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INDUSTRY 4.0

A Risky Road?
Only if You're Not Prepared.

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Anders Noe Dam, FLSmidth Cement, explores why the cement sector lags in embracing Industry 4.0 technologies and highlights key opportunities to accelerate the digital transformation of cement plants.

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The world is currently experiencing the fourth industrial revolution – or Industry 4.0. This is an era of digital transformation characterised by the introduction of AI and machine learning, connectivity (the internet of things (IoT)), and big data – all of which are powered by cloud computing. To put it another way, there is much more computing power and much more storage. And, combined together, this is providing data analytics at an entirely new level. These are transformative times, with examples evident in nearly all aspects of life. The pioneering cement producers who have integrated Industry 4.0 report remarkable benefits. Plants utilising smart sensors, IoT devices, and real-time data analytics have experienced up to a 20% increase in overall production efficiency, 15% reduction in energy consumption, and a 10% decrease in raw material wastage.[1] The tangible benefits of AI-driven tools are many:

- Lower environmental impact – greater efficiency reduces fuel and power use per tonne of cement while optimising clinker quality, enabling a reduced clinker factor.
- Enhanced quality – real-time process adjustments optimise blending, fuel/raw material feeds, and pyro stability for more consistent output.
- Carbon capture readiness – stabilised flue gas composition increases CO_2 concentration which simplifies carbon capture implementation – and makes it much more cost effective.
- Increased uptime – continuous monitoring and stability reduce the frequency of issues and prevents minor issues from escalating into major failures.

It is hard to imagine any other investment having a more attractive ROI. One would assume that virtually all plants would be embracing Industry 4.0 immediately, and many are, particularly for applications regarding condition monitoring and proactive maintenance. But, from the perspective of advanced process control, the cement industry is not quite there. That is the inspiration for this article. This is not intended to be an in-depth technical piece, nor is this for the purpose to promote a specific offering. Rather, the objective is to explore why the cement industry seems to be struggling to implement the latest digital technologies at speed and what can be done about it.

From Industry 3.0 to Industry 4.0 – the digital transformation of cement production

The latest estimates suggest that just 30% of cement plants worldwide have begun implementing Industry 4.0 technologies in various stages of the process. That may sound somewhat respectable, but that figure gives no indication of how far the plants have actually progressed with implementation, or even if the plant intends to rollout Industry 4.0 across the entire flow sheet rather than just isolated applications. So, what is going on here? Well, in short, it is not easy to move to 4.0 unless the plant has fully implemented 3.0 in a way that provides a solid foundation.

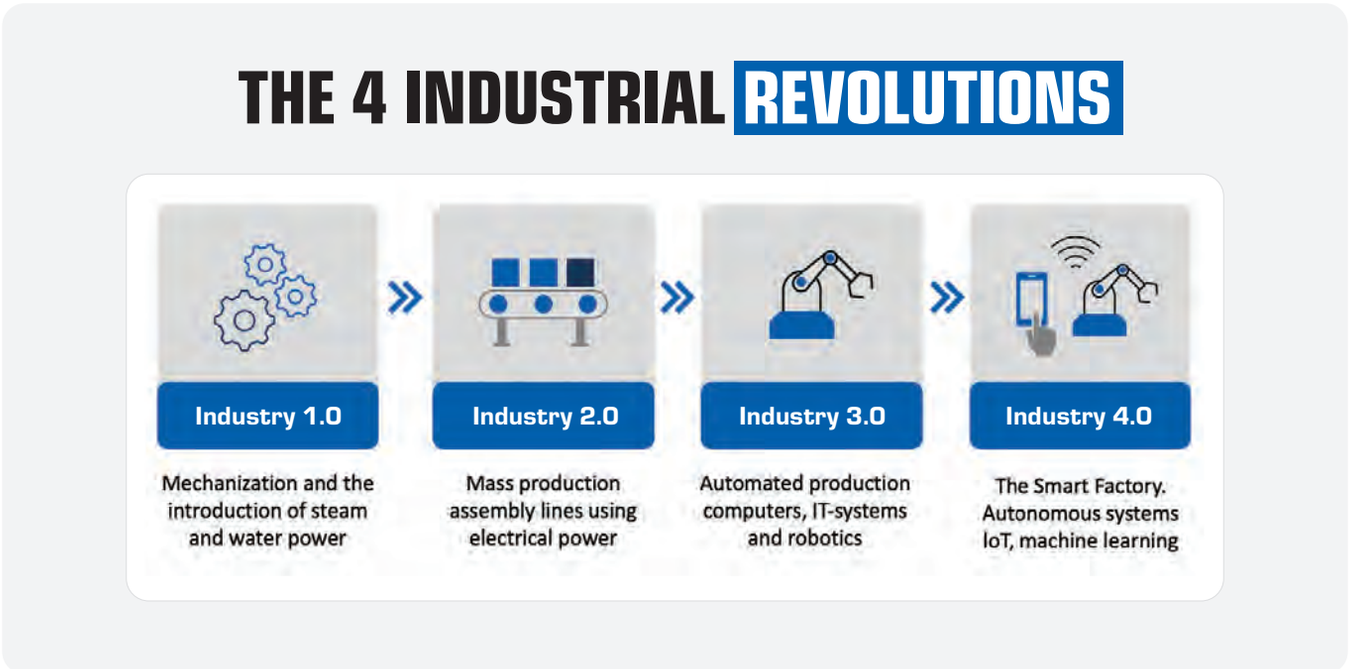
Let's take a step back. Industry 3.0, also known as the digital revolution, initialised the automation and digitisation of manufacturing systems through solutions such as programmable logic controllers (PLCs). Process control focused on the automation of linear tasks, reducing manual intervention and increasing the precision and speed of processes, resulting in a marked improvement in process efficiency and an easier path to a high-quality end product.

