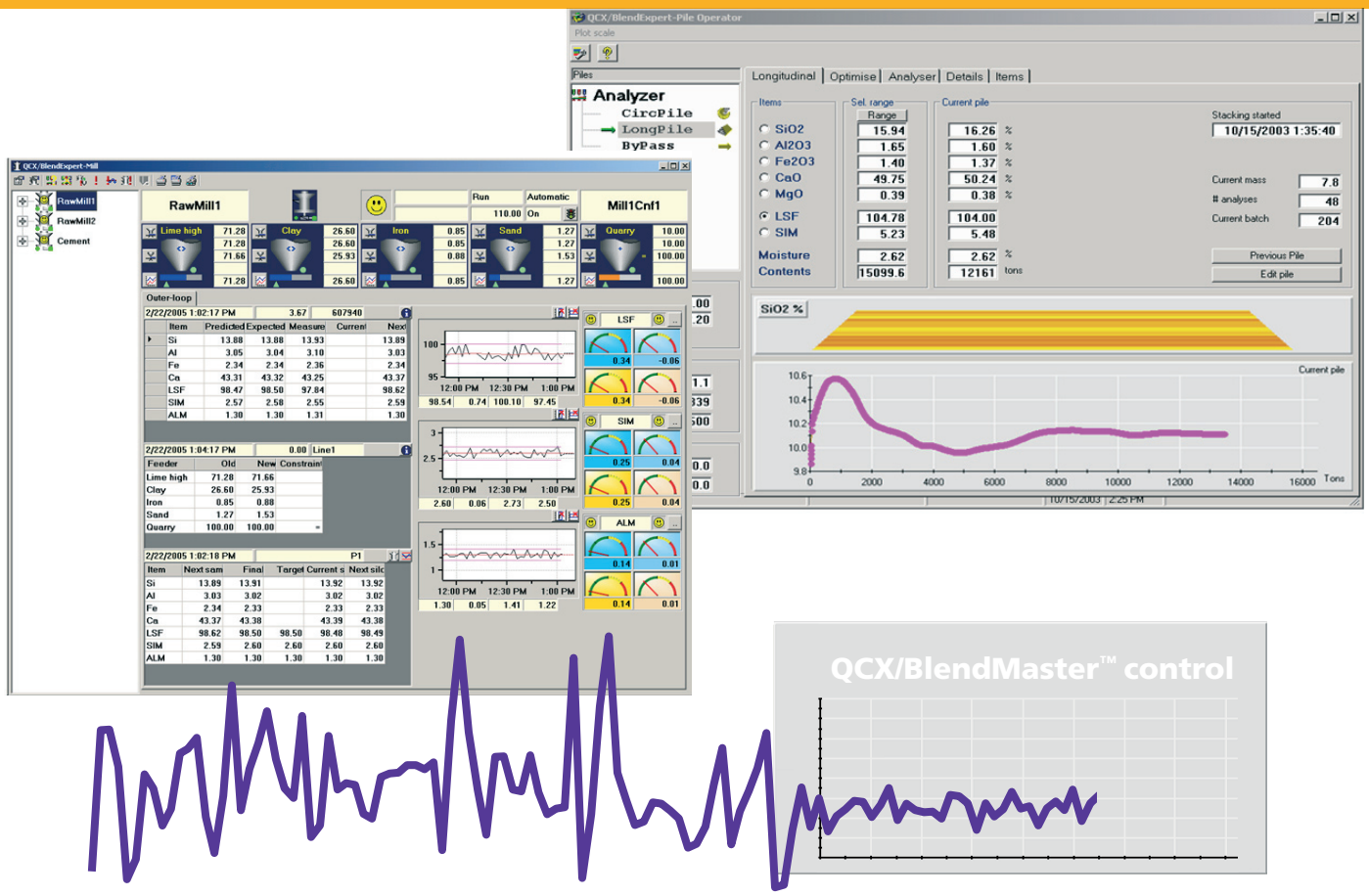
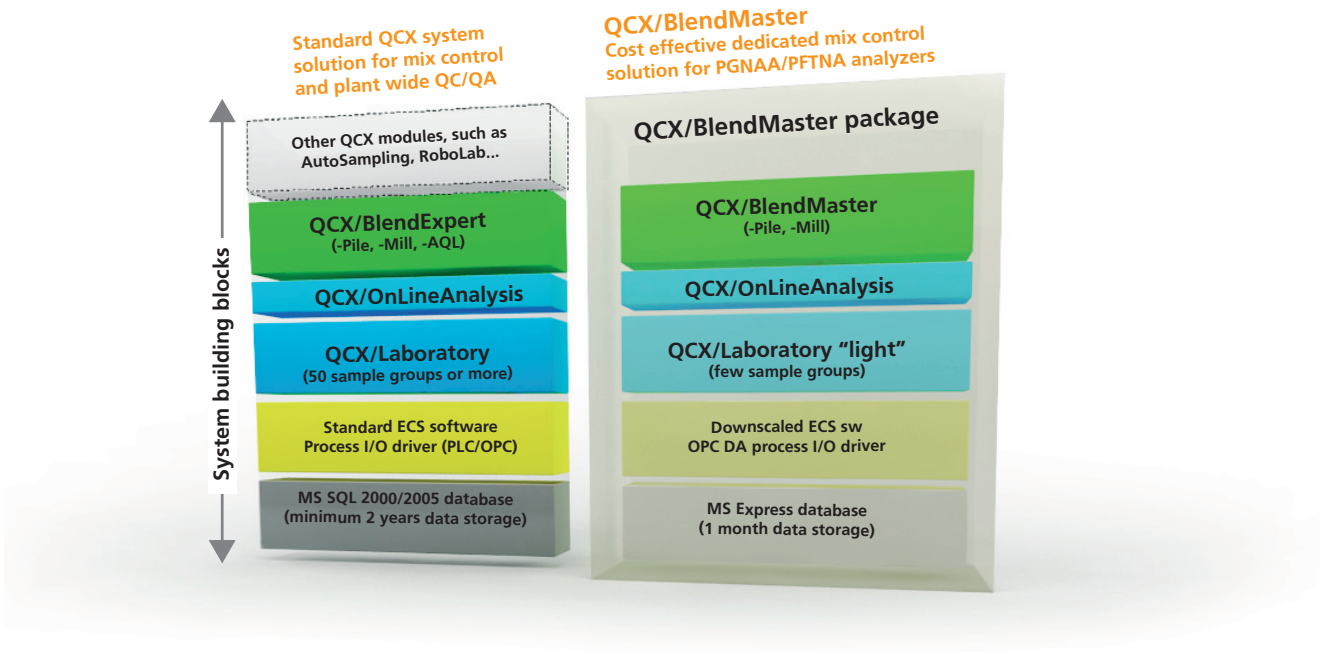
– a leaner, yet powerful version of QCX/BlendExpert™

