How cement producers are using AI to transform their operations — and future trajectory

Best practices

AI and the bleeding edge

Leading cement producers are constantly looking for ways to minimize the cost of operations while maximizing yield, improving quality, and reducing emissions. In their search, many are considering artificial intelligence (AI) as an enabler to achieve these objectives.

AI is the buzzword of the year in many industries, including cement. But AI today means a lot more than "a thinking machine." At ABB, we see the use of AI accelerating and expanding across the cement industry and other process industries.

There are three primary drivers behind AI adoption among cement producers:
- computing power
- connected devices
- algorithms

AI in the aggregate

As the cement industry adopts AI, it is also adopting a new vocabulary.

Artificial Intelligence is like a formula that achieves goals in new situations. The formula adapts to change rather than remain a static algorithm.

Machine Learning (ML), a subset of AI, is the principle that a machine can learn without human intervention, developing its own algorithm to improve the performance of a specific task. ML can only solve problems formulated for it. Not every optimization method it learns from data makes sense in real life, or delivers tangible benefits.

Neural Networks is a set of algorithms loosely modelled on the way the human brain processes information.

Deep Learning is a more sophisticated version of ML used to perform more complex tasks or to produce data needed for decision-making. It uses multi-layered neural networks for a more powerful way to filter and process information.

AI adoption key drivers

Computing power
Greater computation power and increased training speed of deep neural networks.

Connected devices
More connected devices and endless data storage accessible via the cloud.

Algorithms
Algorithms are finding patterns and optimization opportunities from access to more data.

AI at work

For the cement industry, AI means looking at persistent problems with a fresh perspective. It also means solving challenges around the accuracy & explainability of AI techniques so that a machine's recommendations can be trusted and addressed.

The new world of AI involves cleansing data, removing anomalies, analyzing correlations between parameters, interpreting results, and more.

First, a successful ML solution implementation requires standardized data, with a data management approach closely aligned to the business strategy. The best classification model requires many iterations and a unique combination of data science, cement industry expertise, and ingenuity.

To operate assets and dynamic processes optimally, cement plants must not treat them separately. **Value and understanding come when plants uncover previously hidden relationships and correlations.** Increasing volumes of data, combined with better-quality data, will improve model performance in the future. We are just at the beginning of this exciting journey.

Decoding the cement-manufacturing process

Just about every area of a cement plant can be decoded over time. AI can learn multiple process areas, including quarries, raw material/meal preparation, clinker production, cement production, and dispatch. AI and ML can understand virtually every asset or asset system's DNA, given enough data.

Technology, capital, and manual processes are all valuable assets that can be optimized by AI algorithms, provided there is enough data and

the right people to teach machines. Success with AI in cement production requires specialists using their expertise to show machines how to structure their computing methods more like human thought, and to how to break problems into simple steps.

These specialists teach machines how to solve complex tasks faster by using lesson plans that explain vital information and offer guidance on how to self-monitor for effectiveness.

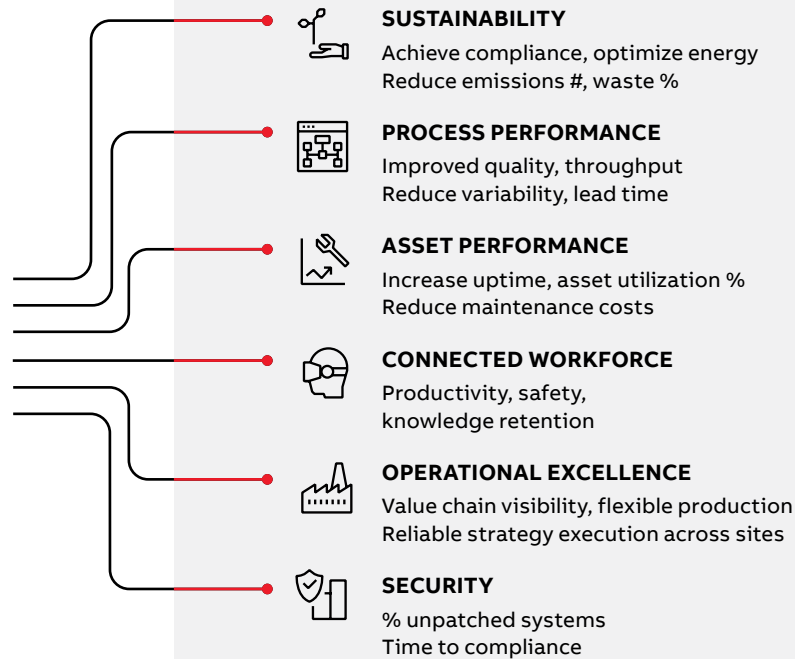# AI use cases in the cement industry

The cement industry faces a range of challenges in its day-to-day operations around profitability, cost control, quality vs throughput, emissions, and environmental sustainability. AI delivers many advantages that help cement producers meet these challenges.

