Predictive confidence for the finish mill

Artificial intelligence is moving beyond pilots and experiments in cement plants. Predictive quality systems now allow producers to stabilise strength, optimise clinker content and unlock hidden mill capacity - all while maintaining confidence in product performance.

■ *by **alcemy GmbH**, Germany*

Artificial intelligence is rapidly moving from experimentation to everyday operations in cement and grinding plants. Yet while predictive models may appear straightforward, the true challenge lies in integrating them into the daily rhythm of industrial production. A recent deployment with TITAN illustrates both the potential of AI-driven quality steering and the hidden complexity of making industrial AI truly work.

From German innovation to global deployment

alcemy was founded in Germany in 2018 from within the cement and concrete industry for the industry, with the goal of applying machine learning to one of the sector's most fundamental challenges: predicting and controlling cement quality under real production conditions.

Germany proved an ideal starting point. The country is widely regarded as one of the most technically demanding cement markets globally. Today, approximately 45 per cent of all cement plants in Germany operate with alcemy software.

Since then the platform has expanded internationally. The company's systems now operate in cement plants across 17 countries and it works with many of the industry's leading producers.

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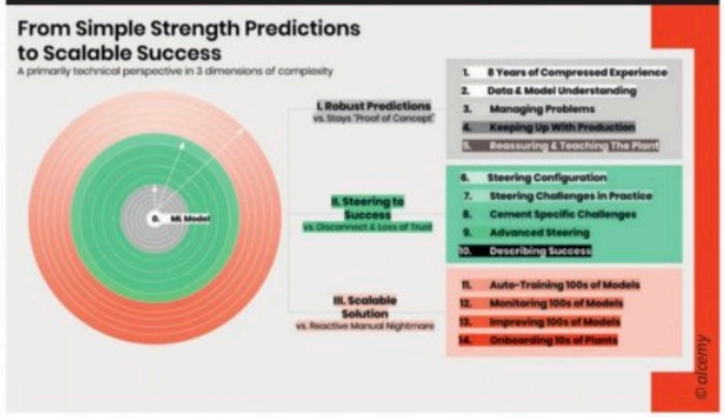
Figure 1: scalable predictive AI Software requires many layers of complexity to operate successfully in industrial real-time environments



In North America recent deployments include collaborations with TITAN, Votorantim Cimentos, Ash Grove, Moctezuma (the joint venture between Buzzi and Molins), Amrize and another major multinational producer operating confidential installations. Within only three years of entering the market, alcemy is now working with four of the five largest regional cement producers.

At the core of the platform lies predictive quality intelligence, the ability to forecast cement performance before the product leaves the mill and translate those predictions into operational guidance for plant teams.

TITAN: 10x ROI, major quality and throughput gains within months

One of the earliest North American deployments involved collaboration with TITAN Group, focussing on predicting cement strength using laboratory and production data.

The models incorporate signals from routine plant instrumentation, including XRF chemistry, XRD mineralogical analysis, particle size measurements and compressive strength testing.

Using these inputs, the system forecasts compressive strength development and identifies opportunities to adjust grinding fineness while maintaining product performance.

The impact was immediate. Within the first months of operation, the plant achieved a 30 per cent reduction in the standard deviation of 28-day compressive strength, dramatically improving production consistency.

For TITAN, the decision to adopt the technology was straightforward. The company is well known for maintaining strict internal standards for digital investments and only deploying solutions that can demonstrate at least a fourfold return on investment.

"TITAN is dedicated to leading digital innovation by embedding AI and digitalisation throughout our operations. alcemy has proven instrumental in achieving greater efficiency and we are enthusiastic about scaling this successful partnership."

Antonis Kyrkos, TITAN Group

That threshold was quickly reached through grinding energy savings and clinker reductions. The value increased further once the plant began increasing throughput by grinding slightly coarser while maintaining strength targets.

Encouraged by the results, TITAN decided last year to roll out alcemy across its US operations and expand its use to flagship operations in Europe and to concrete.

