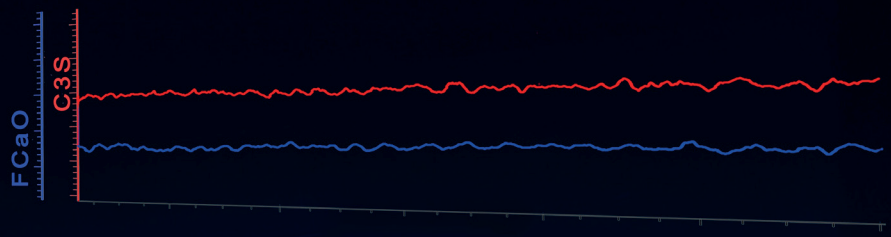
WORLD CEMENT
October 2025

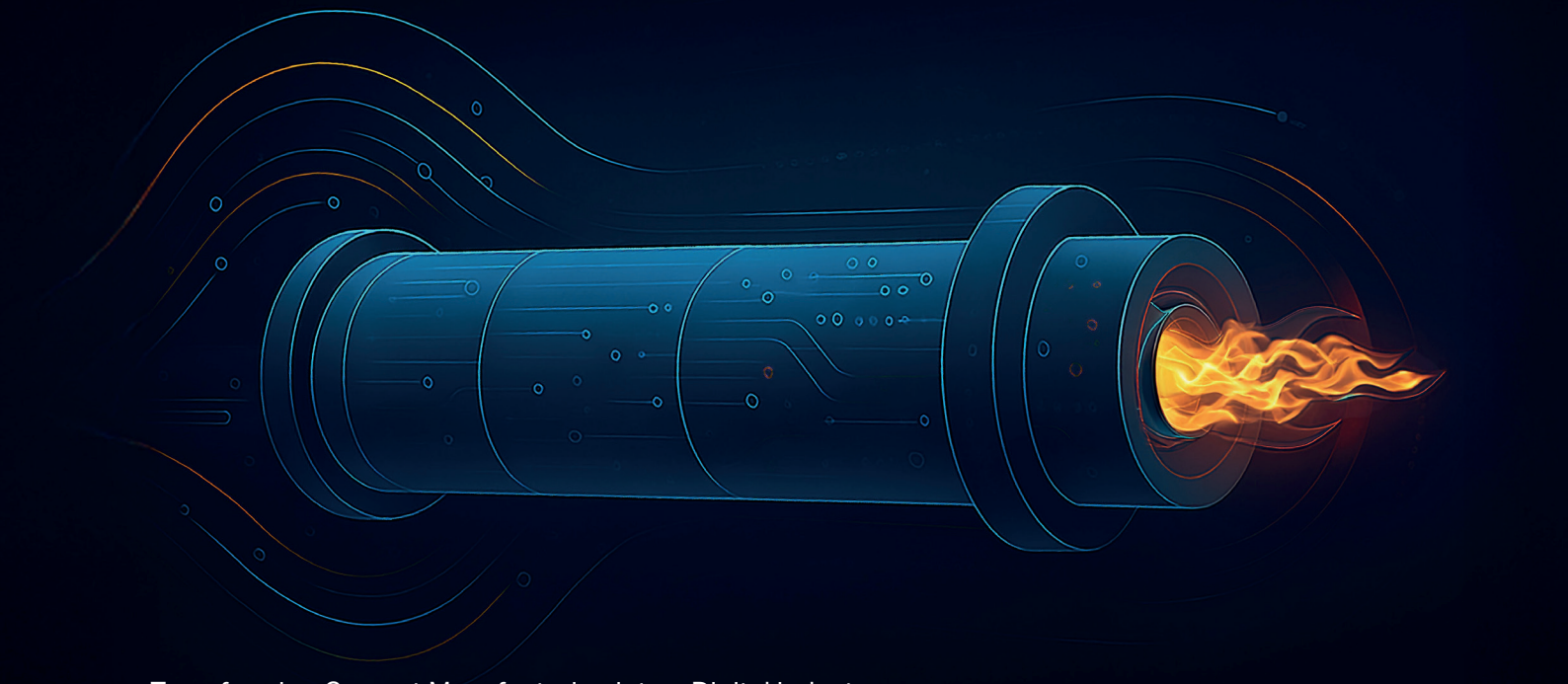
AI/APC Kiln Optimizer

Fully Autopiloting the Cement Process

AI-Powered Soft Sensors, Model Predictive Control & Real Time Optimizer working together to deliver the Highest Stability, Quality & Efficiency.