The ability to perform advanced data analytics and smart optimization powered by AI is the game changer many cement producers have been looking for. AI allows cement producers to achieve key performance indicators around sustainability, process performance, asset performance, connected workers and operational excellence. Here are some common use cases for AI in cement production.

Industry constants - value drivers

The need to relentlessly improve - at hyper-scale

SUSTAINABILITY
Achieve compliance, optimize energy
Reduce emissions #, waste %

PROCESS PERFORMANCE
Improved quality, throughput
Reduce variability, lead time

ASSET PERFORMANCE
Increase uptime, asset utilization %
Reduce maintenance costs

CONNECTED WORKFORCE
Productivity, safety,
knowledge retention

OPERATIONAL EXCELLENCE
Value chain visibility, flexible production
Reliable strategy execution across sites

SECURITY
% unpatched systems
Time to compliance

FORWARD THINKING

Enhance cyber security

Increasing numbers of cement producers on the digitalization journey want to take a more proactive approach to cyber security. AI-powered analytics solution and services will let plants continuously monitor, diagnose and resolve security issues, helping safeguard people, assets and reputation. And because technology and cyber threats both change unpredictably, ABB can help plants review their strategies periodically, including performing simulations under multiple circumstances, such as a major ransomware incident. Data analytics can also be used to test "what-if" cyber security scenarios.

Enhancing sustainability with AI

AI will play a vital role in reaching environmental sustainability targets, and not just around reducing emissions, but also energy optimization and management. This will create immediate benefits for operating costs and margins, also enabling new business models for high-tech, low-CO_2 cements.

Reach environmental sustainability targets

Cement plants are constantly focused on avoiding deviating from daily SO_2 emissions limits and associated hydrate consumption. They must juggle numerous process constraints. Due to variability in feed and fuel sources, coupled with complex dynamics, manual operators with PID control tend to remain at "safe distances" from process constraints, at the cost of plant profitability.

Today, CEMEX is already using ABB's advanced process control (APC) solution to **improve SO_2 emissions control while reducing hydrate consumption by 11%.** Operators select either normal or aggressive optimization models, and the solution automatically adjusts the multiple feeder points of lime.

F O R W A R D   T H I N K I N G

AI-based detection app

ABB's AI-based system anomaly detection app can learn a plant's "normal" states and use adaptive setpoints to detect unusual patterns and anomalous behaviors.

By triggering alerts, it can reduce the level of effort required to identify and rectify energy consumption deviations. Operators will no longer experience the hassle of setting manual setpoints or alarms, and there will be no more notification overload. The app can also learn from a plant's energy usage, production schedules and other factors to deliver accurate forecasts, helping plants to reduce peak demand charges on electricity bills.

Ongoing process performance optimization

Advanced process control solutions are perfect use cases for AI and ML, moving towards adaptive APC in order to achieve ongoing process performance optimization.

Today, traditional APC solutions successfully address thermal efficiency, fuel switching, reduction of the clinker-to-cement ratio, and other processes so that plants run more profitably. For example, they:

- **increase feed by over 3 tph while reducing specific energy by 20 kcal/kg**

- **deliver overall productivity increases of 4% with better and more consistent cement quality**

Tying analytics and APC together will enable re-modelling and tuning in an automated way and optimizing additional variables.

ABB is also working on utilizing data collected through cement information management system to address challenges that have not yet been tackled - like cement quality prediction. Traditionally, cement strength is measured after 28 days—obviously too late to make corrections in the process. Therefore, plants usually "overdeliver" on product specs. ABB is leveraging ML with data-driven soft sensors to predict 28-day strength on the day of sampling, allowing for immediate

process corrections. This involves setting new daily $CaCO_3$ / blaine targets. And it means cement plants will be able to sell more product at correct specifications while reducing additive (lime) consumption. With analytics, AI, and reinforcement learning from neural networks, APC apps can be further automated in a way that the performance

and accuracy of the models are continually monitored. In the future, analytics will re-tune the models, simulate and remodel processes, optimize additional variables, and move towards adaptive APC and autonomous operations. This will reduce engineering time and allow systems to operate at peak performance.
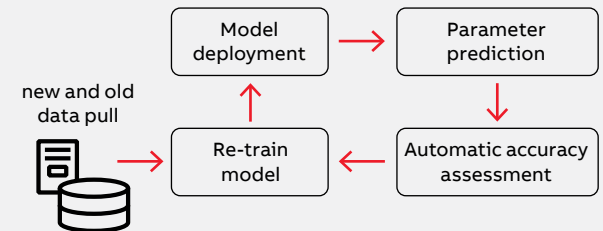