The scope of the solutions was either specific applications such as the pyro process or perhaps even multiple applications at a site. But, with few exceptions, the solutions always stayed within the gates of the plant. Understandably, the cement industry was focused on squeezing out as much value as possible, as soon as possible, and was largely successful. But, at the same time, much less effort was given to laying the groundwork necessary to support easy adoption of 4.0.

What are the barriers of implementing Industry 4.0 at scale?

Given the capabilities of the latest APC solutions, why is it that so many plants are lagging on the adoption of smart technologies? Lack of awareness – some in leadership may not appreciate how important it is or have the full perspective of their plant's situations.

- Change management – embracing advanced process control software is a culture change for some operators. Without reinforcement such as periodic refresher training, there can be a risk of reverting to former practices.
- Trust – between cybersecurity concerns and the range of new solutions on the market, there is a lack of trust around which solution can deliver without risk.
- Immature technology – though there is a lot of potential out there, real impact will only be achieved when APC solutions are mature
- Enough and designed to be rapidly deployed from site to site, a capability many start-ups lack the experience to deliver.
- Cost – the lack of technical maturity also as few benchmarks or past examples are available to support estimates for the actual
- Data is not usable at scale – there is a lack of structured, high resolution data – often missing crucial metadata (such as calibration details and process changes) – which is essential for training robust algorithms.



How can progress be made toward Industry 4.0 readiness?

First, plants as well as suppliers must deliberately put Industry 4.0 at the forefront of their automation strategies and make sure the proper foundation is in place. For example, at FLSmidth Cement, R&D roadmaps for each product are solutions or other technologies. This includes the need to support the creation of usable data sets, mobility, and cloud computing so that AI solutions can be most effective.

Data that is usable at scale

Data quality and accessibility is the most prevalent and challenging obstacle that cement plants battle. Industry 4.0 solutions – especially AI-driven ones – require more than just sporadic historical records. A robust metadata foundation is essential, including calibration dates, process changes, and measurement precision. For some applications, having a time series of one year this level of detail, even well-collected data can to predict process behaviour and optimise operations.

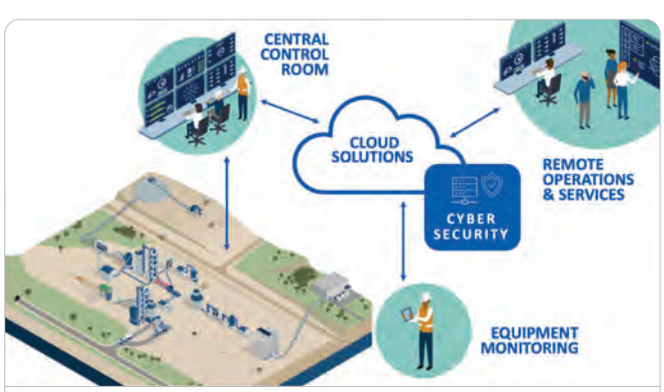
To fully unlock AI's potential, companies must strengthen their data foundations. Start by auditing current automation identify gaps in data collection and metadata. Ensure sensors are calibrated for and control systems ready for continuous, high-resolution data capture. Standardised, centralised data Next, structure metadata management by documenting process changes, calibrations, and measurement precision. Break down departmental silos and integrate data experienced providers to build a scalable, future-proof architecture.

Sample data is an area of special concern as many plants still operate manual labs, but that data and the surrounding meta data is essential. The lack of such will severely strain efforts for clinker substitution. A sampling and lab audit will reveal a clear view of data quality, accessibility, and consistency, and help identify gaps that could undermine AI-driven optimisation. By tackling these areas early, plants can establish a strong foundation for a smooth and effective digital transformation. This will enable full optimisation solution as they mature over the coming years.