Every 30 seconds,
Our KPO drives the kiln to Perfection





Transforming Cement Manufacturing into a Digital industry.

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The Rise Of Smart Kilns

Ravi Kiran Puthi & Tony Salameh, ES Processing, explores how AI and advanced process control are reshaping kiln operation and cement plant performance.

Operating a cement kiln is one of the most complex and challenging tasks in the cement industry. Dozens of interdependent process variables including fuel mix, airflow, raw meal chemistry, and flame shape must be monitored and manipulated simultaneously. Even minor deviations in a single parameter can quickly cascade into wider instability, leading to wasted fuel, higher operating costs, and inconsistent clinker quality.

For decades, kiln operation has been largely a reactive process, where operators have relied primarily on their own experience and delayed laboratory measurements to make critical process adjustments. While this approach has served the industry for many years, the pressures facing cement producers today are very different. Rising energy costs, stricter sustainability requirements, and increasing demand for higher and more consistent product quality mean that reactive manual control is no longer sufficient.

ES Processing has sought to redefine kiln operations through its AI and advanced process control (APC) solutions that offer a fully autonomous autopiloting solution – optimising operations, enhancing efficiency, stabilising processes, and helping cement producers achieve new levels of performance.

Digital transformation in the cement industry

Across the global cement sector, digital transformation is gaining serious momentum. Concepts such as Industry 4.0 and predictive analytics are steadily moving from research projects into day-to-day operations. Cement plants are already realising the benefits of smarter monitoring and automated adjustments in areas such as energy management and quality control.

The kiln, as the central unit of clinker production, is now at the heart of this digital revolution. By combining real-time soft sensor predictions with advanced model predictive control (MPC) algorithms, ES Processing has developed a kiln process optimiser (KPO) that evaluates and predicts the entire process dynamics for the next hour – every thirty seconds.

The vision: autopilot for plants

At ES Processing, the vision has been clear. The aim is to transform cement manufacturing from a largely manually operated industry into one that is digitally driven and operated by full autopilot systems. For many years, ES Processing has been recognised as a pioneer in APC solutions for the cement sector. By combining deep process knowledge, sophisticated algorithms, and digital tools, ES Processing

has built systems that have helped plants to achieve more with fewer resources. Today, ES Processing is taking this vision further by fully autopiloting the very core of kiln operations and quality perfection. These AI/APC enabled solutions act as an autopilot for the kiln, reducing the need for constant manual adjustments and giving operators a reliable digital partner that can monitor, predict, and manipulate in real time every process parameter around the clock. The result is not only higher efficiency and performance but also a meaningful contribution to sustainability goals.

