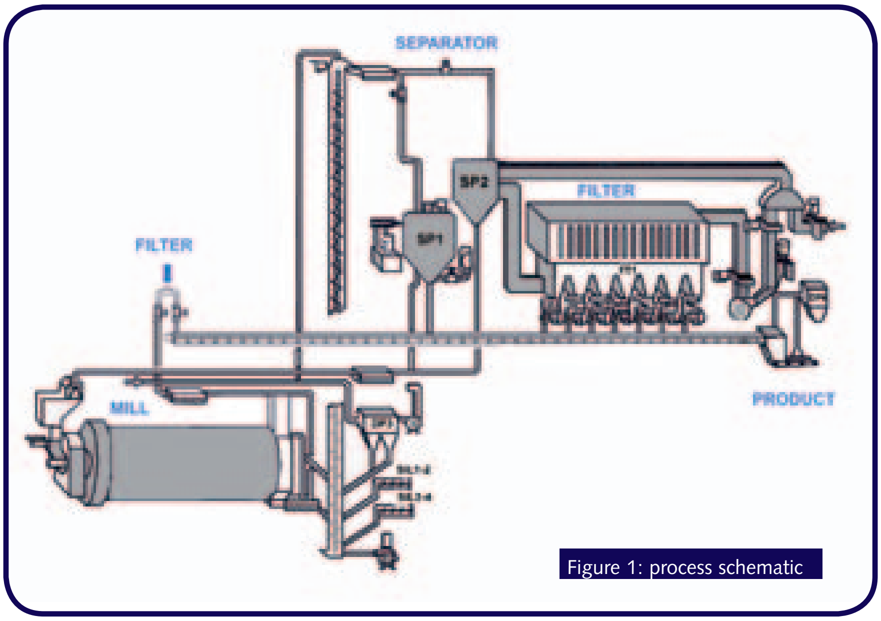

Figure 1: process schematic

At the site, cement is produced in two independent ball mills. Both have classifier and filtration units downstream of the mills to extract a final product cut from the mill exit stream, coarse material being recycled to the mills (see Figure 1). The feed rate of each constituent is manipulated to achieve the required chemical composition, while particle size is controlled using a combination of mill and separator variables (see below).

Before installation of the automated laboratory, X-ray Fluorescence Spectrometry (XRF), X-ray Diffraction (XRD) and particle size analysis were carried out in a centralised facility some distance from the process line. Sample procurement, delivery, preparation and

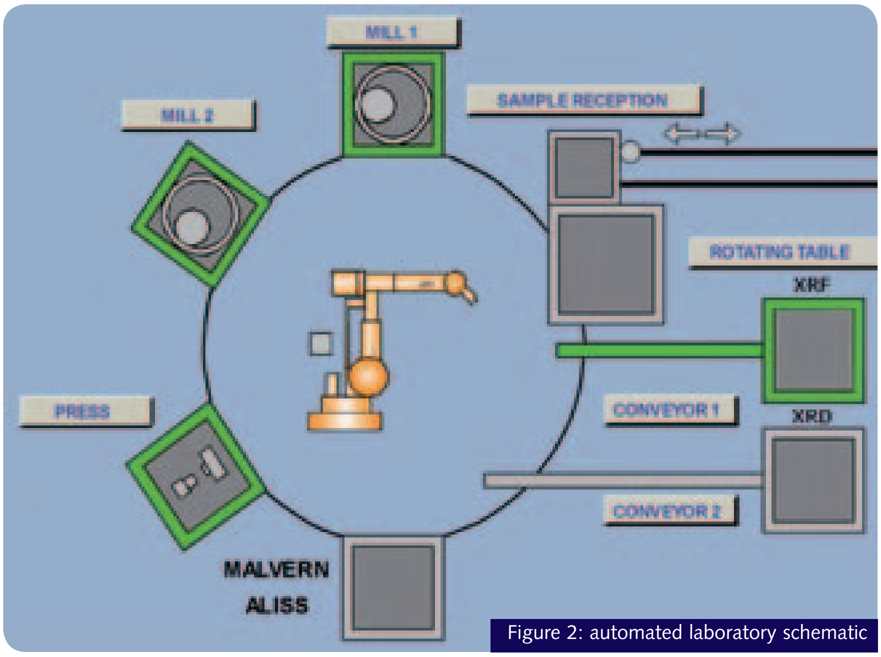

Figure 2: automated laboratory schematic

subsequent analysis were automated but the equipment was aging and required daily cleaning/maintenance. Distances between the lab and the process were significant and therefore not ideal for sample transport. Two years ago the decision was taken to upgrade facilities at the site through the installation of an automated laboratory designed to meet routine analysis requirements for both composition and particle diameter.

