

The missing link is found

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For nearly two decades cement producers have operated with both types of analysers without taking full advantage of the potential synergy between the two. Although online analysers are real-time, they are not as accurate as the lab analysers for a variety of reasons. XRF analysers in particular benefit from a controlled environment and the ability to run reference standards daily. Online analysers in contrast are challenged by dynamic sample conditions (eg, variable belt loading and layering), varying sensitivity within the cross-section of material on the conveyor and infrequent opportunity to standardise. Thermo Fisher Scientific saw an opportunity to address this accuracy gap and in 2011 introduced a software product, Thermo Scientific AccuLINK, to bring lab-type accuracy to the online analyser.

The AccuLINK™ value proposition

Today, cement producers with raw mix online analysers (see Figure 1) rely upon them for frequent adjustments in mix proportions, to adjust to real-time changes in the composition of the raw mix components. In most cases, the proportion changes occur automatically with blending software, either from the analyser supplier or from a third-party provider. What is not automated, however, is the calibration of the online analyser from corresponding lab analysis. Conscientious raw mix analyser owners routinely gather hourly analysis results from the online analyser and compare to the lab analysis on the same lot of material, using raw meal samples and the lab X-ray system (see Figure 2). Linear regression analysis is applied to the data, and a determination is made by the plant whether a calibration adjustment is warranted.

Thermo Fisher designed AccuLINK to

Today, approximately 750 online elemental analysers using Prompt Gamma Neutron Activation Analysis (PGNAA) technology are installed in the global cement industry. About 40 per cent of those, some 300 machines, are used for automatic raw mix proportioning. Historically, these online analysers act as a complement to the traditional lab X-ray fluorescence (XRF) systems. The value of the online analysers stems from their real-time capability, whereby the plant can adjust raw mix proportions in sync with actual chemistry changes, as frequently as once per minute, rather than endure the time lag associated with raw meal sampling, transport, preparation and XRF lab analysis. The superior accuracy of the lab XRF system coupled with the timely nature of the online system have proven to be an optimal quality control mechanism for the modern cement producer.



Figure 1: this Thermo Scientific CB Omni raw mix analyser at a cement plant in the eastern US was used as a beta site for testing the AccuLINK product

automate the process used to calibrate the online analyser and to achieve unprecedented levels of accuracy with its online PGNAA systems. The company had introduced a software product about five years ago, called Thermo Scientific PACT, that attempted to facilitate calibration as well as evaluate raw mix process issues. This product gained little traction primarily because it still relied upon operator involvement in two areas: moving data from the lab analyser to the online analyser to facilitate statistical comparison, and actually applying any calibration adjustment to the online analyser. With AccuLINK, those two steps – data transfer and actual calibration adjustment – are now fully automatic (see Figure 3).

Graphics galore

The Bias Summary Screen (see Figure 4) shows a pair of plots for each of the main quality control parameters (eg, LSF,

silica ratio) or individual oxides (eg, MgO, CaO). The first plot in each pair shows the hourly lab versus analyser trends for the most recent 2-3 days, while the second plot shows the bar chart of the average bias between the lab and the analyser, where each bar represents a calibration period, for the past three months.

The Quality Control RMSD Summary Screen presents a three-month bar chart of the Root Mean Square Deviation (RMSD) for the main quality control parameters of interest.

The Oxide RMSD Summary Screen presents a three-month bar chart of the Root Mean Square Deviation (RMSD) for the main oxides.

The Calibration Overview Screen presents the current calibration constants in use for each detector, along with an indication of any oxide/detector pair which appears to merit a recalibration at the next calibration interval.

Figure 2: the Thermo Scientific ARL 9900 lab XRF analyser was also used in the beta testing of AccuLINK



The Oxide Calibration Screen (see Figure 5) includes two plots (a scatter plot of lab versus analyser values for each detector, and a trend plot of the same data, both shown from the chosen calibration interval). The User Interface also includes an XRF Lab Analysis data base and an analyser calibration history trend plot. In addition, the look of the several plots and the choice of parameters are easily customised by the user with convenient pop-up screens.

User flexibility

AccuLINK derives much of its utility from the ease with which the product can be configured to suit the user. All of this flexibility is found in the configuration pop-up screen with six tabs.