Antonis Kyrkos, chief digital and strategy officer of TITAN Group, summarised the collaboration between the companies: "TITAN is dedicated to leading digital innovation by embedding AI and digitalisation throughout our operations. alcemy has proven instrumental in achieving greater efficiency and we are enthusiastic about scaling this successful partnership."

The collaboration also reflects the strong human dimension behind industrial AI deployments. Andrea Tito, previously quality control manager at TITAN, played a central role in the strength prediction initiative. After relocating with her husband to New York, she has since joined alcemy full-time as a customer success manager, supporting cement producers across the Americas in successfully deploying the AI software.

A tool built for today's North American market

The dynamics of the North American cement market make this type of technology particularly valuable.

In many regions, demand for cement currently exceeds available production capacity at least seasonally. Under these conditions, producers are both concerned with incremental cost optimisation and maximising output while maintaining consistent quality.

Across deployments, producers working with alcemy typically focus on several key operational levers.

Maximising limestone and SCM content

In Portland limestone cements such as Type IL, maintaining limestone content at the highest level accepted by downstream concrete producers can significantly reduce clinker consumption and emissions.

AI-supported strength prediction allows producers to operate consistently at this upper boundary while maintaining confidence in final product performance.

Increasing mill throughput

By stabilising strength outcomes, plants can reduce overgrinding or slightly lower strength targets while still meeting specification requirements and market demands.

Even modest fineness adjustments can translate into meaningful increases in mill output.

Managing variable clinker quality

Another increasingly common challenge in North America is the use of clinker that

Figure 2: data sources, predictions and steering workflows for optimised grinding

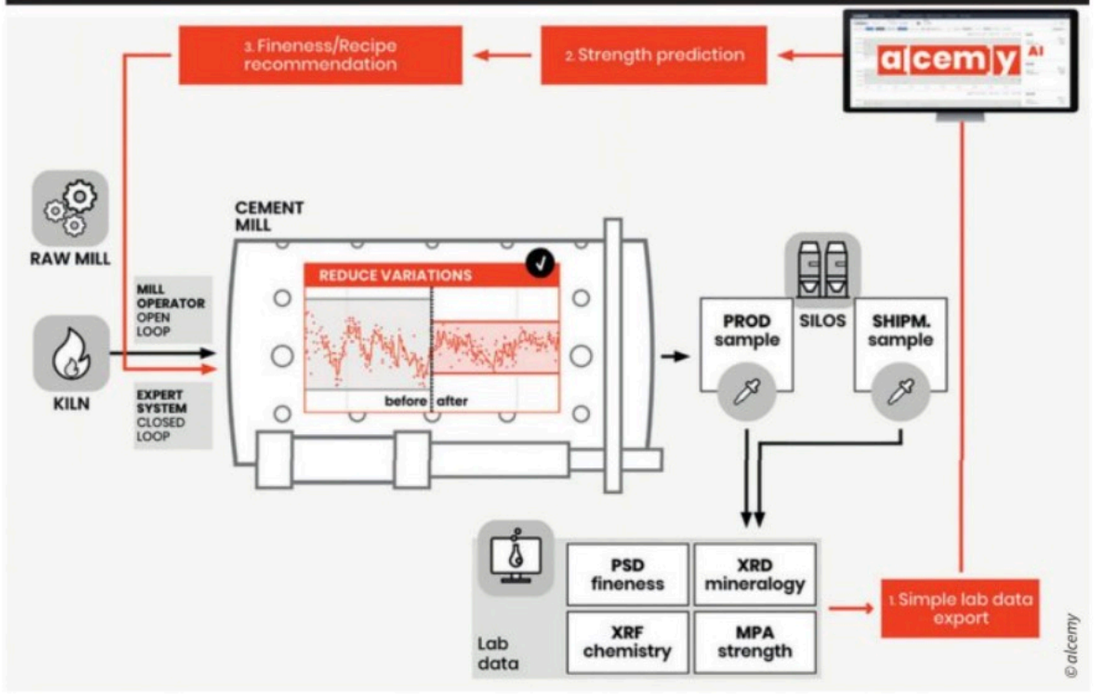


Figure 3: alcemy actively supports plants from following recommendations to tracking success

is stored outside. Weathered clinker can develop surface hydration layers, leading to unpredictable strength development in the final product.