QCX/BlendMaster™



FLSmidth AUTOMATION



Application

For more than 35 years FLSmidth Automation has been developing the QCX/BlendExpert™ product range to cover virtually any mix control scenario at a cement plant from quarry to bagged cement. QCX/BlendExpert software was developed to support a multitude of analysis techniques as well as basically every possible process lay-out. Several advanced control features have been added over the years. QCX/BlendExpert has successfully been applied in numerous projects with PGNAA - both for stockpile and raw mill quality control.

QCX/BlendMaster is built on QCX/BlendExpert technology, but is a leaner package focused on high frequency, on-line PGNAA based quality control. A QCX/BlendMaster application supports one PGNAA unit and one mix control task for either a stockpile or a raw mill. A QCX/BlendMaster project comes pre-configured for either a stockpile or a raw mill on-line analysis control set-up. The product supports all leading PGNAA brands and is configured with an 'OPC DA' interface to the general process control system. Compared to a standard QCX/BlendExpert solution it means reduction in LIMS style data presentation & reporting and high focus on QC support for high frequency on-line analysis.

A QCX/BlendMaster project also means streamlining of software engineering & configuration, so that a given project can be delivered within a short delivery time and with reduced on-site commissioning.

QCX/BlendMaster controls the proportioning of raw material feed to a stockpile or a raw mill to obtain the desired chemical product quality with respect to chemical constraints and various process constraints. Data capture and subsequent optimization calculations are fully automatic. Upon completion of every few minutes´ analysis cycle, the mass balance accounting is updated and new optimal feeder set-points are calculated and passed on to the general plant control system.

Stockpile accounting and associated application specific accounting and control utilities are supported by the QCX/BlendMaster-Pile application module. Recent software developments offer unique accounting and graphic data presentation facilities. Raw mill control applications are handled by the QCX/BlendMaster-Mill application module, which comes with a dedicated operator UI including a selection of available short term reports & trends.

Basic software functionality & feature

Applying object oriented programming techniques, the QCX/BlendExpert software features and associated data are structured in these functional blocks:

Analysis estimation

Optimizing

Feed/mix analysis

Production accounting

Set-point control

A detailed description of this functionality is found in the QCX/BlendExpert product profile. However, compared to the full QCX/BlendExpert functionality some limitations apply. The most important of these are:

Feed/mix analysis
- only PGNAA/PFTNA analysis technology supported.

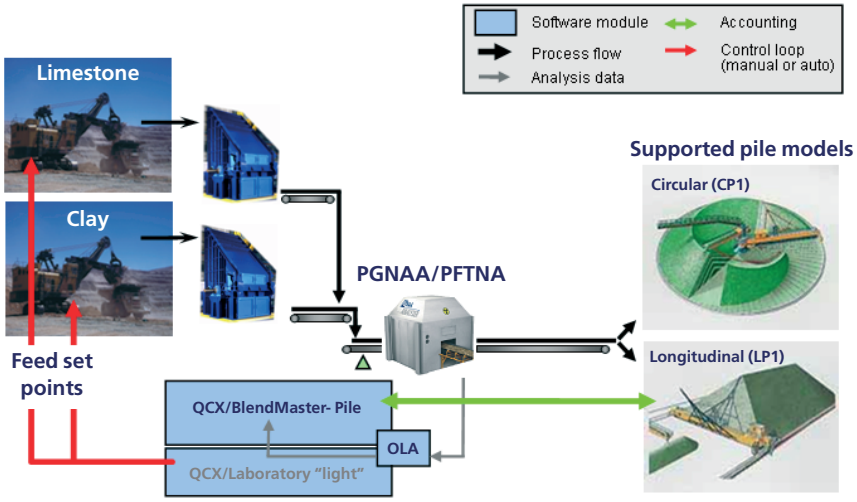
Analysis estimation
- multiple feed estimation is not supported

Optimizing
- advanced constraint set (or priority set) control is not supported
- material cost is not available as optimization parameter

Other software differences relate to limitations in free user access to re-definition of the mix control setup, such as definition of material balances, addition or deletion of feeders, etc.

The differences between QCX/BlendMaster and QCX/BlendExpert are implemented in the following way: the Operator UI's show entries for the entire suite of QCX/BlendExpert functionality, but features not available with QCX/BlendMaster are dimmed and appear none accessible for the user. A detailed list of all differences between the two product levels is available as an addendum to this Product Profile. After purchasing a QCX/BlendMaster solution, should you wish to upgrade from QCX/BlendMaster mix control to QCX/BlendExpert level, it is just a matter of acquiring a new software licence, and all dimmed

QCX/BlendMaster™- Pile



entries will be activated. Likewise, it is possible with a license upgrade to activate the standard QCX data presentation and reporting functionality. With such upgrade(s) the process I/O and data base specifications remain unchanged.

