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*Dear readers,*

Welcome to the May 2021 issue of *Global Cement Magazine* - the world's most widely-read cement magazine. This issue has a number of articles that coincide with the *2nd Virtual Global CemProcess Seminar & Exhibition* on 11 May 2021. Firstly, we are very pleased to include the first in a series of articles by Intec Services' Neil Taylor on the topic of 'better and cheaper cement' (Page 10). Throughout the summer issues, Neil will look at ways to produce 'better and cheaper' cement via the right clinker properties, optimising raw material properties, effective cement grinding and better testing and control. We look forward to the rest of the series!

Also on the topic of optimisation, authors from KIMA present ways to optimise cement plant grinding efficiency (Page 14), while AI optimisation experts Seebo (Page 20), Carbon Re (Page 34) and Schneider Electric (Page 24) present machine-led solutions to improving and controlling the extremely complex cement production process. Meanwhile, Enotec and HeidelbergCement report on the use of the CEMTEC probe at the Burglengenfeld plant in Germany (Page 30) and thyssenkrupp Industrial Solutions introduces its polysius® pure oxyfuel system (Page 38).

There is also a strong refractory theme, with three articles that explore the latest in this area of the plant. Refratechnik shows how veneering can provide a rapid and inexpensive way to repair refractories without major interruption (Page 40), while SKG Refractories presents a way to stop unexpected brick falls in larger and older kilns (Page 48). Last but not least, we speak with RHI Magnesita's Heinz Telser about the company's latest innovations in cement plant refractories, including cement-free and low-$CO_2$ products (Page 44). Elsewhere, this issue has all of the latest cement and concrete news, as well as *Global Cement*'s review of the US, Canadian and Mexican cement industries (Page 60) to coincide with the *Virtual American Cement Conference* on 27-28 April 2021 and the IEEE-IAS/PCA Cement Industry Technical Conference, which takes place online on 24-28 May 2021.

Enjoy the issue!

Peter Edwards
Editor

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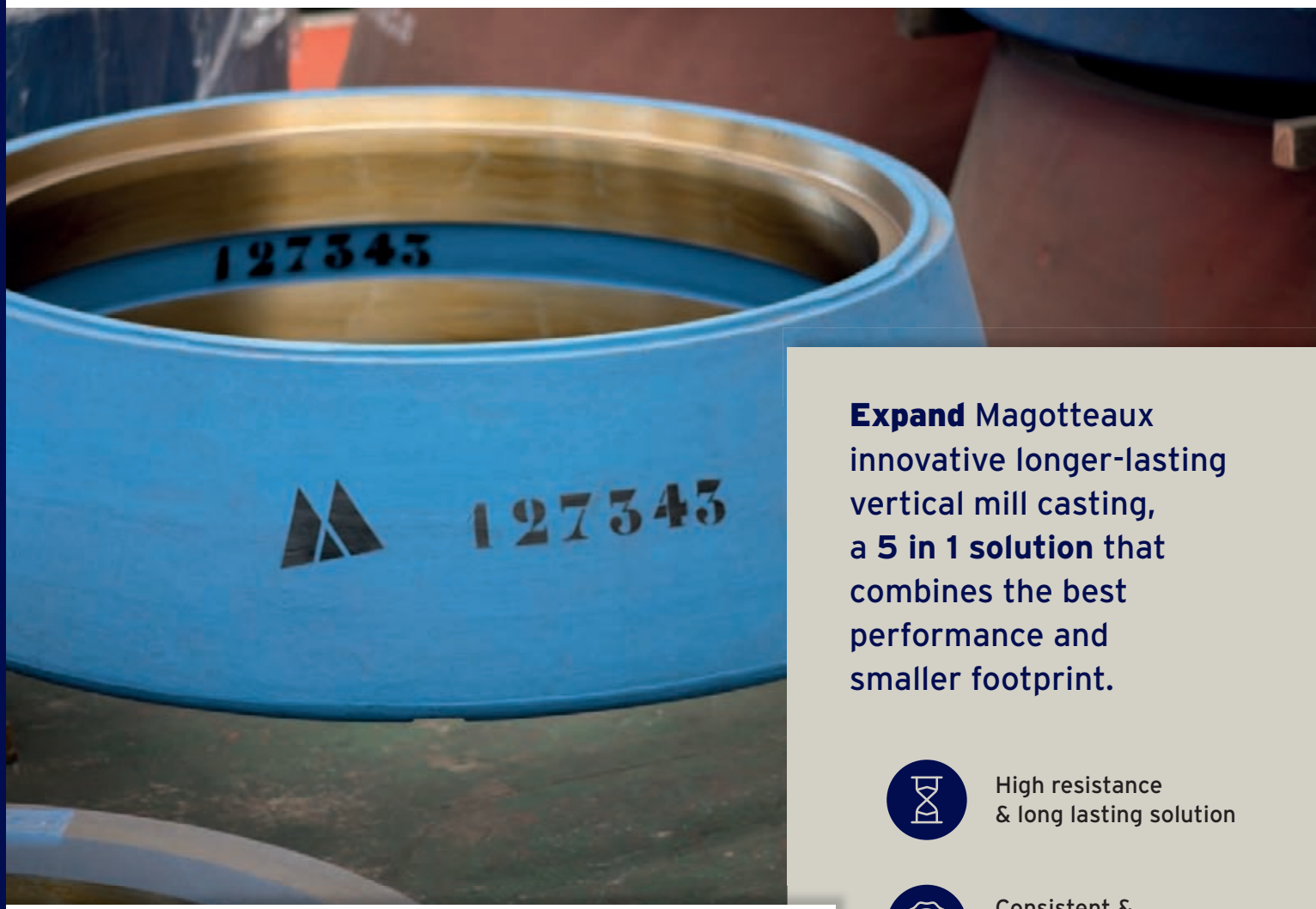


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*Neil Taylor, Intec Services P/L*

# Better and cheaper cement: An overview

Neil Taylor of Intec Services presents the first in a series of articles that aims to help cement producers deliver competitive product quality without sacrificing process performance or profitability.

The cement industry has unique quality challenges when it digs up rocks, processes them at high temperature into clinker and then grinds it into reactive products for sale. With the range of raw materials and equipment used, as well as the high process complexity, it would be reasonable to expect wide variations in product quality. However, decades of experience has shown that, as long as the raw material chemistry is kept within typical industry limits and the materials are processed and blended properly to reduce variability, most plants can produce commercially-acceptable cement without worrying too much about what happens in the kiln.

This leads to many plants using a 'black box' quality model, where the clinker is made to a typical industry 'recipe' and any cement quality problems are fixed at the end of the process. The downside of this approach is that the corrective options are usually limited to grinding the cement more finely, using fewer mineral additions or adding some kind of chemical improver (Figure 1).