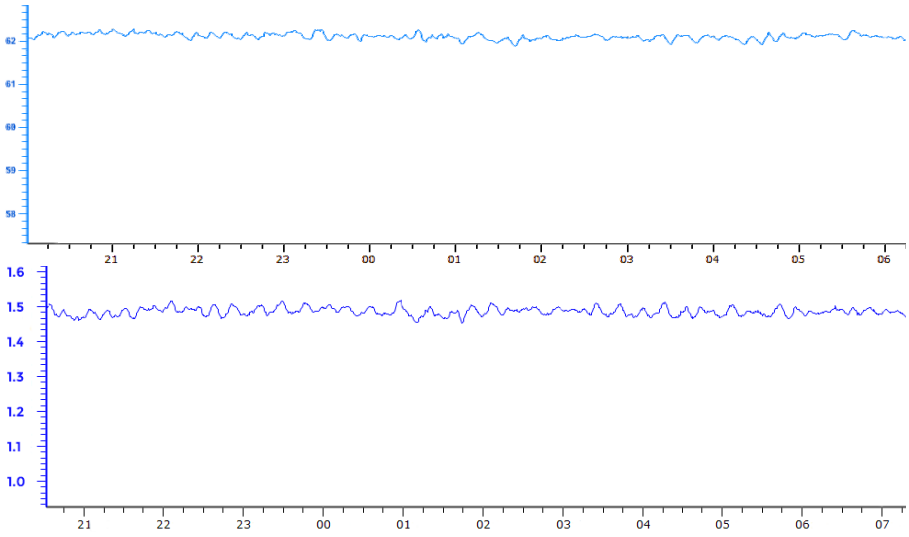
Predicting quality with soft sensors

One of the biggest challenges in kiln operation has always been the delay between process changes and laboratory results. Critical quality indicators such as C3S and free lime are typically measured in the laboratory, which means operators only receive the data a couple of hours after the clinker has been sampled. By that point, the kiln conditions may already have shifted, making corrective actions much less effective.

To address this challenge, ES Processing has developed AI powered soft sensors. These are essentially virtual analysers that use machine learning models trained on historical plant data to continuously predict accurately the clinker quality.

The soft sensors provide highly accurate predictions of C3S and free lime in real time. This enables both the KPO system and the operators to obtain accurate clinker quality predictions instantly, rather than waiting for delayed laboratory confirmation.

With this capability, kiln adjustments can be made by the KPO proactively instead of reactively. Moreover, operators gain greater confidence, decisions are taken quicker, and clinker quality becomes far more consistent. In practice, the soft sensors replace guesswork with data driven clarity.



AI-powered soft sensors provide highly accurate predictions of C3S (top) and free lime (bottom) in real time. This enables both the KPO system and the operators to obtain accurate clinker quality predictions instantly.

Smarter control with MPC

Prediction is only the first step. The real value emerges when predictions are translated into precise corrective actions. This is the role of the MPC, the second pillar of the ES Processing's KPO.

Traditional PID control loops treat each process variable in isolation. While effective for simpler tasks, this approach cannot effectively manage the highly interconnected and nonlinear dynamic behaviour of a rotary kiln. MPC, in contrast, considers the kiln as a complete system – it continuously evaluates how a change in one parameter will affect others and then determines the optimal set of adjustments.

Every thirty seconds, the MPC within the KPO forecasts the process trajectory and calculates the best setpoints for parameters such as meal feed, fuel feed, kiln speed, and airflow, etc. These adjustments are made in a coordinated way that minimises oscillations in the temperature profiles, improves stability, and maintains clinker quality within tighter limits.

The benefits are clear: the kiln operates more smoothly with fewer disturbances, the quality of clinker is more uniform, and fuel is used more efficiently. Instead of reacting to problems after they occur, the system anticipates them and steers the kiln away from potential instability.

Operators and AI: working together

A common concern surrounding the adoption of AI in industry is the fear that it might replace human expertise. In practice, evidence shows the opposite.

The KPO functions as a partner rather than a replacement. It handles high frequency simultaneous manipulations and time sensitive actions, while providing continuous visibility into predicted process behaviour and quality parameters. Operators will then be able to better focus on strategic decisions as they are supported by an intelligent system that helps them get to their targets better and more efficiently so they can focus on higher level decision making.

This partnership between human knowledge and machine intelligence reduces stress in the control room, builds trust in the system, and ensures that operators play an essential role in guiding plant performance.

Broader impacts: efficiency, consistency, and sustainability

The benefits of AI and APC optimisation go well beyond short term process stability:

Energy efficiency

By ensuring more stable kiln operation, the KPO solution reduces specific thermal energy consumption. This translates not only into significant cost savings but also into tangible progress toward the cement industry's critical carbon reduction objectives.

Product quality

Greater consistency in clinker parameters leads to improved downstream cement performance. Fewer deviations in customer products enhance reliability, strengthen market trust, and support long-term client relationships.

Operational scalability

Perhaps most importantly, AI/APC technologies are inherently scalable. The same optimisation framework applied to the kiln can also extend to raw mills, cement mills, and ultimately to full plant-wide integration.

The long-term vision for tomorrow's cement plant is its transformation into a fully optimised, intelligent, and proactive environment – where efficiency, quality, and sustainability reinforce one another to define the future of the industry.

