Learning the ABCs of APC

Max Tschurtschenthaler and Ryan Koorts, ABB, explain how technological developments such as the Internet of Things (IoT), data analytics, and cloud technology are underpinning progress in advanced process control.

The pressures facing manufacturing sectors, such as the cement industry, are well known and are often discussed in the pages of trade magazines and at industry conferences. Similarly, the benefits of digitalisation and Industry 4.0 have been much advertised by suppliers and users, keen to position themselves at the forefront of industry development.

Terms such as Internet of Things (IoT), big data, data analytics, artificial intelligence, and cloud technology have become largely familiar – if not fully understood.

The question is no longer one of whether these digital technologies can bring significant advantages to cement operations, but how they are able to achieve ongoing process optimisation in practice. This article will take a look at one aspect of that, focusing on the use of advanced process control (APC).

Connected, intelligent operations

When planning and implementing a digitalisation strategy, it is important to take a holistic approach. This means moving the process from using isolated and discrete functions to one in which processes are connected, via developments in IoT technologies, and then automated. From there, it is possible to transition to autonomous operations, whereby optimisation and asset management functions occur largely without human interaction within a secure cyber environment.

The key therefore to successful digitalisation is data, collected directly from connected equipment and processes or derived from soft sensor models. The latter can be used to infer data where no measurement exists, e.g. when real-world measurement would be too expensive, or to increase the frequency of data input and provide backup for unreliable measurements.

Using this data, it becomes possible to supplement the human operator's skill and creativity to better control the process and optimise performance. Central to this process is advanced process control (APC).

The autopilot to an optimised plant

APC – such as ABB's Ability™ Expert Optimizer – is best conceptualised as the autopilot that drives a plant to its optimum state. Using model predictive control (MPC), APC is able to reduce process variation and move the process closer to the constraints. It is able to achieve this by first understanding process interactions and delays through data-driven empirical models, such as state space models, and then making small changes, much more frequently than a human operator could. This thereby creates a much more stable process environment than is possible under manual control (Figure 1).

The use of APC therefore offers the potential to overcome a range of customer challenges to:

- Minimise costs:
  - Minimise energy consumption.
  - Minimise consumables.
- Maximise yield:
  - Minimise variability.
  - Maximise throughput while minimising give-away.
  - Minimise shift-to-shift variations.
  - Minimise upstream disturbances.
  - Honour environmental process constraints.

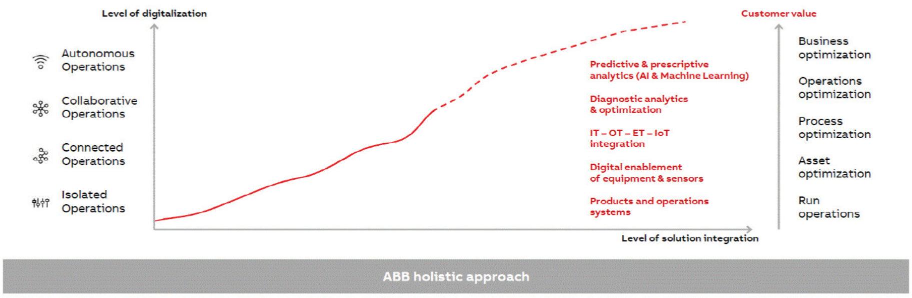

Figure 1. ABB holistic approach: driving up the digital value chain.

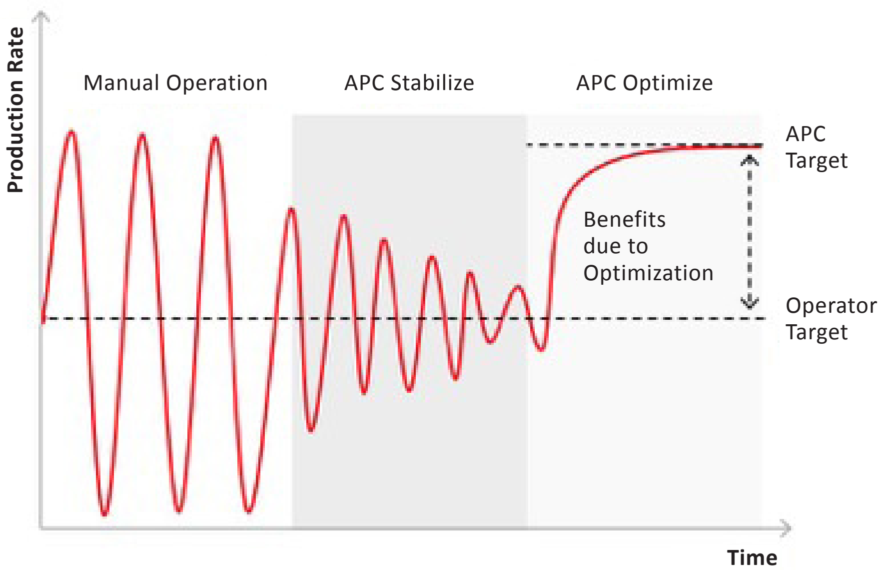

Figure 2. APC first stabilises and then optimises the process.

