Quality kiln feed with RMCS

The Raw Mix Control System (RMCS) has been developed for the cement industry by PSCL to achieve superior quality kiln feed. The process control software aims to provide consistent, homogeneous, on target, low-cost and optimised kiln feed using extensive understanding of process control and quality systems.

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The Raw Mix Control System (RMCS) is a computer-based goal-seeking optimiser. It provides real-time monitoring of raw mix chemistry and feeder performance while tracking and referencing the historical storage of this data. The system monitors quality values and provides the application of constraint rules as well as ongoing XRF correction factors based on closed-loop control of raw feeders. The goal is to utilise frequent online chemical analyses to track the changes in quality while considering the contributing feeder settings to predict and adjust for variations in the raw material chemistry.

RMCS has been successfully installed in close to 30 cement plants globally, including locations in Canada, USA, Australia, Algeria, Jordan, Colombia, Chile, Costa Rica, and two new installations in Turkey and Argentina to be completed by year-end.

Figure 1: typical implementation of the RMCS with four weighfeeder bins

XRF, cross-belt, RMX analysers

RMCS has grown and developed over the years with advances in process and technology. In the early years, it was proven to be very effective with XRF analysers. Cement plants benefitted from the automation of the XRF and the large depth of consideration that the computer algorithm performs with each analysis. RMCS was upgraded to adapt and control with high frequency analyses of the cross belt analyser. The journey of continuous development based on the feedback of cement plants has been beneficial. More recently, RMCS was integrated with the FCT post-mill RMX analyser to provide more timely and accurate analyses for improved control.

Benefits to cement plants

RMCS has benefitted cement manufacturers such as LafargeHolcim, HeidelbergCement, Argos, Buzzi Unicem and McInnis Cement by improving kiln feed homogeneity and reducing costs.

Key benefits include:

- configurable consideration for material cost, allowing optimisation of high cost material based on the respective chemistry thus reducing overall production expenses
- robust algorithm handling complex calculation scenarios, providing the best possible option for control with each analysis
- configurable feeder strain and swing functions
- controls and optimises with multiple, variable raw mix analyses – adaptable to control with XRF, cross-belt (gamma and neutron) and post-mill RMX (COSMA) analyses
- full raw mix quality control capability by switching over to control with XRF analyses allowing routine maintenance for online analysers
- controls automatically but allows manual override for handling obstructive plant conditions – eg, material contamination, feeder control problems
- allowance for operational issues such as feeder starvations and flushes
- allowance for material variation to obtain consistent raw mix
- alarm configuration capabilities, visual on-screen notifications, signalling process systems, email and audio notifications
- real-time data screens to review performance and diagnose issues
- can provide 'what if' scenarios to evaluate possible mix options
- data export capabilities beyond the standard raw mix control data exchange
- 24h support from experts with over 10 years of cement customer experience
- consultation from over 25 years of servicing the cement industry.

The control concept

Figure 1 shows the transport of raw material to proportioning feed bins and passing through an online analyser before feeding the vertical roller mill. It depicts a typical implementation of the RMCS with four weighfeeder bins. The online feed analyser provides chemical results for the raw mix. RMCS efficiently monitors the raw mix process by analysing raw mix samples and calculating with a control algorithm to make recommendations to a process control system (PCS) to adjust weighfeeder settings based on target achievement. The analysis of the changes will in turn cause a re-evaluation of the feeder settings, providing a closed-loop control of the raw feed.

The RMCS program uses the contributing feed rates and raw material chemistry analyses to compute an expected analysis. The actual analysis is compared to this expected analysis and the current material variation is determined. With this knowledge, RMCS can determine new set point ratios that will bring the raw meal back to target. Critical primary targets include mineralogical values such as LSF, SR, AR, C_3S, etc, and secondary targets such as material cost can further optimise the raw feed when primary targets have been satisfied. Targets can also be set to minimise the use of materials containing contaminants such as mercury or chlorine when those values exceed pre-set thresholds.

A change to the feeder ratios is made with each new analysis received. This way the process does not need to go out of control before the system will react. If the raw meal analysis is very close to target, only very small changes will be made to feeder set points. These changes may be even smaller than the known error in the feed system.

The process

RMCS uses four basic steps to determine the overall quality of the raw mix:

1. measuring the process
2. eliminating variances for consistency
3. monitoring the process
4. recommending the best feeder set point values.

Two types of analyses (direct and indirect) typically facilitate monitoring the raw mix samples' chemical composition. An online analyser performs direct analysis, by frequently analysing material samples from the belt and sending the results electronically to RMCS. The online analyser provides an exact analysis of the four core oxide elements and the remaining compound minerals may be calculated by RMCS. Results are then used in the control algorithm to determine improvement areas of raw mix. RMCS uses the analyser's current and recent analyses for statistical process control (SPC) graphs and grids for monitoring performance.

A laboratory X-ray analyser performs the indirect (offline) type of analysis. An indirect analysis produces a more accurate analysis of the composition of the raw mix according to a set sampling period. The results of the X-ray analyses are imported into RMCS. In addition to monitoring the raw mix, based on analysis results, the raw mix feeders are also monitored.

RMCS uses a control algorithm to determine if the analysis results indicate an improvement or a decline in the raw mix, by comparing the elemental chemical values to defined targets specified by the user. RMCS provides a fitness rating to determine the best optimal solution of feeder set point adjustments to meet the target requirements using the current feeder materials. The feeder set point results of the calculation are recommended to the PCS.

Drift correction

RMCS has full capability of controlling sufficiently with any single analyser independently. However, a more robust flexibility can be realised by combining the online and offline analyses in RMCS.