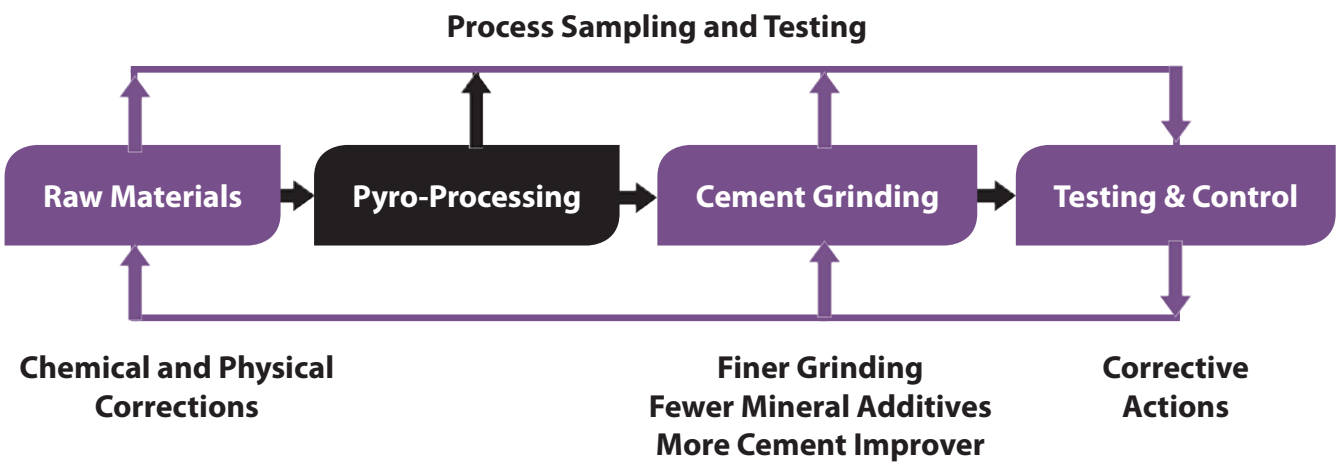
However, trying to correct product quality variations at the end of the manufacturing process can't correct all issues. It can also make the cement more expensive and has negative effects on emissions and capacity, which reduce plant profitability. Trying to correct problems later in the process also increases product variability and can increase costs for the customer, making the cement less competitive. Even worse is that, in many cases, the cement has already been used by the customer before problems are identified and corrective action can be taken by the producer.

By ignoring the most important value-adding part of the manufacturing process, plants using the black-box model also lose their best opportunity to improve both quality and capacity and reduce their cost/MPa and cost/t expenses. Making sure that the full potential of the material and equipment are captured at each processing stage, especially in the kiln, and then minimising negative effects, such as prehydration, is the most cost-effective way to deliver competitive cement quality at the lowest cost.

## A better approach

A more profitable, although more challenging, alternative to the black box approach is:

**1. Prioritising clinker quality above cement quality:** Prioritising clinker quality, in terms of low chemical variability, appropriate free lime and optimum nodule size, has huge advantages over waiting to fix product quality problems at the end of the process. Identifying and addressing potential quality problems earlier in the process also




**Below - Figure 1:** The 'black-box' approach used by many plants prioritises product quality over plant capacity and cost.

**Left - Figure 2:** Optimised clinker with a narrow PSD and low dust content.

generates less off-spec product and provides more opportunity for blending out non-conforming material before the final grinding stage. This makes the product more uniform for the customer and less likely to need corrective action, lowering production costs in many cases.

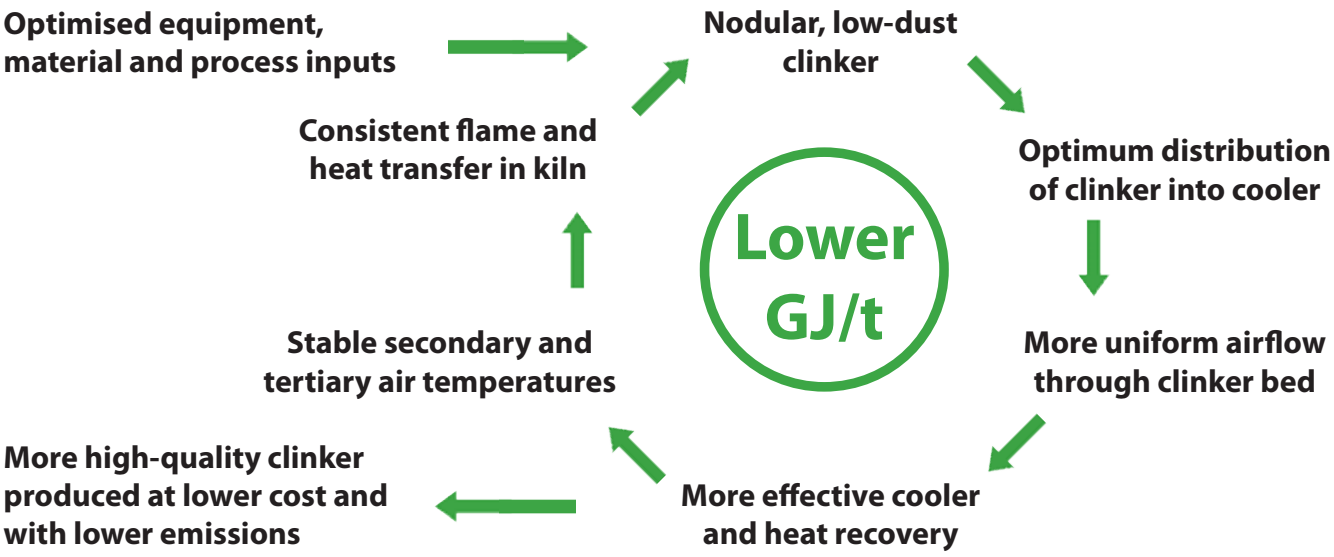
**2. Optimising the right clinker properties:** Keeping clinker chemistry in the right range and making sure it is properly burned to keep quality under control is only part of the battle. Clinker particle size is also an important, yet commonly ignored, clinker property that can have major effects on both quality and capacity.

Clinker quality is typically controlled in terms of hypothetical mineralogy and free lime, yet the actual clinker mineralogy can be very different to the hypothetical composition. While microscopy and XRD techniques can help identify the differences in mineralogy and pinpoint potential material and processing problems, translating the mineralogical information into practical improvement actions is much more difficult. However, with good laboratory testing capabilities, reliable process information and some cause and effect modelling, it is usually possible to improve properties like compressive strength without getting into detailed clinker mineralogical studies.

The clinker particle size distribution (PSD) can make a critical contribution to operating efficiency and capacity that is not usually recognised except by kiln operators. Yet clinker with an optimised particle size distribution and low dust content (Figure 2) provides a feedback loop that has a major positive impact on kiln/cooler stability, heat exchange, energy consumption, emissions, kiln capacity (Figure 3) and, ultimately, plant operating costs.