Predictive quality systems help plants compensate for these fluctuations and maintain stable cement performance despite variable feedstock conditions.

In these environments the value proposition becomes straightforward: stabilise quality, optimise clinker content and increase throughput to maximise domestic production.

The hidden challenge of industrial AI

While machine learning models often receive the most attention, the real challenge of industrial AI lies elsewhere.

In principle, modern AI tools make it relatively easy to build predictive models. The emergence of large language models has accelerated experimentation across many industries.

alcemy itself explored whether such technologies could replace parts of its existing architecture. The conclusion was clear: they cannot. Large language models excel at reasoning across text and unstructured information, but cement production is fundamentally a physical process governed by chemistry, mineralogy and thermodynamics. Predicting strength development requires models trained on plant-specific laboratory data and continuously adapted to changing raw materials, fuels and operating conditions.

Therefore, a successful industrial AI system must integrate several layers simultaneously:

- prediction models trained on plant-specific data
- continuous retraining as materials and fuels evolve
- integration with laboratory workflows
- compatibility with process control systems
- seamless transparent web applications for the plant team
- scalability across multiple plants.

This complexity explains why many internal AI initiatives struggle to move beyond pilot projects.

The challenge is not building the model – it is ensuring that the model continues to work reliably as plant conditions change.

alcemy addresses this through automated retraining of models using continuously updated production data, allowing predictions to adapt dynamically as the plant evolves.

Equally important is the human dimension. Cement plants rely on experienced engineers and operators whose decisions ultimately determine production outcomes. Therefore, AI systems must support these experts rather than attempt to replace them.

The goal is not automation for its own sake, but augmented decision-making.

Looking ahead: predictive confidence

As the cement industry moves toward lower-carbon materials, process complexity will only increase.

Alternative fuels, diverse supplementary cementitious materials (SCMs) and evolving cement formulations all introduce new sources of variability. Historically, producers addressed this uncertainty through conservative safety margins – finer grinding, higher clinker factors or overdesigned concrete mixes.

Artificial intelligence offers a different approach: predictive confidence. By forecasting performance outcomes in advance, producers can reduce these safety margins while maintaining compliance and customer trust.

Interestingly, one of the fastest pathways to value lies not in the kiln, where optimisation is inherently complex, but in the finish mill.

The mill represents the final opportunity to balance variations occurring earlier in the production process. By adjusting grinding fineness and recipe parameters, producers can stabilise strength, maximise limestone or SCM content and ensure consistent final product quality.

For many plants, including grinding facilities, this represents a rapid and low-risk entry point for AI adoption. Today alcemy systems can operate successfully even with minimal laboratory infrastructure, requiring little more than sieve measurements and XRF chemistry.

In these environments the value proposition becomes straightforward: stabilise quality, optimise clinker content and increase throughput to maximise domestic production.

Looking further ahead, the next stage of optimisation will likely connect cement and concrete production more closely. In Europe, where alcemy also operates a concrete optimisation platform, more than 90 per cent of producers using the cement system adopt the concrete solution as well, reflecting the benefits of optimising both processes together.

Demand for similar capabilities is already emerging in North America.

Ultimately, however, the most important impact of these systems may not be technological but human.

Production and quality managers, process engineers and sales teams alike have long balanced competing objectives – maximising production, ensuring compliance, reducing emissions and maintaining customer trust. AI-driven quality intelligence does not remove these responsibilities. Instead, it provides the information needed to navigate them with greater clarity. Or, put simply: not replacing experience, but reinforcing it with predictive confidence. ■