1. Statistical significance: the user can decide the statistical confidence threshold that must be met for a new calibration to be applied. A 95 per cent confidence interval is typical, meaning there is only a five per cent chance that the data considered did *not* warrant a change in the calibration constants. In the same tab of the pop-up window is found a minimum threshold for r-squared for those situations in which both a gain and offset appear warranted: ie, the user might decide not to apply any full gain and offset calibration based upon data in which the r-squared is less than 0.5
2. Frequency of evaluation: with this parameter, the user can decide at what time interval they wish to scan recent data (see point 3 below) to determine whether a calibration change is warranted.
3. Days of data to use in each evaluation: the data with which an evaluation of the need to re-calibrate is made can also vary. The user might want to ensure that the calibration is robust and include a longer time period, one week for example, than

Figure 3: the AccuLINK software links the Thermo Scientific Laboratory XRF Analyser with the Thermo Scientific online analyser

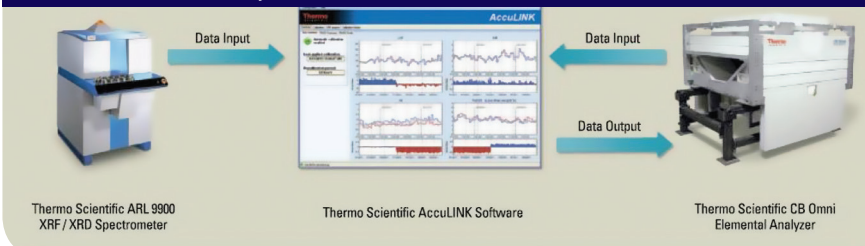


Figure 4: the Bias summary screen on AccuLINK provides a recent look at trends in the lab and analyser values for the key quality control parameters, as well as a longer-term look at the trends in bias between the two systems

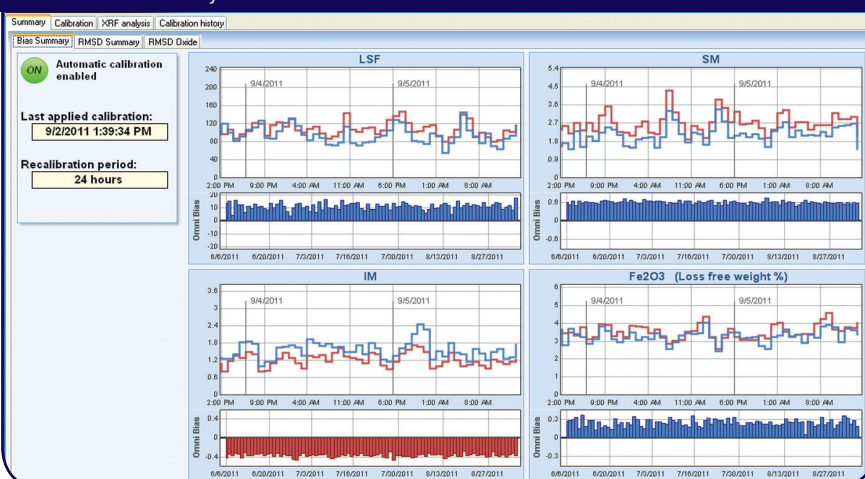
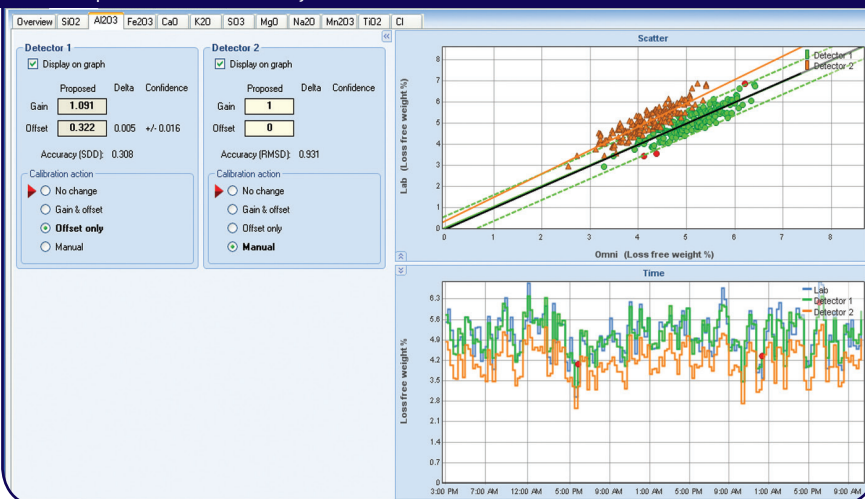


Figure 5: the Calibration Oxide screen on AccuLINK gives an x-axis/y-axis depiction of the relationship between lab and analyser values for each oxide and for each detector



the interval at which the evaluation itself is made. Hence, the evaluation interval might be every 24h, while the data under consideration might be the most recent 96h, or four days.

4. Outlier rejection criterion: the user can easily select the sigma value (away from the best-fit linear regression) beyond which a data point will be rejected and not included in the data set used to derive the calibration gain and offset.

