when Fauji Cement Company (FCC) built a second kiln line to expand cement production it similarly invested in a SpectraFlow online analyser and a preblending software to optimise its stockpile blending. It did this, because in the expanded operation both lines are fed with material from the existing stockpile and therefore, the turnover at the pile will be significantly higher. This optimisation is based on the raw material analysis of the online analyser, which is used by the preblending software to evaluate the best set-points of the clay and limestone feeders into the crusher.

FCC's operational set-up and the results of the stockpile blending optimisation, with a special focus on the ABB SpectraFlow online analyser optimisation and performance, is now described.

Operational set-up at FCC

FCC uses two feeder bins before the crusher that are filled with clay and limestone. The LSF of the material in the limestone bin is always above the target LSF, whereas the clay LSF is always below the target LSF. This arrangement permits a continuous variable material dosing from each bin. Therefore, a continuous adjustment to the target LSF of the material from the crusher can be achieved. Material is then moved forward via the ABB SpectraFlow online analyser to a 55,000t capacity circular stockpile. The pile feeds Line 1 with a capacity of 250tph and the new Line 2 at 570tph capacity. Before each raw mill, three additive bins with high LSF material (high-grade limestone), low LSF material (clay) and iron corrective (laterite) are available, and as corrections in both ways are

The online analyser is now seen as essential to many manufacturers to improve raw material quality and consistency in the modern cement plant. The benefits of such control combined with additional software programming to advance the blending process is an excellent way to ensure that the cement production process begins in the best possible way. And with less need for large raw material correction, costs can be significantly reduced.

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View of Fauji Cement plant, following expansion of the second line

Figure 1: overview of control circuit at Fauji Cement
possible the pile can be adjusted right on the target of the raw mill LSF set-point.

ABB installed two sets of online control software to regulate the raw mill LSF set-point: the preblending software controls the apron feeders out of the crusher bins based on the analysis of the ABB SpectraFlow analyser and the raw mix proportioning (RMP) software directs the additive input at the raw mill on the basis of the XRF hourly samples.

**The ABB SpectraFlow online analyser**

ABB made its well-known Near-Infrared technology available for the minerals industry with the introduction of its SpectraFlow online analyser. Advantages like the absence of a radioactive source as well as low maintenance and investment costs, while achieving very accurate measurement results, makes this analyser very attractive for the cement industry. The SpectraFlow online analyser cannot only be used for the measurement of raw material on a conveyor belt but also uniquely for the online measurement of raw meal, kiln feed or finished cement in the airslide. Combined with ABB’s well-known optimisation software Expert OptimizerIT, the SpectraFlow online analyser is a powerful device for the cement industry to achieve a better quality performance and to reduce costs (see Figure 2).

**Installation and optimisation of the ABB SpectraFlow online analyser**

The ABB SpectraFlow analyser at FCC was commissioned in October 2011 and has run continuously since then. The optimisation is based on a back-calculation of the XRF raw mill results, as this is the only possibility to evaluate the performance of the SpectraFlow online analyser. A direct spot sampling from the conveyor belt would only deliver random results as the SpectraFlow analyser scans the material every 125ms (40 scans are averaged to a single spectra). Out of nine single spectra, a one-minute average value is calculated. At FCC the throughput at the crusher is about 2000tph and therefore each one-minute value of the SpectraFlow analyser represents around 30t of raw material. It is obvious that it is
not possible to compare 30t with a spot sample of some kilos, especially if there are high variations in the material.

The back-calculation compares the average SpectraFlow results with the average XRF results of each constituent over one complete pile, which at FCC is 55,000t.

To be able to compare the results, all influences on the material stream from the SpectraFlow analyser to the raw mill sampling station have to be considered. First, the additives have to be subtracted according to the hourly feeder setpoints at the additive silos. To be able to do this, the additive average chemical composition has to be evaluated. This has to be combined with the hourly mill throughput. The result is the chemical composition of the raw material from the stockpile and all these results have to be averaged over the complete pile. The SpectraFlow one-minute results also have to be tagged with the one-minute beltweigher values that have to be moisture-corrected as the XRF raw mill results are also dry values. The moisture measurement is made by the ABB SpectraFlow analyser itself and no additional moisture measurement device is needed.