Kilns that produce clinker with a low dust content and small to medium nodule size typically operate with lower volatile recirculation and have

**Below - Figure: 3** Positive feedback loop produced with an optimised clinker PSD.



fewer build-ups and blockages. More stable and predictable kiln operation allows operation at higher kiln and cooler loadings, increasing output, reducing energy consumption, equipment stress and refractory wear. Low dust clinker with a smaller average particle size is also easier to cool, which reduces the potential strength loss that can occur with higher levels of periclase, high temperature cement milling and prehydration. Smaller clinker nodules are also usually easier to grind, so they also help improve cement mill output and reduce kWh/t.

**3. Optimising raw material properties:** There is usually good scope for improving clinker reactivity and modifying nodule size by adjusting the physical and chemical properties of the feed and fuel inputs. Minor inputs of alkalis, sulphur, MgO, fluoride, phosphorous and other feed components can have significant effects on clinker mineralogy, reactivity and strength development. The mineralogy of some raw feed components can also affect feed particle size, feed burnability and volatile recirculation.

Some of these components also affect the clinker melt phase and nodule size, so careful optimisation, monitoring and control of these and other melt phase components can provide big benefits to both quality and capacity. Appropriate fuel particle size, moisture and ash content and making sure alternative fuels are used in the best way are also important to provide the optimum combustion conditions needed for good heat transfer, efficient operation and low cost production.

**4. Getting cement grinding under control:** Cement grinding represents the last major processing opportunity to modify product properties and positively influence capacity and cost. These opportunities typically include optimising fineness, product particle size distribution, gypsum level and dehydration degree, mineral addition rate and final adjustment with chemical additives.

Yet there is often a significant, but unrecognised loss in product quality during milling due to deficient water injection, low airflows, high dew points and poor mill operating strategies that expose the cement to prehydration, which degrades strength and other important product properties. Cement quality can also be negatively affected by prehydration during silo storage. This can lead to lump formation in the product and silo build-ups, which may need frequent removal.

**5. Testing and control**: Developing good testing capability with methods such as XRF analysis and low variability mortar strength testing are essential for investigating the cause-and-effect relationships that drive process and product performance. This information can be used as the basis for making simple but effective predictive models and operating guidelines to help reduce product quality variations from the raw material stage onwards. A customised predictive model also minimises the risk of over-control and unnecessary corrective action. This reduces product variability and makes the cement more competitive.

## Looking ahead

The next article in this series, *'Better and cheaper cement: Optimising the right clinker properties'* will look at some of the main factors that affect clinker quality and particle size. It will also examine a case study in which clinker properties were modified to solve a cooling problem and improve capacity and quality performance.

**Right - Figure 4:** Cement plant operators should be wary of turning their kilns into 'black boxes.'

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*Dirk Schmidt & Eugen Geibel, KIMA Process Control*

# High-level control in cement production

Attaining 'Industry 4.0' has been seen as an essential task of the cement industry for many years, with terms such as 'big data' and artificial Intelligence (AI) heavily used. It is hoped that AI, combined with big data, will provide solutions to long-standing problems. It might therefore be surprising to learn that fully autonomous mill operation (including the use of AI) has been taking place since 2009. This article will briefly summarise how the methods of High-Level Control (HLC) were used in the cement industry already in the early 2000s and how they manage to control ever more complex closed-loop-controlled processes in situations where standard controllers fail.

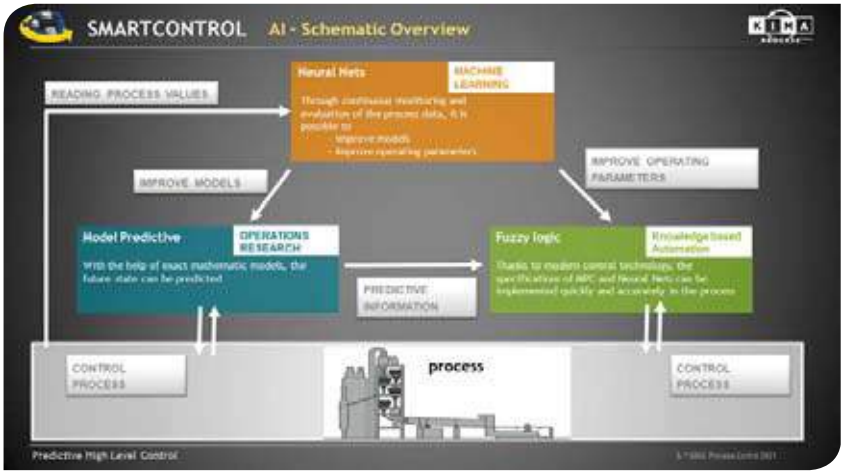
To accelerate the integration of advanced technologies in the cement industry, some business consultants proposed to 'copy-paste' Industry 4.0 solutions from chemical plants/refineries and apply them to cement plants. A recent example is a report regarding the first successful conversion of regular plant control to AI control, which was qualified as a breakthrough.

Caution: The capabilities of AI are still limited. This is in part because AI is a very broad term and it is difficult to find a definition on which everyone agrees. In the wider sense, it can be defined as a branch of computer science dealing with the simulation of intelligent human behaviours in computers. Technically speaking, the majority of the AI-systems that are used in industry today are data-driven algorithms. The basic principle is relatively simple, but they gain their capabilities from huge amounts of data, rapid and repetitive calculations and multiple interconnections.

The use of AI is not new. The development of faster computers with the possibility to store and process big data make the use of AI both possible and reasonable. Deep Learning, which is itself a part of Machine Learning, makes use of multi-layered artificial neural networks (ANNs) to learn from Big Data and search for patterns that could be used for problem solving after ANN training. Knowledge based automation, including fuzzy logic and analytical methods such as, for example, Model Predictive Control (MPC) are also part of AI.

Depending on the task, different AI methods are more applicable than others. Nowadays it is clear that there is no one-size-fits-all AI module for the cement production process. Fuzzy logic is applicable for closed-loop control of technical processes with a moderate number of variables and data for which a control strategy can be expressed. It is a good choice for processes where safe operation in critical situations is mandatory. ANNs are used for recognition of hidden process patterns for which a control strategy cannot be expressed and that have a high numbers of input variables. MPC is a good choice for well-understood processes for which a mathematical model is available. Optimisation is possible if the model can be calculated faster than real time. On-line adaptivity is definitely not practicable in cement production.