5. Graphs to be included on the main

screen: cement producers often vary considerably from plant to plant in the choice of which quality control parameters or which oxides are the most critical for raw mix control. Some plants are especially concerned with MgO or total alkali, while others care only about LSF, silica ratio and alumina modulus. AccuLINK's configuration screen allows the user to choose exactly which parameters to graph on the main screen. Not only can the user select the

parameters to follow, but the operator can easily adjust the span of the x-axis for the trend comparison of the analyser and the XRF lab analyser. He can also adjust the span in time for a bar graph showing the average bias between the two. Typically, the analyser versus the lab trend display will cover 48-72h, while the bias bar graph will span 2-3 months.

6. Phantom raw mix components: in most cement plants the raw meal sample is not exactly the same material that has passed through the analyser just minutes prior. There are often process streams such as recirculating dust that factor into the raw meal, that are not exactly equal to the raw mix. AccuLINK has a means for the user to reflect this in an easily-configurable table.

Fear of automation

Applying calibrations without a "man in the loop" can be a rather frightening prospect at first. There are AccuLINK features to give the plant confidence in the product before letting it apply calibrations automatically. One logical approach is to run the AccuLINK initially in semi-automatic mode. In this mode the recommended calibrations are shown to the user, but not applied without the operator's assent. The plant could operate this way for days and weeks until they achieve a level of comfort that the product is doing what it should.

Once the plant has confidence in AccuLINK, and it wishes to go fully automatic, there is still an additional level of protection for the user. That comes in the form of limits that are user configurable. The operator can decide just how much difference in gain or offset is tolerable; recommended calibration changes which fall outside this tolerance

Figure 7: LSF Standard Deviation results from Beta trial

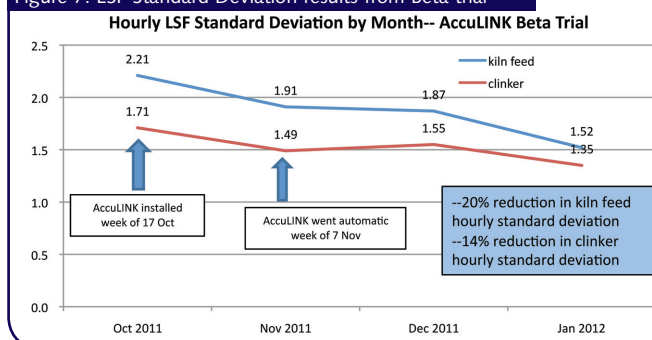
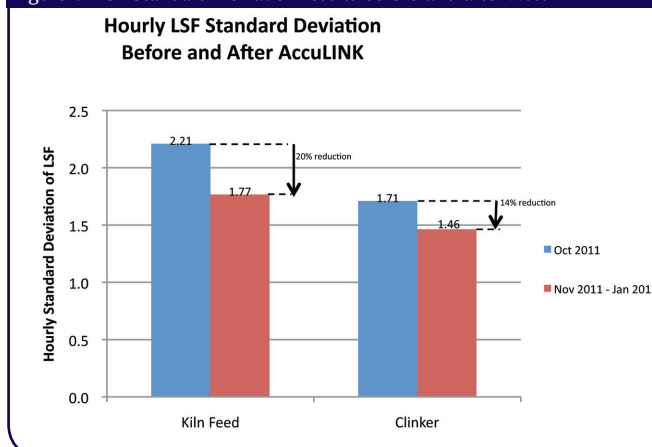


Figure 8: LSF Standard Deviation results before and after AccuLINK



band will not be automatically applied. Instead a pop-up message alerts the operator to this phenomenon, and the user must approve the calibration change prior to its insertion.

Beta trial experience

Thermo Fisher found a willing beta partner at a plant belonging to a leading cement producer in the eastern US. The AccuLINK software was installed in October 2011, and has run flawlessly for more than three months as this article went to press. The cement producer provided some suggestions for improvement that were promptly

implemented.

The system was run in "manual" mode for two weeks, then was placed into "auto" mode, where it has remained ever since (see Figure 6).

Among the advantages experienced by the plant's quality control supervisor was a more consistent kiln feed (see Figure 7), the ultimate value proposition for online analysis. It has improved kiln stability without question. He said: "It has helped me across the board and the system is working very,

very well. I now don't worry as much about what is happening to raw mix chemistry overnight." When asked which user interface screens he most relied on, he said, "I don't even look at them any more. I don't need to."

Summary

Online analysers are frequently used by cement producers for raw mix proportioning. These analysers enable the user to improve process efficiency, achieving more consistent kiln feed chemistry with all the well-known associated economic benefits. Until now, however, the potential of online analysis has been somewhat limited by inexact and too infrequent calibration assessment. The AccuLINK product from Thermo Fisher addresses those limitations, fully automating calibration of the online analyser, and thereby bringing, for the first time, lab-type accuracy to an online analyser. It is available for use in cement plants that have both a Thermo Scientific raw mix analyser and a Thermo Scientific ARL lab analyser.

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Figure 6: actual LSF trend data taken from the beta trial