Accounting on stockpile build-up

Depending the type of stockpile the accounting functionality comprises:

- on-line accounting of 'to pile' material feed
- on-line modelling of discrete material layers and accumulated material composition of the pile
- calculation of modules and quality deviations
- facilities allowing manual correction of accounted data
- 'by-pass' accounting when material is not fed to a stockpile
- mimic display of stockpiling operation with key parameters
- reports on completed stockpiles and single stockpile details
- alarm/event reporting, such as announcement of predicted out-of-range chemistry for the stockpile section/layer
- option for claiming of material from a stockpile

QCX/BlendMaster-Pile offers high flexibility in terms of supporting a wide range of process lay-outs (see QCX/BlendExpert-Pile Product Profile). The chosen lay-out comes pre-configured with the installed software.

For **longitudinal** stockpiles (model LP1) the accounting & modelling continues until the active section is filled up. Then the status changes to become a 'historic' pile, and a new pile accounting period is initiated. For **circular** stockpiles (model CP1) the accounting is based on an advanced computerized model of stacked and reclaimed layers based on simulated stacker location. For both types of piles the software provides graphic depiction of quality variations within a stockpile.

Optional optimizing and screening & sorting

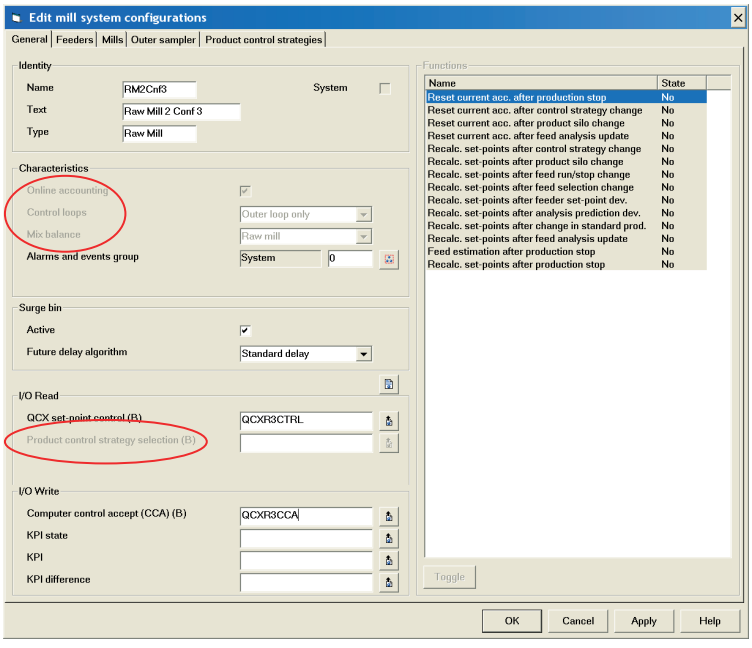
The optional optimizing functionality comprises:

- Optimizing - based on linear and quadratic optimization techniques - can be activated at any time during pile build up, and is based on already registered pile tonnage & chemistry and quality targets. The planning horizon can be either the remaining quantity to fill up the pile/pile sub-section or any other (shorter) operator specified period. For a circular pile the optimization calculations can be based on the registered contents of the actively stacked part of the pile
- Off-line control in form of on-screen reports on calculated optimal feed to the pile(s) from specified quarry sections
- Option for on-line control of 'to-pile' materials, provided that controllable feed devices are available, e.g. apron feeder belts before or after crusher(s)

The also optional screening & sorting functionality comprises:

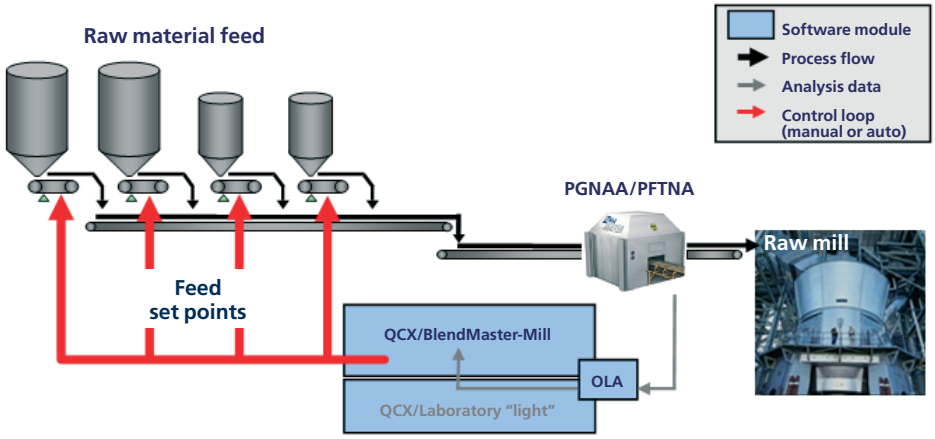
- Sorting of pile feed to one of multiple accessible piles
- Screening of current pile feed to the active pile
- Feature for on-line control of pile feed switching between accessible piles or a waste material dump, provided that the involved feed/transport devices can be remotely controlled