**Below - Figure 1:** High-level control relies on AI.




## The AI in cement story

A short discussion with AI-solution providers makes it clear that the current 'revolution' in cement plant control systems is simply operating with MPC and soft sensors. Germany's Powitec Intelligent Technologies used self-adapting MPC and machine learning as early as 2001. It was the first comprehensive black-box controller that operated a rotary kiln fully autonomously for more than 24hr without manual interaction. The core of the system was an image-processing camera that analysed the main burner flame and an online prediction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**Above - Figure 2:** The Loesche type LM 46.2+2 S VRM at the EQIOM Ciments plant in Dunkerque, France. See Case-study 1, overleaf.

of free lime. Various AI components were used as far back as 2002. Using adaptive MPC, the fluctuating energy input to the kiln and calciner was adjusted automatically.

Pioneers in the use of AI during these days were the cement producers Leube (Austria) and Maerker Zement (Germany). Soon after, companies such as ABB, FLSmidth, Pavilion, KIMA Echtzeitsysteme and Rockwell entered the market with similar model-based controllers. Today, many companies have returned to the more robust fuzzy logic control. Predictive models are used for soft sensors. The reason for this are the serious differences in the cement manufacturing process compared to other common production processes.

## Special process conditions

Clinker production is a complex operation. The so-called 'multi-dimensional non-linear process model' of a kiln or a mill has failed to model the real systems adequately. The real kiln or mill unit is subject to wear and other natural variations, which models have so far failed to represent. Broadly speaking, the behaviour of a kiln or mill tomorrow is different from its behaviour today.

**Right - Figure 3:** An optimumly-filled ball mill chamber as a result of precise fill-level measurement reduces wear of liners and balls and boosts production.

There have been attempts at implementing software features, such as self-adapatation and self-learning, but a host of changes has to be considered: liners, balls, chutes, feeders, valves, refractory, fuels and the raw materials themselves. And then there are even further changes to consider: the quarry components and additives, the fuel calorific value, water and ash changes, the change of coal and petcoke particle size distribution from their mills and the related change of combustion (ignition point, burn out, flame shape, etc.). All of these changes can affect the quality of clinker and cement - a significant challenge for any controller.

If a multi-dimensional process model is fed with signals that have a drift, or are not stable, it fails. It is possible to teach these models with an ANN in order to catch the drift and to adjust the model accordingly. The question is: How fast does the process change? If the changes are too rapid, the ANN based model has to be re-trained regularly, which is impractical for many manufacturing processes. It follows that for 'drifting' systems, MPC is not the best solution. In such cases we need to include some rule-based system to control the process when MPC and/or ANN results are not realistic.

Assisted by modern modules of AI, these systems can reach a new level in automation. Below we detail some plants that operate their mills fully autonomously over several days. The 'auto-pilot' is not limited to smooth operation conditions only. KIMA's Millmaster allows for fully automated start and stop of the mill, automatic recovery after emergencies and switching between cement types. We will also discuss case-studies where plants have increased their performance using KIMA's Smartcontrol system. This software-platform has been supplied globally in nearly 200 rule-based Millmaster systems.

## High-level control as a combination of different AI modules

In 2008, KIMA Echtzeitsysteme (the previous name of KIMA Process Control) published an article about a project to supply 30 Smartcontrol packages for ball mills (including the Smartfill fill-level measurement system) to a selection of Holcim group plants in Eastern and Central Europe. After the commissioning and later, during steady operation of these plants, the development of Millmaster continued separately in the Holcim group as well as in KIMA Process Control. New designs of the human machine interface, programming logic and new software modules were developed to follow new trends in automation.

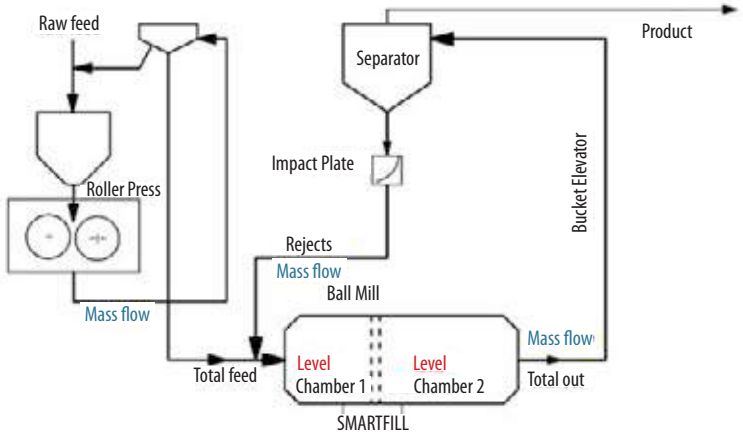
Figure 2 shows a combined grinding circuit, consisting of a roller press and a ball mill. Such a grinding circuit for cement is quite widespread because of its advantageous specific electrical energy demand and high product quality. From the

viewpoint of control theory however, this is a difficult system, with three sub-systems (roller press, ball mill chamber 1, ball mill chamber 2), each of which is critical. Each is also part of a respective feedback loop with individual delay times. The feedback loop enables each of these subsystems to oscillate on their respective resonance frequency, which is determined by the aforementioned time constant. Even worse, these time constants are non-linear functions of clinker quality (grindability), which is never guaranteed to be constant. Conventional PID-controllers are not able to handle such systems due to the oscillations.

To better understand the complexity of the combined grinding circuit, such a system can be compared to three pendulums, which are coupled by springs with different stiffness levels, as shown in Figure 3. The time constant of each pendulum is determined by its mass and the length, the coupling is determined by the stiffness of the connecting springs. In the ideal case, this system is excited (shifted) by a constant raw feed, each pendulum moves to a new equilibrium state and remains there.

In practice, however, the excitation by raw feed is not constant and the length and stiffness of each 'pendulum' change with time. The result is a system, which is oscillating permanently at varying frequencies and amplitudes (Figure 6).

The task of a closed loop control system is to adjust the excitation (i.e. raw feed), the resonance frequencies (length of pendulum, i.e. transport speed of bucket elevator, conveyor belts and air slides) and the stiffness of the coupling springs (i.e. mass flow from roller press into chamber 1 and from chamber 1 into chamber 2). Controlling such systems is a difficult task and cannot be performed by using a single PID controller. According to KIMA's experience, such a system can be controlled successfully with Millmaster.