The challenges of APC

APC as a concept has been around for some time: the first description of the use of MPC to control applications was presented in the 1970s by Jacques Richelet. Despite its potential advantages, however, APC has acquired a mixed reputation.

A typical APC project starts with the design, installation and commissioning of the applications, at which point the benefits are realised. With the system performing as promised, the user might well decide against the cost of a service-level agreement, preferring to maintain the system via an onsite champion. Over time, however, this onsite champion moves on, while operating conditions, such as raw materials and fuels, gradually change to the point that the predictive model no longer reflects the actual operating conditions. As a result, performance of the application starts to deteriorate and it is eventually turned off.

The development of new digitalisation technologies, such as IoT and cloud computing, offers a solution by moving APC from a CAPEX-led investment with separate software license and maintenance agreements, to a collaborative and continuing partnership between APC supplier, such as ABB, and plant, based on the idea of subscription licenses and services. Not only does this mean that the advantages of the system are maintained, but it opens up an opportunity to achieve enterprise-level multi-site optimisation.

The benefits of this approach can be summarised as follows:

- Collaborative: Information is accessible to anyone, anywhere, on any device, at any time. This brings operational visibility to all levels of a business, from a top-level fleet view to compare and benchmark plants, to looking at individual plants to assess critical KPIs, down to viewing individual operations and assets.
- Faster: Quicker reaction to changes in the process.
- Lower risk: The approach is lower risk as a result of lower operational costs and a completely managed environment. The APC is maintained and the benefits are sustained and no longer de-activated and then forgotten.

APC: a guide to success

As APC implementation has not always been successful over the long term, ABB offers a three-phase approach to ensure continuous system performance under the banner of ABB Ability™ Performance Optimization for mining and cement (PRISE; Figure 3):

- Evaluate.
- Implement.
- Sustain.

Under the first phase, a plant's needs are assessed via a site study (fingerprint), which helps to define and evaluate a digitalisation roadmap based on tangible monetary benefits (ROI), including process stabilisation, consumables reduction, throughput increase and quality increase. The goals of the study are:

- To identify bottlenecks via data analytics of real plant and process data.
- To deduce recommendations to handle the identified issues.
    - To provide a roadmap for APC applications based on ROI and speed of implementation.
    - To provide a budgetary costing and resource planning for both parties.

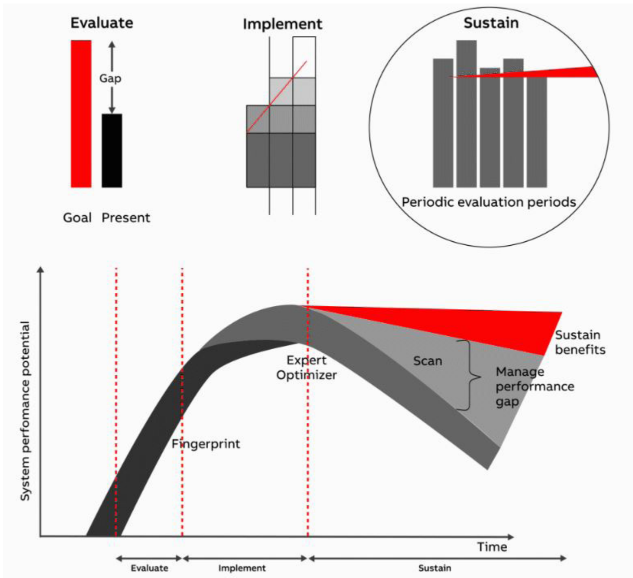

Figure 3. Performance optimisation for cement (PRISE).

The analyses and KPIs included in the scope of the study vary from site to site but generally cover raw materials processing, raw mill, calciner, kiln, cooler, and cement mill (Figure 4). It is also recommended that certain preliminary data is provided before the onsite study begins, such as a process flowsheet, heat and mass balance (where relevant), process description and standard operating procedure.