Installation of the new facility afforded the Obourg team an opportunity to address issues with their current systems and design a laboratory to meet fully their ongoing needs for consistent analysis with minimal manual input. Key requirements for instruments for the new installation were negligible or fully automated cleaning regimes, high reliability, and the ability to operate 24/7 with little maintenance. Integration with existing control platforms in terms of daily operation and data transfer was also important as control at the site is becoming increasingly automated.

The automated laboratory

Holcim's automated laboratory is a dedicated room, close to the main control area; it is run by a single person during the day and is essentially unmanned out of normal hours. At the centre of the laboratory is a robot, which divides incoming samples, transporting them through sample preparation and analysis, and cleaning the sample pot after measurement (figures 2 and 3). Around the robot are the units with which it interfaces: a sample reception area; two mills and a press for the preparation of samples for XRD and XRF; two conveyors for transporting the resulting discs to associated analysers; and the Insitec ALISS, for fineness measurement.

The Insitec ALISS measures particle size using the technique of laser diffraction, a well-established method within the cement, and other, industries. At Obourg, laser diffraction analysis has been used for many years, a Malvern Mastersizer being a valued piece of laboratory equipment. When selecting an analyser for the automated laboratory, Holcim's experience of the support offered by Malvern and Goffin Meyvis, the company's supplier in Belgium, was an important factor. Service from the two companies had always been exemplary and the Holcim team knew they could rely on this if they encountered any problems with the new laboratory. Furthermore, previous experience with other Malvern systems was very positive.

The recently developed Insitec ALISS is an at-line particle sizing option designed for manual or fully automated analysis, for use within the process environment by relatively unskilled personnel. It has a robust design, is immune to dust and vibrations in the surrounding environment, and is easy to use – simply load the sample and start the analytical procedure. Data presentation is easily customised to meet user requirements and communication with existing control platforms is straightforward thanks to a sophisticated software package.

The Insitec ALISS offers Holcim a range of features that are particularly important for an automated laboratory cement application. These include: abrasion-resistant ceramic lined parts; highly polished surfaces that prevent product build-up thereby reducing cleaning requirements; and a rapid measurement time of less than one minute. As no sample preparation is required the robot simply pours the material directly into the analyser, subsequently cleaning the sample vessel using a nearby air jet. The resulting data are fed into the control system facilitating both automated and manual control of the milling circuit.

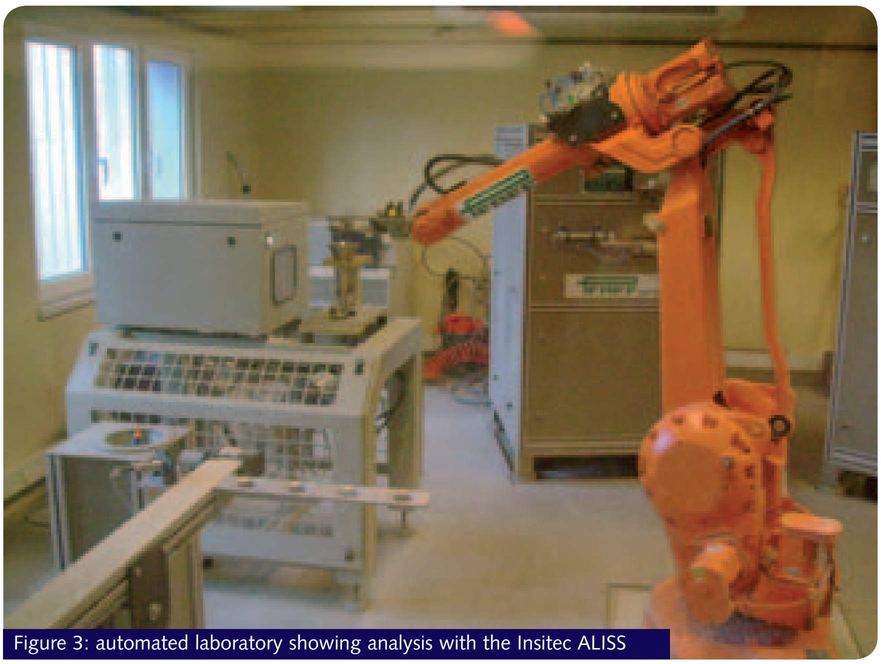
Figure 3: automated laboratory showing analysis with the Insitec ALISS

Sampling the cement

A fully automated system is used to extract a representative sample from the conveyor belt carrying finished cement from the exit of the milling circuit to storage. This involves a pair of rotating tubes swinging through the layer of cement on the belt; these fill rapidly as they pass through the position directly opposing the direction of flow. Once back in the vertical position the tubes empty, passing the collected material into a mixing chamber. During routine operation, the sampling arm rotates five times every hour with all five samples being mixed to form a homogeneous composite, from which a smaller sample is extracted for analysis.