**Above - Figure 4:** Schematic of a typical grinding circuit, consisting of a roller press and a ball mill.

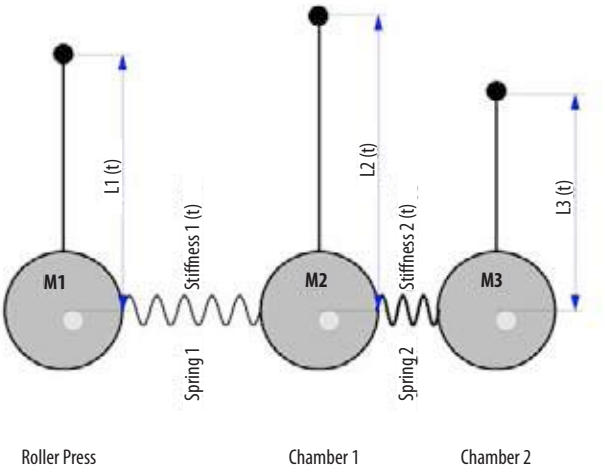
## Case study 1: Fully autonomous mill operation at EQIOM Ciments

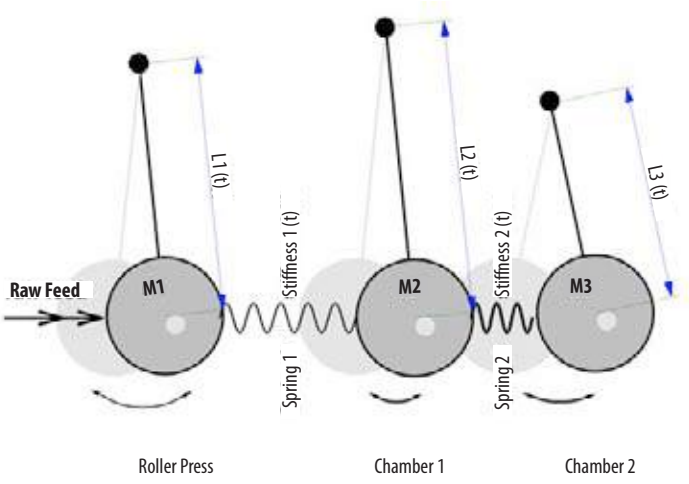
At its plant in Dunkerque, EQIOM Ciment's Loesche type LM 46.2+2 S vertical roller mill mainly produces slag cement. It is controlled by a Millmaster system. From Friday afternoon to Monday morning the plant is operated completely autonomously under the control of a Millmaster system.

"The Millmaster system is used daily and gives us the opportunity to concentrate on performance optimisation while the mill is running. It is also faster than an operator when it comes to protecting the equipment in case of important changes in mill behaviour. It would be hard to run without this expert system for a long period," says Pierre Vonstein, Operations Manager for North and Normandy Grinding Stations at EQIOM.

## Case study 2: Increased production at Fabrika Cementa Lukavac

A key advantage of the Millmaster system is that it can be configured in such a way that the




**Below Left - Figure 5:** Mass-spring model of the combined grinding circle with a roller press and a two-chamber ball mill.

**Below - Figure 6:** Excited spring-mass system.

operators do not see much from the system. Just the 'on/off' switch allows them to start or stop the 'auto-pilot'. Switching it on is only for one purpose: increased production. A representative example is Fabrika Cementa Lukavac in Bosnia & Herzegovina. In 2018, the system was installed on a ball mill rated at 65t/hr. The mill usually reached a base line of 67t/hr, according to Process Manager Emir Cilimkovic. Table 1 shows the before and after situation at the plant. There was also reduced fluctuation in quality and less wear on the grinding media due to a higher fill level in the mill. The optimal filling level was confirmed by means of the crash stop method.

"The MILLMASTER is a useful tool for us to achieve lower standard deviation of cement fineness, which worked out to our full satisfaction," reported Cilimkovic. "Today, we need 2hr less to produce the same amount of cement as before. Power consumption has been reduced by 9-11%.

**Right - Figure 7:** View of the Cementa Lukavac plant in Bosnia & Herzegovina.

| Cement Type | Test duration (hr) | Production (t) | Rate (t/hr) PID-Control | Rate (t/hr) MILLMASTER Control | Increase (%) |
|---|---|---|---|---|---|
| CEM II/B-M (V-L) 42.5 N | 12 | 898 | **67.0** | 74.8 | 10.5 |
| CEM I 52.5 N | 13.1 | 712 | **50.0** | 54.4 | 8.1 |

**Right - Table 1:** Production increase at Cementa Lukavac after installation of the MILLMASTER system.

SMARTFILL also reliably helps to detect blockages in the intermediate diaphragm of the mill. This feature has become especially important because of the increased usage of alternative fuels in cement kilns and the ongoing change of the clinker chemistry. For maximum production levels, we carried out extensive checks on the system from time to time. The filling level inside the chambers and the condition of our balls and liners is checked using the crash-stop method."

## Case Study 3: Increased production at Opterra Karsdorf, Germany

After the merger of Lafarge and Holcim, plenty of plants were told to switch off their former expert systems LUCIE (Lafarge) and MILLMASTER (Holcim), as they left the group. Both expert systems required a certain level of support by technology centres, and experts visited on a regular basis to secure successful day-to-day operation. Following this, 'a couple of well-known suppliers' were asked to equip these plants with an alternative software that offered the same performance as the previous systems but, if possible, with easier handling from the plant site and without the necessity for regular maintenance from external resources.

In 2015, KIMA Echtzeitsysteme was awarded a contract to equip all ball mills at the plants that had been acquired by CRH in Germany. While there were a few concerns about the small, albeit well established, supplier KIMA, it was also known that this company had previously equipped some 30 Holcim plants in Eastern Europe with SMARTCONTROL systems. The former Lafarge plant in Karsdorf was also equipped with the MILLMASTER expert system. A total of six cement mills, four of them centre discharge mills, received an individual software package and parametrisation. This was to reach challenging optimisation guarantees of either a 5-8% production increase or 4-6% reductions in specific energy demand. All of the performance goals of the project were achieved, with full acceptance by the operators.

## Conclusion

Many believe that AI consists soley of self-learning ANN that feed on big data to automatically control complex processes. This is not accurate. As already mentioned, different AI methods should be chosen depending on the task. It seems that the complexity of the clinker burning process makes it a bad candidate for pure ANN control, not least because of the wear of the involved equipment, which changes the system that the ANN was initially trained for. The significant components of AI being used today are similar to those used 10-20 years ago. However, today's computers have become much faster and have access to large amounts of historic data.

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*Seebo*

# Continuous kiln stabilisation: What's holding *you* back?

Most cement manufacturers face regular production losses due to unknown inefficiencies in their process. Seebo can help identify and optimise them.

Seebo Process-Based Artificial Intelligence™ is designed to solve complicated process inefficiencies - revealing the hidden causes and recommending the right actions. By providing production teams with ready-to-use Artificial Intelligence, continuous process mastership becomes a reality. With Seebo, teams know why process inefficiencies happen. The company was selected as a World Economic Forum 2020 Technology Pioneer, and has raised US$46m in funding for its Process-Based Artificial Intelligence™ solution to reduce manufacturing losses.

Kiln throughput, cement and clinker quality, balancing variances in raw materials, ammonia cost optimisation, energy optimisation, $NO_x$ and $CO_2$ emissions... These are just some of the challenges cement manufacturers struggle with every day. Each is a constant battle. There is no 'Aha!' moment, when the operator discovers the ideal process settings, fixes all the inefficiencies and walks off into the sunset.