Once the site study has been undertaken and presented to the site, and assuming APC implementation moves ahead, the challenge then becomes maintaining the benefits after commissioning. As noted previously, this has been the downfall of APC systems and the reason behind its sometimes less-than-favourable reputation. ABB overcomes this through a process of KPI monitoring.

The monitoring of KPIs provides a quick overview of application performance and availability with the following goals:

- Monitor ongoing application performance.
- Highlight areas of concern.
- Minimise engineering required to troubleshoot misbehaving controllers.
- Maximise application performance.

KPIs are either predefined and set up during commissioning or can be customised by the client. Predefined KPIs relate to the general performance, effectiveness and utilisation of ABB Ability Expert

Optimizer, or to the manipulated and controlled variables.

By regular monitoring of the system's performance, the problems posed by it 'going out of date' or a site losing its APC champion are avoided, ensuring the benefits continue to be enjoyed long after commissioning and eliminating the potential for the system to be switched off by operators.

The benefits of APC

When implemented and maintained to these best practices, APC becomes a powerful tool for ensuring a cement operation survives and thrives in a competitive business environment. Indeed, typical improvement values delivered to users of APC applications such as ABB Ability Expert Optimizer include:

- Up to 50% use of alternative fuels.
- 1% – 3% recovery of product.
- Up to 30% reduction in consumables.
- Up to 8% increase in throughput.
- Up to 50% reduction in quality variability.
- Up to 10% reduction in emissions levels.
- Longer equipment lifetimes.
- Improved operational discipline.
- Reduced energy consumption.

Equipment Assessment		
	Input signals:	• process and design
	KPIs:	• design capacity/limitations to achieved performance delta
Base Level Control & Process Performance		
	Input signals:	• historized process data, PID loops
	KPIs:	• process variability • base level, PID performance • process KPI targets, e.g. blaine, LFS, BZT • performance gap between constraints and achieved • operator control intervention/experience
Equipment Changes		
	Input signals:	• equipment design changes
	KPIs:	• effect on throughput • effect on availability
Alarm & Event Analysis (if applicable)		
	Input signals:	• alarm & event log
	KPIs:	• most frequent alarm/trip • alarm distribution over time • alarm distribution over assets • severity ratio
Downtime Reduction		
	Input signals:	• alarm & event log, runtime
	KPIs:	• number of trips • most frequent trip during runtime • number of trip types during runtime • table of all detected trips during runtime
Blasting and Stockpile		
	Input signals:	• upstream operations changes
	KPIs:	• plant stability • throughput • product variability

Figure 4. Analyses and KPIs that can be included in site study. The scope is subject to change during the site visit, depending on plant suitability and information availability.

Conclusion: a data-driven revolution

Data lies at the heart of this revolution. Cutting edge technologies, such as IoT and cloud computing, are connecting equipment and processes to plant operators and company management like never before. With more and better quality data now available, advanced data analytics and artificial intelligence can be applied to enhance process control and bring the concept of an autonomous plant into reach. Boosted by these advances, APC is moving beyond its checkered past to play a leading role in the development of the intelligent cement plant. ■

About the authors

Max Tschurtschenthaler leads the global cement industry market for ABB. He has worked for more than 16 years in the cement and mining industry having gained extensive experience as Project and Sales Manager for greenfield cement plant projects in Asia and the Middle East.

Ryan Koorts is Product Manager for ABB Ability™ Expert Optimizer. His experience spans nine years in process plant optimisation across several industries including mining and cement. It also includes all three major pillars of brownfield value creation from identification of potential benefits, to implementation and long-term service maintenance.

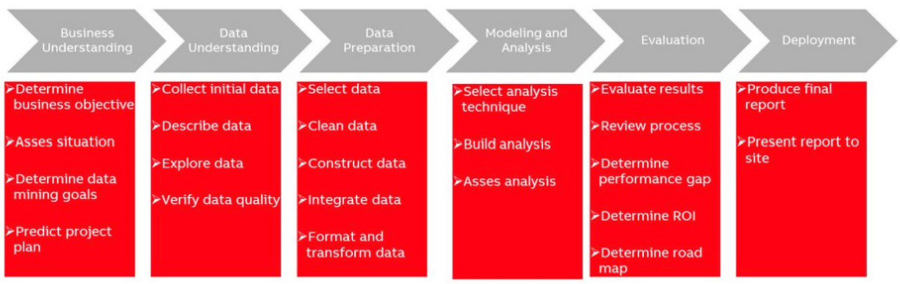

Figure 5. Work flow of site study: data understanding and date preparation are critical steps. It is therefore critical that the information collected is as accurate as possible.