In order to prevent very frequent change of identified pile or of "go" / "no go" status, which may cause unwanted mechanical equipment wear, the sorting & screening may be subject to a hysteresis band applied around the limit value.



Functions/features not available for 'QCX/BlendMaster are dimmed (grey) in the selection menus.

QCX/BlendMaster™- Mill



Mill control application

QCX/BlendMaster-Mill continuously integrates material tonnage and analysis figures and compares the achieved product quality with the defined target quality. Optimal feed proportions are calculated and implemented typically every 5 minutes. Taking into account target chemistry and chemical & process constraints, QCX/BlendMaster-Mill will at all times produce the desired chemical product quality with minimum product quality variance.
Virtually any possible process lay-out of feeders, direct feed from stockpiles, surge bins, transport systems, mills, silos, etc are supported by standard software functionalities. Based on state-of-the-art predictive modelling computing, the dynamic production accounting for mill quality control comprises:

- On-line accounting of individual raw material feed streams
- Accounting of total mill production and predicted mix analysis
- Calculation of accumulated chemical composition, modules and quality deviations for the product mix
- Accounting of silo contents and composition in accordance with the applied silo model
- Mimic display of mill department operation with integrated graphs for key control parameters
- Smart UI for presentation of trends and key performances
- Alarm/event reporting

In addition to the comprehensive on-line production accounting and mix optimization functionality, the software also offers a wide range of special exception handling utilities to take care of upset conditions and special operational conditions.

Smart presentation and easy interpretation of control figures has been the driving objective behind the latest addition to the software functionality. The output from the advanced control algorithms applied by QCX/BlendMaster-Mill is evaluated by the use of key performance indicators, and the comparison against 'good performance' is transferred into a suite of user friendly iconized data entries, graphs, indicators and 'smiley' icons. A 'smiley' icon is a graphical representation of the value of a Key Performance Indicator (KPI), defined as a weighted sum of the normalized performance in three categories.

- Tracking error: The control loop should eliminate tracking errors in the controlled variables. This is tested by calculating the moving production weighted average
- Standard deviation: The control loop should minimize the standard deviation of the controlled variables. This is evaluated on the calculated standard deviation
- Low frequency transients: When homogenizing the mix in a silo, it is crucial that the frequency of mix variations is such that the variations can be sufficiently dampened. This is tested by calculating the standard deviation of mix variations above a given cut period (expressed in minutes)

Based on these three indicators an overall key performance indicator is calculated for all applied quality targets. Customization of parameters and weighting factors is open for the user.

Operational benefits

QCX/BlendMaster sofware means:

- state-of-the-art control accounting and optimizing software techniques, ensuring lowest possible quality variations after the stockpile, mill or silo
- high configuration flexibility to match virtually any occurring process lay-out details
- unique exception handling features for optimal control in upset conditions, where less advanced solutions would require switch to manual control
- powerful application support dedicated for on-line PGNAA

While high frequency on-line analysis, such as PGNAA, is a key to obtaining best practice control performance, the mix control software applied is equally if not more important in achieving these improvements. Very often a substantial part of the control performance improvements are attributable to the applied computerized mix control techniques. QCX/BlendExpert & QCX/Blendmaster have a proven track record of maximizing the potential performance improvements.