The road ahead

The successful deployment of ES Processing's KPO marks an important milestone for the evolution of kiln operation.

ES Processing's complete AI/APC optimiser solutions cover the entire cement process where they automatically adapt to changes in raw material properties and fuel mixes without requiring manual interventions. Looking ahead, ES Processing also anticipates plant-wide optimisers that integrate quarry, kiln, and grinding operations into a single coordinated digital framework.

ES Processing also foresees cloud-based platforms that allow producers to benchmark performance across multiple plants in different regions.

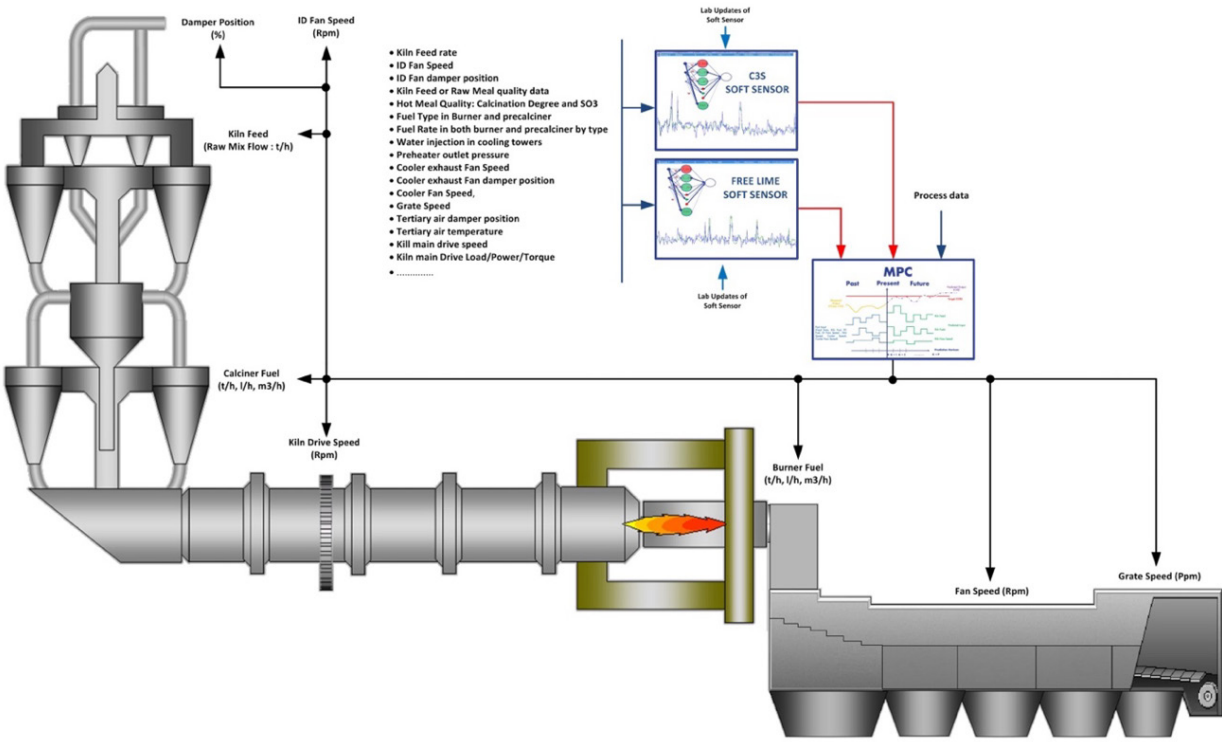
The direction is clear: the cement plant of the future will operate with full autopilot, where human operators and AI systems work side by side to achieve the highest levels of efficiency, consistency, and sustainability.

Conclusion

The cement industry stands at a turning point. The old ways of reactive operation – relying on delayed feedback and manual corrections – are giving way to a new era of proactive, data-driven optimisation.

Combining AI and APC enables kilns to operate with greater stability, predictability, and efficiency. The successful deployment of the kiln optimiser in a recent project for Secil Group demonstrates that this is not a distant vision but a practical reality already delivering encouraging results.