A perfect use case for AI/ML: move towards adaptive APC for re-modelling & tuning, optimizing additional variables

Periodic evaluation of APC performance

e.g. weekly data pull → Performance KPI computation → Reporting to customer

KPIs and context info
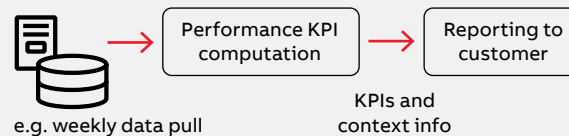
- The performance KPIs can be used to asses the solution over time
- Performance KPIs:
  Control: IAE, ISE
  Estimation: measurement-model mismatch
- If critical thresholds are hit, re-identification can be triggered automatically

Machine Learning component

new and old data pull → Model deployment → Parameter prediction → Automatic accuracy assessment → Re-train model

- Automatic re-identification based on new and old data
- KPI comparison for old and new model
- Automatic assessment

A step change in asset performance management

Leveraging AI for asset performance management (APM) is a step change in the way maintenance and reliability team members collaborate with other functions. AI ensures that assets are available at the time and at the performance level required by the operations—depending on changing production goals.

Predicting how assets react and respond to various factors (like age or operating condition) is difficult because complex systems interact in unexpected ways and are always evolving. Problems are often beyond the sight of human eyes. To provide accurate target parameter predictions in near real-time and to prevent failures, AI/ML models can be continuously trained with relevant datasets. These datasets feature deep understanding of both cement processes and asset behavior.

AI-enabled APM as the most cost-effective way to extend the life of aging and newer assets, and to decide on the optimal timing for scheduled maintenance turnarounds (one of the biggest costs in cement plants).

USE CASE

Predictive Asset Models can enable a cement plant to operate 24 hours a day with just three people

Predictive asset models can help cement plants operate with fewer workers, and to manage operations remotely. At the time of writing, which is in the midst of the global COVID-19 pandemic, operating a cement plant 24 hours a day with three shifts but just three people would be possible. An APM solution, powered by predictive asset models, would give the remote teams, all working from home, full visibility into data that would tell them the health of all assets in the plant.

Connected workforce as a catalyst for change

ABB is working on helping companies move towards an immersive workspace with mixed reality (XR) helping people master necessary skills more effectively and faster, establishing a foundation of consistency no matter the personnel. Safety, productivity, compliance, and training can be more effective through software solutions and analytics.

AI will improve workforce productivity by analyzing how operators interact with control systems and how quickly they respond to alarms. AI can learn which priority alarms require faster actions. It will then improve the visibility of these alarms, filtering them and rationalizing them to improve performance.

Use of human-centric control room environment, mobile technologies, smart glasses will make the industry more attractive for the new generation of engineers. ABB can help cement manufacturers develop their employees' AI capabilities by making low-code/ no-code solutions accessible to more people, letting them capture "tribal knowledge" on a common platform, innovate and achieve better outcomes.

FORWARD THINKING

How AI can interact with control systems and human operators

Human operators tend to operate cement plants within the limits of control systems. But AI can help operators learn from the past while managing the present.

Looking to the future, AI systems will interact with control system history data to learn from patterns, recommend optimal parameters and warn how to avoid negative impacts. After an AI system learns the best setpoints for quality, energy, eliminating downtime, and more, the core software will write these to the control system. This can be done either directly by rewriting a set point (close-loop system) or indirectly by providing recommendations to a human operator (open-loop system).

Visibility is key to operational excellence

Enterprise-focused, AI-based solutions have enormous potential for operational excellence, helping cement producers understand the reasons behind differences in plant performance levels.

Transferring knowledge and process methodology from higher-performing to lower-performing facilities helps companies optimize production and uncover best operating points to expand margins.

With less cement required in the future for modular, pre-fabricated buildings, AI will play an important role in restructuring operations to retain profitability during reduced cement demand. By analyzing how procurement was done in the past, AI assists with better planning for supply chain management.

Enabling autonomous operation

Without a doubt, more and better quality data - gathered directly from connected equipment, processes, soft sensor models and other systems - lies at the heart of the cement industry digital revolution.