This is because the struggle begins anew every day, with competing KPIs and ever-shifting variables making it particularly difficult to figure out the root-causes of inefficiencies. The underlying issue is the complexity of the process itself. Even the most experienced and intelligent process expert can't possibly analyse all the data, all of the time, all while keeping track of all the complex relationships between different parts of the production line.

## The limits of human decision-making

Despite the advances the cement sector has undergone in recent decades, it remains a fundamentally 'manual' industry. Plant staff make dozens of critical process-related decisions every day. These decisions can certainly be enhanced, informed and effectively executed via analytics platforms, measuring tools, expert systems and so on. Ultimately, however, the *decisions* are taken by humans. This is an inherent limitation, as everyone approaches a problem with their own biases and preconceptions. It's natural: engineers have no choice but to conduct ad-hoc analyses based on their own experiences, knowledge and, in some cases, intuition. Often this works, but often it doesn't, at least not continuously. A correct decision today might not be correct tomorrow, or even in a few hours' time. Even with the best expert systems and analysis tools, many plants remain subject to the following limitations:

**1. Dependence on human bias:** Control and analysis systems are set up by humans. For example, process experts use analytics tools to analyse a selection of data tags that they have opted to focus on. Expert systems are particularly troublesome. They are a closed-loop system and will do as instructed. What if the instructions themselves are incorrect? What if a particular factor further upstream or downstream should have influenced a calculation, but it wasn't taken into account?

**2. Asset-focused (not process-focused)**: Expert systems are meant to regulate a particular asset or point within the production line. They do this very well, but they don't take into account the entirety of the production process. Optimal settings for a particular asset or point in the line may appear to fall into a certain range when considered in isolation. However, when considered together with other data, the situation might look quite different. For example, the 'ideal' speed of the kiln might change depending on the raw material variances of the day.

**Below:** Manual kiln stabilisation can be a constant battle, even with the best expert systems.

**3. Expert systems can't adapt to change**: Expert systems use closed-loop models that don't update continuously. They are built once and then remain constant. Such systems cannot react to all the dynamic changes on the line - whether further upstream, downstream or within the specific asset it is monitoring. They can't simply be reprogammed each time a factor changes, as this is a lengthy, resource-heavy and expensive process. Also, plant staff aren't always aware of a specific change on the line or its implications in the first place!

So what's required to fill this gap? In short: a decision-support tool, that provides key insights that can better inform the decisions that teams make. From Seebo's conversations with dozens of cement manufacturers, it has identified three key criteria which, if fulfilled by such a system, can empower teams to achieve continuous process mastership:

**1. Reveal the hidden causes:** The issues holding the process back the most are the 'unknown unknowns,' hidden causes of inefficiencies and production losses that the team isn't even aware of. By revealing those hidden causes, teams can take efficiency to the next level.

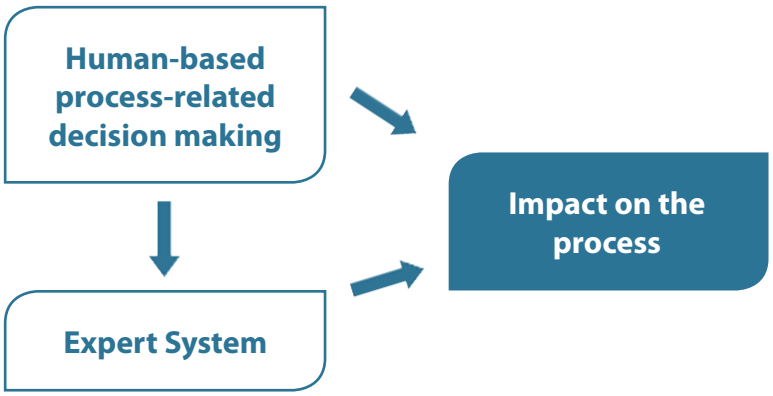
**2. Continuous, scalable, multivariate analysis of all the data:** Another glaring gap is the ability to continuously analyse all the data, all the time, while taking into account the complex interrelationships between different points throughout the line. While humans can't do that, Artificial Intelligence (AI) can, specifically by using supervised Machine Learning (ML) algorithms to understand the patterns of behaviour that commonly lead to losses.

**3. Focus on the process:** You can't look at one point of the cement production process in isolation. A decision-support tool, driven by AI, can provide insights. However, those insights will only be relevant if the AI understands the full, unique complexities of the individual plant. If there is no embedded process expertise within the algorithm, the AI will simply analyse the data without the unique context - and come to wrong or incomplete conclusions.

## Automated root-cause analysis

If manual root cause analysis is what's holding cement manufacturers back, then automated root cause analysis is the solution. Automated root cause analysis uses Process-Based Artificial Intelligence™, which understands the unique production process, to conduct continuous, multivariate analysis of the entire data set, and to reveal the hidden causes of production losses.

The following is a case study that shows how automated root cause analysis worked for a cement plant that sought to reduce instances of kiln ampere usage inefficiencies. These inefficiencies were causing a number of process-related losses, including: fuel and energy consumption; electrical consumption; product quality; throughput; clinker quality; refractory lifetime; maintenance costs; $NO_x$ emissions, and; kiln feed variances.

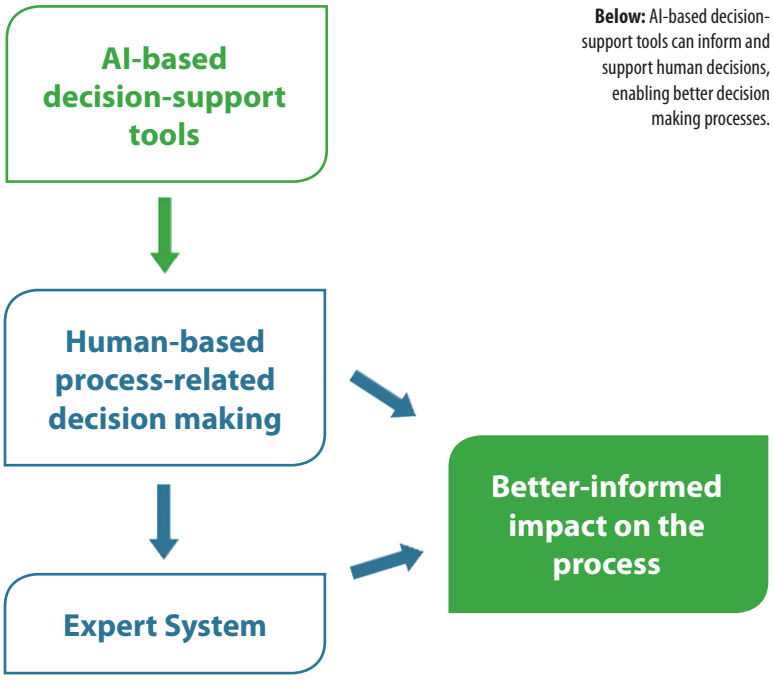



**Above:** Ultimately, the plant staff are in the driver's seat, whether directly or via expert systems. They need to make the right decisions.