A screw auger extracts this 250g sample for analysis as the mixing chamber is emptied. All unused material is recycled to the line. The final sample is automatically transferred into a canister that is subsequently sealed and pneumatically transported to the automated lab.

This process delivers a representative sample every hour. More rapid sampling is achieved by rotating the arm five times in relatively quick succession. This operation delivers the same quantity of sample over a much smaller period of time, providing a spot check as required.

Control of the milling process

Samples from the exits of the two mill lines are sent routinely to the automated laboratory every hour. Sampling systems on the final product conveyors extract slugs of material for analysis, typically every 12 minutes. This produces an averaged sample for the preceding hour rather than a snapshot of the process. If necessary the sampling mechanism can be accelerated to allow spot samples to be collected. For routine operation, however, more-representative data are generated using samples collected and mixed over a period of one hour. The samples are conveyed through pneumatically driven lines, in canisters, to the automated laboratory where they are split for analysis. 80g from the 250g sample is used for particle size measurement, the remainder being used for other analyses, and to build up a composite sample over 24 hours; this is analysed to give a daily average result.

Data transfer into the Windows CC control system delivers information to the operator for process control. Key parameters are percent less than 10, 22 and 32µm, although many others can be reported if needed. A calculated measure of Blaine number is determined from particle size data, using appropriate values for density.

For each grade of cement, Holcim has constructed control models that describe how different process variables need to change in response to a sub-optimal or out-of-specification particle size measurement. These empirical models were developed following the installation of the Insitec ALISS, utilising data produced with the new analyser. Using the models, the control system manipulates mill feed rate, classifier speed and air flow rate through the filters, to ensure that particle size is maintained within specification. This automated control is closely monitored by the operator and can be over-ridden easily if necessary. Figure 4 shows steady state operation and a grade transition.

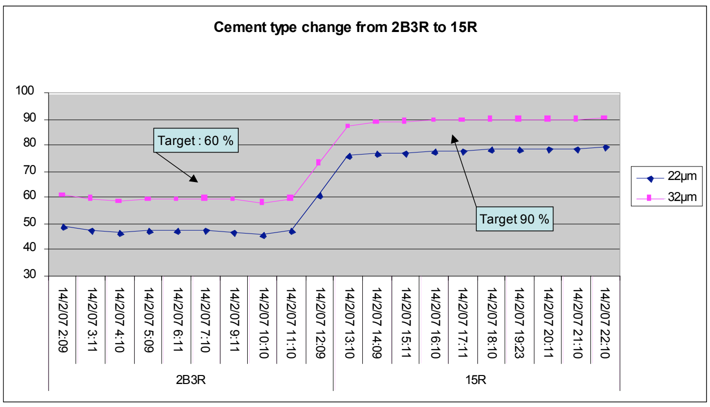

Figure 4: steady state operation and grade transition

Experience with the automated lab

The automated lab fulfils the original brief for the project, operating 24/7 with little manual intervention. Maintenance, particularly cleaning, is much less onerous than with the old set-up and communication with the control system is easier. Holcim has encountered few, and then only minor, problems with the Insitec ALISS, and has received all the necessary support to develop appropriate solutions. By exploiting the full potential of the Insitec ALISS, Holcim hopes to further enhance process efficiency in the coming years.

Conclusion

While on-line particle size analysis coupled with fully automated control is increasingly widespread within the cement industry, good control can also be achieved using automated at-line analysis. An automated lab brings the analytical process closer to production, simultaneously minimising the manpower associated with routine analysis.

Technology has developed to the point where a fully automated laboratory operating 24/7, with minimal manual input, is an accessible reality. Analytical systems such as the Insitec ALISS are designed to operate within the process environment and integrate with existing control platforms, facilitating the use of data in automated control strategies. The application at Holcim demonstrates how successful this approach can be and illustrates some of the benefits achieved by a move from a conventional laboratory to more process-centred analysis.