Afterwards, all the SpectraFlow results have to be averaged over the complete pile. Now the averaged back-calculated XRF value for each constituent can be compared with the averaged SpectraFlow value for each constituent. The difference of these values is the offset.

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\text{Offset}_{\text{CaO}} = \sum_{\text{complete stockpile}} (\text{CaO}_{\text{XRF}} \times \text{tonnes sample XRF}_{\text{complete stockpile}}) - \sum_{\text{complete stockpile}} \left(\text{CaO}_{\text{backcalc add to silo from feeder ABB}} \times \text{tonnes sample stockpile}_{\text{complete stockpile}}\right) - \sum_{\text{complete stockpile}} \left(\text{CaO}_{\text{SpectraFlow}} \times \text{tonnes sample CrusherBeltweigher}_{\text{complete stockpile}}\right)
\]

\[
\text{total tonnes of stockpile}
\]
Since the analyser has been commissioned, two optimisations were performed to firstly evaluate the rough offsets and secondly, to adjust the offsets right to perfection. These two phases were necessary as, before the analyser was commissioned, the variations on the stockpile were very high. This required that additional emergency corrections of the pile had to be carried out via a separate feeder, which was not covered by the SpectraFlow analyser. Therefore, a huge amount of unknown material was forwarded onto the pile which explains why the optimisation had to be completed in two steps.

**Performance of the ABB SpectraFlow online analyser and ABB control software**

The first raw material from the stockpile, which had been built up after the first offset correction, was reclaimed on 27 November 2011 (see Figure 4). The impact of the ABB SpectraFlow analyser and ABB control software was significant, as the LSF standard deviation of the hourly raw mill XRF values was immediately reduced from 4.385 with a limestone/clay additive consumption of 11.778 per cent to 2.695 with a limestone/clay additive consumption of 3.267 per cent with the SpectraFlow analyser. Therefore, no more additional corrective material via an emergency feeder had to be forwarded to the pile and the second optimisation could be started. At the start of January 2012, the first raw material after the second offset correction was reclaimed and from then on the LSF standard deviation of the hourly raw mill values was decreased to 1.503 with an average limestone/clay additive consumption of 1.248 per cent. As iron is very low in all quarry raw materials, about 5tph iron corrective laterite is generally added to the mix. To summarise, after the final optimisation the combination of the ABB preblending software with the analytical results of the ABB SpectraFlow analyser (see Figure 5) ascertains that by taking more than 96 per cent of the raw material from the stockpile, the raw meal has already kiln feed quality.

**Performance validation**

After implementing the final offsets and some months of successful operation, another comparison of the ABB SpectraFlow analyser values with the back-calculated XRF raw mill values was made to validate the accuracy of the SpectraFlow measurement. Two complete piles from 6-20 March 2012 were stacked and reclaimed with a total amount of more than 110,000t. The accuracy of the SpectraFlow online analyser measurement was very high, as there was actually no difference with the XRF values. The calculation itself can be considered as very good, as more than 91 per cent of the total mix was material from the stockpile, while around two per cent was laterite, which is a very stable additive and does not add uncertainties. With the highly-accurate SpectraFlow online analyser measurements the preblending software could adjust the feeder set-points at the crusher bins perfectly, which resulted in a very stable stockpile on the target LSF value (see Figure 6). The stability and homogeneity of the stockpile is also visible in the very low LSF standard deviation of the hourly XRF values.

During the reclamation of pile 1, only raw mill 2 was in operation and with the raw mix proportioning software controlling the additive feeders the LSF standard deviation of the hourly XRF raw meal values was 1.32. The LSF standard deviation of the hourly XRF values after the raw mill 2 of pile 2 was even better at 0.97. Raw mill 1 is running without ABB’s raw mix proportioning software, which is automatically adjusting the additive feeder set-points, according the hourly XRF analysis of the raw meal and therefore the LSF standard deviation was at 1.61.

**Conclusion**

The combination of the preblending software, the raw mix proportioning software and the ABB SpectraFlow online analyser resulted in the direct tangible benefit for the customer that the amount of additives was significantly reduced. A minimum of 90 per cent and up to 98 per cent of the raw meal now comes from the stockpile. The less-tangible effect is that the LSF standard deviation of the hourly raw meal feed is significantly reduced, which means less energy consumption in the homogenisation silo and a smoother kiln operation.