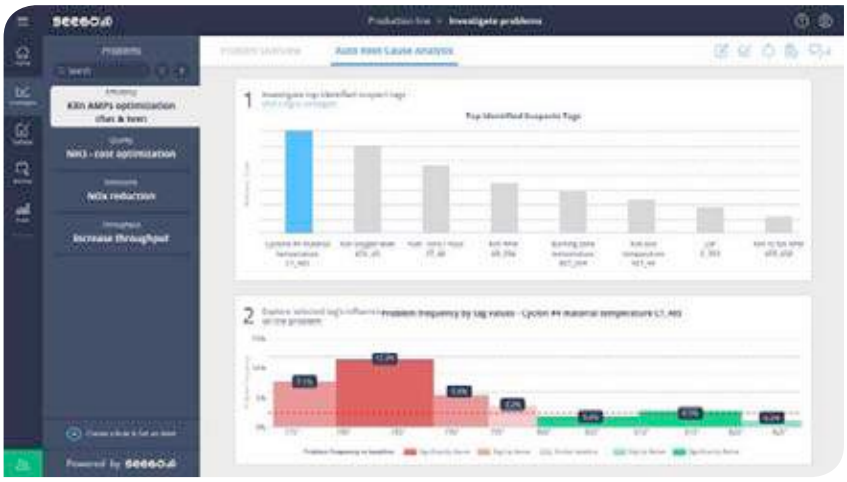
Interestingly, the kiln actually achieved higher-than-average efficiency rates 40% of the time. This is often the case. Production lines, especially kilns, are already capable of achieving the desired efficiency range part of the time. That means the potential for improvement is already there. They don't need any new equipment or assets. The question is: how can the plant increase the amount of time that the kiln operates at a high level?

## Revealing hidden process inefficiencies

Using automated root-cause analysis, the plant was able to identify the hidden causes of its production losses and gain clear recommendations as to how to prevent those process inefficiencies. Those recommendations are also translated into real-time




**Below:** AI-based decision-support tools can inform and support human decisions, enabling better decision making processes.



**Above:** Seebo automated root-cause analysis.
**Credit:** Seebo.

alerts, so the production teams know as soon as those inefficiencies are detected. This means they can prevent losses before they occur.

First, Seebo unified all of the disparate data sources from the production line into a single schema, where it was enriched and cleansed. This included all relevant data related to the process - from raw material data, to process and quality data, to data on weather conditions and alternative fuel characteristics.

Next, the algorithms were taught to understand the entire production process, using Process-Based Artificial Intelligence™, which embeds the algorithms with the context of the unique plant topology, and expertise in the relevant cement manufacturing process. This enables the algorithms to navigate through the unique complexities of each production process and truly understand the data in-context, providing a continuous, multivariate analysis that delivers crystal-clear insights - eliminating data blindspots, and revealing important new insights into the production process that were previously hidden among the data.

These 'process-based' algorithms then conduct automated root cause analysis - continuously analysing all the data tags, including the complex relationships between them. The team can identify process inefficiencies that were previously invisible to human analysis.

For example, the team discovered that when the cyclone material temperature was above 800°C *and* the kiln oxygen level was at 1.5-2.0%, at the same time, the likelihood of a problem with the kiln ampere usage increased very significantly. This is a hugely important insight that the process experts would have found nearly impossible to work out without AI, as both of the parameters remained within their permitted ranges. It was only the unique combination of those two specific ranges of tag values that caused losses.

## Continuous process mastership with AI

Armed with this new understanding, Seebo created a set of Predictive Recommendations, which identify the optimal process settings. For example, the team now has recommended optimal values for the cyclone material temperature and kiln oxygen level, to minimise instances of kiln ampere usage inefficiencies as much as possible without negatively impacting other production parameters.

These recommendations are then turned into Proactive Alerts, which are delivered to the production team via a simple, intuitive screen as soon as the related process inefficiencies occur. The alerts include a clear description of the root-causes, as well as a set of Standard Operating Procedures, so production teams knew exactly what to do to fix those issues before significant losses occur. Using new insights such as this, the plant has been able to prevent process inefficiencies and greatly reduce costly production losses from quality, throughput emissions and energy. It has:

- Reduced energy costs per tonne of clinker by 5.6%;
- Increased clinker quality by 4.2%;
- Increased kiln feed capacity by 3.3%;
- Reduced $NO_x$ emissions by 11.9%;
- Generated Euro521,000-worth of energy savings from a single line;
- Generated Euro780,000 in extra profit from a single line.

## AI-based decision support tools: The missing link

For the foreseeable future, cement manufacturers will still have to invest considerable effort in stabilising the kiln and reducing process-related losses. Using AI-based decision support tools like automated root-cause analysis, it is possible to make that effort more efficient and to meet their KPIs more consistently, by revealing the hidden causes of process inefficiencies. Armed with these insights, process experts and production teams can make better-informed decisions, to optimise and stabilise the kiln and reduce production losses.

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*Interview by Peter Edwards, Global Cement Magazine*

# In discussion: Philippe Reveilhac, Schneider Electric

*Global Cement* speaks with Philippe Reveilhac, Cement Strategic Accounts Executive at Schneider Electric, about the company's capabilities for the cement sector.

**Above:** Philippe Reveilhac has been Cement Strategic Accounts Executive for Schneider Electric within the Minerals Mining and Metals segment since 2015. He joined the company in 1994, initially working with waste water treatment systems in Mexico. He has also worked in France for Schneider Electric's uninterruptable power systems division, as well as in Hungary as Vice-President for Central Europe for the IT business unit and in the Philippines, where he was Country President.

***GC:* Please could you briefly introduce Schneider Electric?**

***Philippe Reveilhac (PR):*** Schneider Electric is a French company that is a leader in energy management, automation and process efficiency, delivered through products, control systems, software and services. We provide integrated efficiency solutions to lower costs and increase sustainability. The company employs more than 100,000 people in over 100 countries, with a turnover in excess of Euro25bn in 2020.