Digital and automation technologies are connecting equipment, processes, plant operators and company management to an unprecedented degree. Advanced data analytics and artificial intelligence will ultimately bring the concept of an autonomous plant within reach.

ABB's experts and ecosystem partners meet the special needs of cement plant owners, collaborating to produce business results they demand and reach decarbonization targets by leveraging **ABB Ability™ Genix Industrial Analytics and AI suite.**
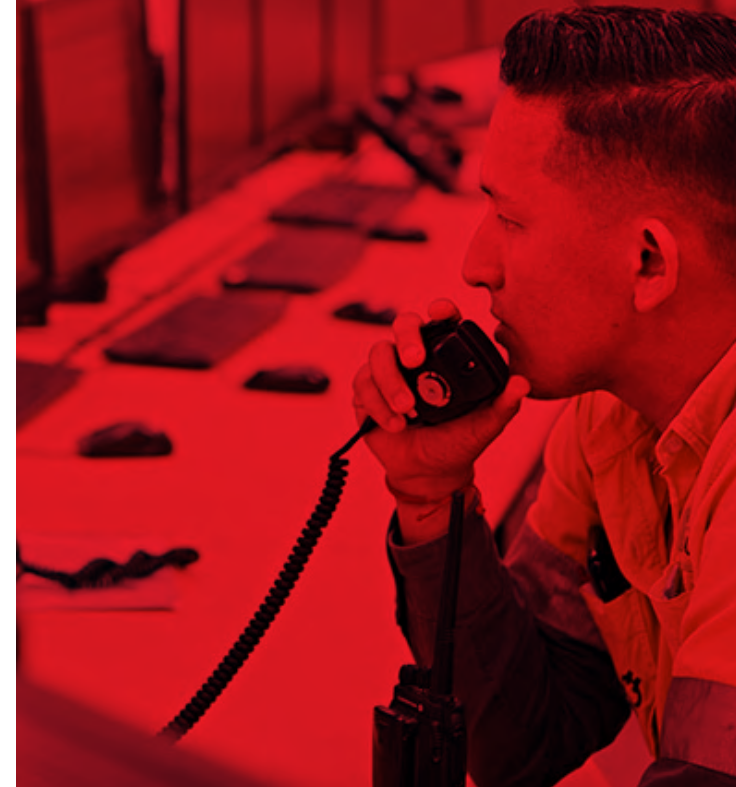
What the future looks like

How are AI technologies evolving? What does the future hold for AI and its use in the cement industry? ABB is monitoring a number of trends.
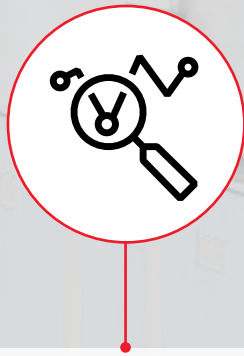
AI will gather data from more sources, including smart sensors, instrumentation, historians, and databases. The data from 20 years ago might be unavailable, but more data will be available for AI algorithms to evolve.

As AI gets easier to implement, more cement producers will embrace AI to reach sustainability targets, since there is no way to reach those targets with manual setpoint adjustments alone. AI will help the cement industry reduce its carbon footprint and improve its reputation.

Unit area models will evolve to continuously retrain themselves based on outside disturbances. This will give confidence to cement companies, making them more comfortable with having fewer human operators in a plant through autonomous operations.
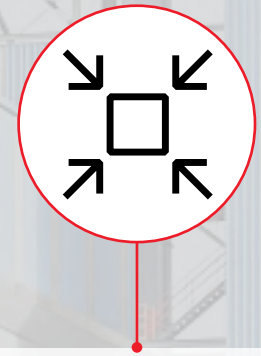
Core areas like operational excellence, process performance, and asset performance will continue to provide value, but **AI will help them become autonomous themselves.**

Bringing it all together

Digital transformation discussions will continue between the many cement industry leaders and technology implementors and innovators.

Increased complexity requires the ability to master different technologies, industry-specific processes, and cyber security, and to provide the needed consultancy and assistance to the end users from the early design stages up to system commissioning and maintenance. The reward for cement owners adopting digital solutions will be better performance at a reduced capital cost, and overall standardization of operational, process, maintenance, environmental and supply chain management practices, which will help in reducing and managing inherent complexity.

At ABB, we combine first-hand experience with tailored, co-created digital solutions to solve tough problems and deliver real value. Whatever stage you're at with Industry 4.0, we'll get you where you want to be.

Let's join forces to co-develop and collaborate to set new standards for the cement industry.

Learn more