Break free from vendor lock-in

In Industry 3.0, proprietary automation solutions were standard, and while not ideal, they were causing frustration in today's digital landscape.delay digital transformation, and drive-up costs. Companies struggle to adapt to new innovations and align with long-term operational goals without the freedom to evolve their technology stack.

It does not have to be this way. Supplier-agnostic pathways are available to developing Industry 4.0 automation systems that are independent of proprietary technologies. It enables seamless integration across diverse systems, giving companies the freedom to create cost-effective, scalable, and interoperable digital accelerated innovation outside of cement; the industry must also fully embrace this practice.



Is the connection to the cloud ready to be made safley?

Cybersecurity

Many industrial automation systems are typically older, unpatched, and thus more vulnerable to cyberattacks, which was perhaps okay when they worked in isolation. However, advancing digitalisation and connectivity are exposing these systems to greater risks.
Industry 4.0 is built on cloud computing. Typically, many AI providers structure and execute their solutions in the cloud. They run their algorithms and then send the outcome (set points and predictions) back to the plant. The IT and OT systems from Industry 3.0 were simply not designed for this as there was much less need for data exchange, which kept the risk of cyberattacks much lower.
Certainly, plants can open up the flow of data, but this is an extra step that tends to act as a speed bump. Although some have matured the ability to send data to the cloud, very few have the systems to take data back at the required speed and scale.
Partnering with an experienced supplier who can design a secure architecture and implement best practices is key. FLSmidth Cement is confident of this need as it has been getting frequent requests for assistance from their customers. In fact, there were so many enquiries that FLSmidth Cement was inspired to launch a specific service package for cybersecurity assessments.

Organisational readiness; review KPIs

To fully harness the potential of next-generation optimisation solutions, all KPIs must be aligned so that the optimisation systems and algorithms are configured to give plants what they really want. However, in working with plants, FLSmidth Cement often uncovers competing priorities which can make everything more complicated and impede the best overall outcome.
What is the right trade between maximising alternative fuels in order to save money, versus getting better clinker quality such that more substitutions can be used to reduce CO2, versus getting a stable and ideal flue gas to enable carbon capture? It is unlikely that one can get them all perfectly achieved at the same time, but which should be prioritised over the others? And who decides?
For a given project, FLSmidth Cement usually have a primary contact at their customer. Sometimes that person will guide FLSmidth Cement to design a system that will achieve their own KPIs without full consideration for the greater good of the entire plant. It is not intentional or self-serving. Rather, FLSmidth Cement believes it is just organisational growing pains – because Industry 4.0 and plant-wide optimisation thinking is not yet fully part of the cultures. Consequently, at times, FLSmidth Cement has found itself playing the role of a detective to get the clarity and alignment needed so that it can deliver the best overall solution.
Move to business models that fit the speed of innovation
In Industry 3.0, the normal go-to market strategy consisted of selling software with a perpetual licence. This model was widely accepted as a best practice by everyone involved. FLSmidth Cement's customers owned the software outright, and in turn, received full payment upfront. FLSmidth Cement's competitors did similar. However, updates were not automatic and plants often found themselves running with somewhat outdated versions.
To stay competitive, cement producers no longer have the luxury of waiting for a major upgrade to adopt new features – things are moving too fast. Consequently, FLSmidth Cement has transitioned to offering its optimisation software as a subscription-based service as opposed to a one-time purchase. In other words, rather than owning software, a plant receives optimising services that includes software and proactive monitoring of performance. This concept has been well-received by plants, however many have had the extra administrative hurdle of adapting their approach to budgets and purchasing KPIs. Furthermore, in the same spirit of delivering continuous performance, FLSmidth Cement has seen an uptick in enthusiasm for their PlantLine™ Service Agreements which include secure, trouble-free support with 24/7 coverage and customisable modules for cybersecurity, remote technologies, lifecycle management, and proactive maintenance.

Conclusion

Plants that fully adopt Industry 4.0 will have a powerful competitive advantage, accelerating efforts regarding productivity, decarbonisation, quality cost savings. Much of the technology is already available. And, with the right strategy in place, the obstacles can certainly be overcome. Begin by assessing the current digital maturity of the plant, with particular focus on the OT systems. Conduct audits on data, cybersecurity, and sampling and laboratory processes. Then, collaborate with industry experts to implement the next generation of advanced process control. The sooner action is taken, the sooner efficiency gains and sustainability improvements can be realised. The future of cement production is digital; delay may result in falling behind.

References

1 ‚Pioneering the global cement industry', World Cement, 2024 – https://www.worldcement.com/indian-subcontinent/18032024/pioneering-the-global-cement-industry/