The automated online analyser typically has a short analysis frequency (1-10min) and the XRF has a longer frequency (1-3h). The XRF also acts as a backup in case of either failure or routine maintenance of the online analyser.

RMCS can be configured to use the XRF analyses to automatically factor data received from the online analyser. Online analysers measure short snapshots of the unhomogenised material moving on the belt whereas XRF measures a prepared, homogenised, typically 2h composited sample. The offline analyses are considered more accurate but take time and effort to prepare. RMCS provides

Figure 2: the graph view shows more detail on how the control algorithm of RMCS works

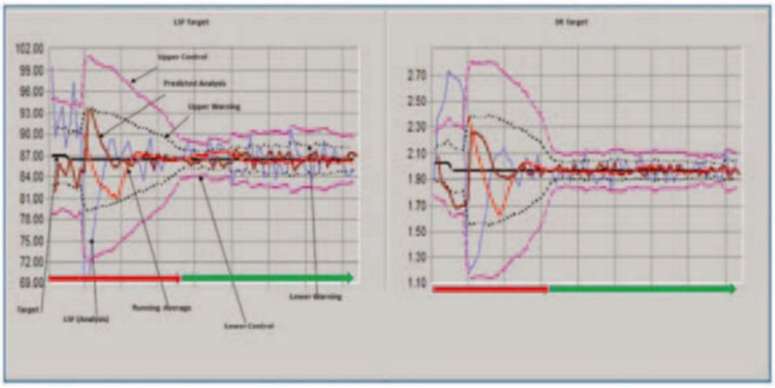

Figure 3: in the grid view, the analysis results are shown as numerical values

Defined Target	90.8	2.61	1.35
Kiln Adjusted Target	86.3	1.94	1.89
Average	86.63	1.97	1.81
Target Deviation	1.99	0.14	0.11
Standard Deviation	1.98	0.14	0.09
Minimum	81.97	1.70	1.54
Maximum	93.91	2.63	2.04
Sample Times	**LSF**	**SR**	**AR**
11:33 24-Jul-2019	83.72	1.99	1.93
11:28 24-Jul-2019	88.39	1.95	1.82
11:22 24-Jul-2019	90.00	2.15	1.75
11:17 24-Jul-2019	85.74	1.99	1.71
11:12 24-Jul-2019	90.37	2.09	1.80
11:07 24-Jul-2019	87.21	1.82	1.86
11:01 24-Jul-2019	84.44	1.96	1.61
10:56 24-Jul-2019	85.80	2.14	1.58
10:51 24-Jul-2019	87.27	2.00	1.74
10:45 24-Jul-2019	84.69	1.81	1.95

the option where the lab analyses are used to factor the online data that is then used for control.

RMCS can automatically start making control decisions with the offline XRF data if it no longer receives new data from the online analyser. Alarm notifications are configurable within RMCS to alert the lab and process control people of the control analyser change over.

RMCS displays

RMCS displays the chemistry of interest such as targets and constraints on the SPC screen views that can be either graphs or grids. The SPC views are calculated and updated for every new analysis to help the operator monitor the target achievement status. The graph and grid views described below depict a customer project in the USA showing how RMCS improved consistency of their raw mix.

Graph view

The graph view in Figure 2 shows more detail on how the control algorithm of RMCS works. The LSF and SR graphs are shown in two periods, the initial period represented by a red arrow, and the latter period represented by a green arrow. The red arrow shows the period where RMCS is 'Off' ie, 'Manual mode', which means RMCS calculates the new set points but does not send them to the PCS, consequently, the target achievement is poor.

In the latter part of the graph represented by green arrows, RMCS is 'On' ie, 'Automatic mode', which means RMCS calculates and sends the new set points to the PCS and the target achievement is visibly improved. The description of the various trends is given below for better understanding:

- Predicted analysis – the next analysis that the RMCS control algorithm is predicting.
- Target – what the algorithm is aiming for.
- Lower control limit/lower warning limit/target/upper warning limit/upper control limit. These values are illustrated as dotted lines behind the analysis results. When a configured rule has been broken the user will be alerted with a message below the graph. These lines are dynamic and will change as target and limit values are changed.
- Running average – although it is good to keep the chemistry on target, when chemistry does deviate from target, it is important that these deviations appear on both sides of the target line so that when the material is blended, the average target chemistry is achieved.

Grid view

In the grid view (see Figure 3), the analysis results are shown as numerical values instead of points on a graph. Additionally, reference information is provided in the upper rows of the grid, and is used to illustrate the defined target, kiln-adjusted target, average, target deviation, standard deviation, minimum and maximum values defined for each element. The description of each is given below:

- defined target – target value for the associated field name
- kiln-adjusted target – the new calculated target for the associated field name
- average – calculated average for analysis period or of number of points.
- target deviation – difference between the target and the mean for analysis period.
- standard deviation – calculated amount of natural material variability for analysis period.
- minimum – minimum value of the associated field name for analysis period.
- maximum – maximum value of the associated field name for analysis period.

The analysed result of each element is dynamically colour-coded to indicate the deviation from the target value: black indicates an on-target value, blue indicates a value below the lower control limit and red indicates a greater than upper control limit value. In addition to the colour-coding scheme, the colours also indicate how close the results are to the limit values.

Cruise control for the quality lab

RMCS is a tried, tested and true solution to raw mix control. It provides a 'cruise control' tool for the quality lab with manual override options for when circumstances in the field require a temporary hands-on approach. It provides several options and details that help diagnose when issues arise.

RMCS gives consistent control and considers many factors in its decision-making. It is designed to be flexible in its commissioning and adaptation to every plant's unique environment from material variance to process system structures. PSCL works with its customers and incorporates feedback to continuously improve products and better handle the functions of the cement manufacturing process. ■