The journey has just begun, but one thing is clear: the future of cement production will be digital, intelligent, and sustainable, with AI serving as a trusted co-pilot guiding operators toward that future. ■



KPO is the real AI-APC optimiser autopiloting the kiln in a closed loop continuously.

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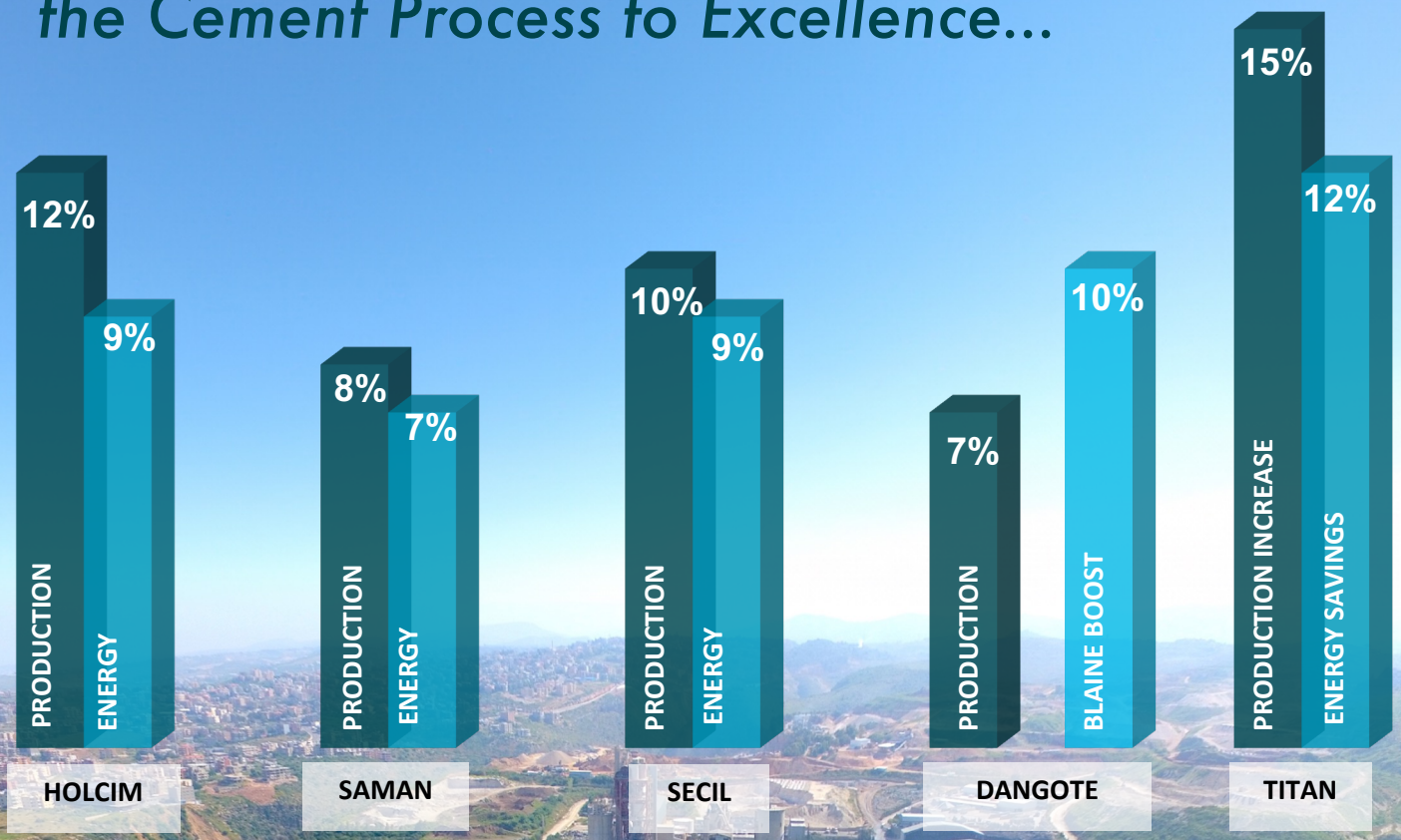
AI/APC FULL AUTOPILOT

We Pioneered it, We Master it!

Over a Decade of Continuously Autopiloting the Cement Process to Excellence...



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