***GC:* What does Schneider Electric provide to the global cement sector?**

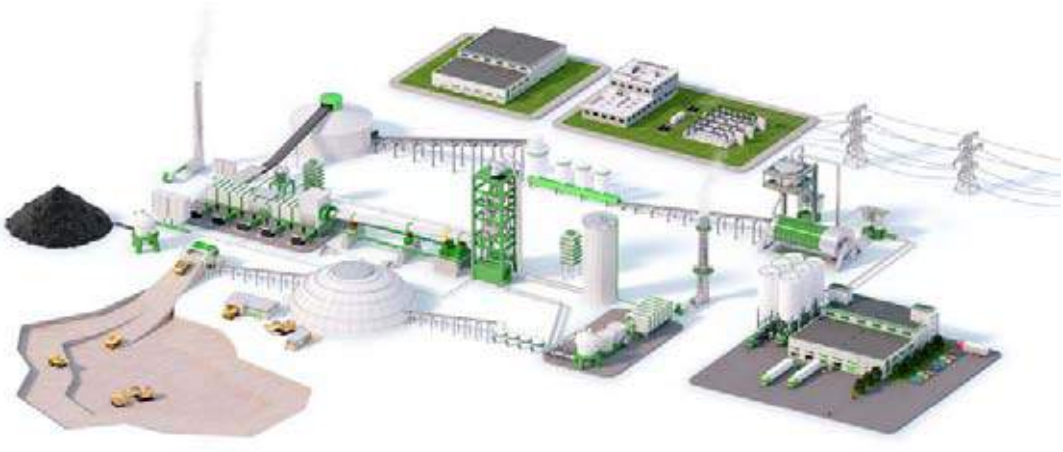
***PR:*** We serve the global cement sector with equipment from the simplest of switches to complex operational systems. Our technology, software and services improve the way our customers manage and automate their operations, to help them make the most of their energy and resources. We aim to minimise cost per tonne and optimise energy and production efficiently, with dedicated cement production optimisation solutions. The most advanced system is our EcoStruxure Plant, with which we aim to lead the digital transformation in the cement sector and provide new opportunities for our clients. For example, our Advanced process control strategy (APC) uses models to optimise the performance of the plants and underlying processing equipment in real-time.

***GC:* Can you elaborate on the APC system?**

***PR:*** Our APC system, based on Model Predictive Control (MPC), aims to optimise the operation of the kiln, preheater, grate cooler and mill system, and ensure their safety and reliability, while freeing up operators and stabilising product quality. APC mimics and surpasses the best operator behaviour, executing every minute or faster. Benefits include energy savings of up to 10%, clinker production increases of up to 10% and a 5% reduction in fuel consumption. This provides a payback period of less than six months.

***GC:* How does the company install such systems?**

***PR:*** The APC system can be installed on any plant, new or old. We find that many generate vast quantities of data that goes unused. By analysing this data, the APC system can help the plant operator identify which parameters need to be changed, in real time, to be closer to operational limits. It does this via a visual interface in the control room, with corrective actions taken either by the APC or by a human. Users can optimise their chosen metric, be



**Right:** Schneider Electric's systems reach every part of the cement plant. Its top five cement sector priorities are:

1. Operational eficiency, including enhancing ease of operation and situational awareness.
2. Energy optimisation benchmarking.
3. Functional safety for all.
4. Enhancing sustainability and profitability.
5. Securing a social licence to operate.

it lower cost-per-tonne, lower emissions, higher or more reliable clinker quality or greater throughput, or a combination of these.

***GC:* What reductions in $CO_2$ emissions can the APC system provide a typical cement plant?**

***PR:*** The $CO_2$ emissions reduction is not the main aim of the APC and the potential for reductions from individual plants will vary. However, the APC can help reduce $CO_2$ emissions. We have reduced energy-related $CO_2$ emissions by up to 20% by reducing energy consumption, procuring more renewable energy and implementing APC to improve mill performance.

To consistently reduce $CO_2$ emissions, for example, Schneider Electric's APC fuel blending optimisation can provide fuel blends with more stable heat values while maximising the use of alternative fuels. An increasingly popular approach is also to pursue calcined clays, where an APC could be successfully implemented as easily as with 'traditional' cement production.

***GC:* How are the demands that the cement sector places on Schneider Electric changing with time?**

***PR:*** At present there is particular pressure for producers to improve their sustainability performance, particularly with reference to $CO_2$. How this affects Schneider Electric is very clear: Producers no longer simply request equipment to do a job, but they want it to be produced in a sustainable way too. Schneider Electric has long been focused on reducing its own $CO_2$ footprint and this makes us redouble our efforts in this area.

As to what they expect from the equipment, I would say the overall trend is increasingly tailored solutions. We are working with clients on many different projects specific to their plant sites and their individual company's aims.

Digitisation has provided many new ways to address the major challenges faced by process industries, such as next-generation intelligent devices and communications, the advent of the Industrial Internet of Things, more sophisticated cyber security protection (and threats) and Industry 4.0. To help with this transition, we propose the software solutions from AVEVA, in which Schneider is a supporting major shareholder, as well as OSIsoft, which it recently acquired. Industry 4.0 is a big challenge, and through its extended ecosystem and broader, deeper portfolio, AVEVA, with its agnostic approach, delivers an enhanced level of efficiency to support the digital transformation of cement industry. For example, the Unified Operation Centers from AVEVA provide a comprehensive view at company level to drive efficiencies at scale by connecting all assets and sites into one repository.

## Meeting energy generation needs

***PR:*** The cement sector is an energy-intensive industry, with a process that must run continuously to keep production costs to a minimum. In areas where our customers are facing escalating energy costs, worsening power outages and a growing imperative to enhance sustainability, we're transforming energy and sustainability into a strategic advantage for our clients through tailored decentralised energy solutions – delivering the benefits of microgrids - local energy systems that integrate distributed generation, storage with advanced automation and control - without the upfront cost, complexity or risk. They bring: **1. Cost stability** through lower, more efficient and predictable energy costs and flexibility, which drives savings and incremental revenue; **2. Reliability and resilience** by generating service loads during times of grid instability and by protecting power-sensitive and critical assets; **3. Sustainability** through reduced CO2 emissions, the attraction of $CO_2$-sensitive clients and improved brand image.

Energy as a Service (EaaS) is a long-term arrangement that transfers the burden of financing, installing, owning and managing distributed energy infrastructure from the client to Schneider Electric. EaaS involves construction of an on-site microgrid, upgrades to energy efficiency, procurement of renewable energy and long-term management and digital optimisation of the end-to-end system. We design, build, finance, own and operate a decentralised energy system that meets our customer's comprehensive goals with no capital expenditure.

***GC:* How do different parts of the global cement sector differ in terms of what they request from Schneider Electric?**

***PR:*** There are differences between mature markets and developing ones. Developed markets such as North America and Europe have mergers and acquisitions, as well as the occasional plant closure, but very few greenfield lines. In this market, plants are more operating expenditure oriented, with a strong focus on optimisation through digitisation (advanced analytics, process digitisation, automation) and sustainability ($CO_2$ reduction) programs. For us, that means field services opportunities, like corrective, preventive and predictive maintenance contracts, spares, on-demand services, as well as modernisation and digitisation. These markets are the ones where we develop and implement some of our most comprehensive solutions. We have to 'push the envelope.' For example, our last successful implementation of our EcoStruxure Asset Advisor, a proactive approach to electrical distribution, which

**Above:** Schneider Electric is a leader in energy management, automation and process efficiency, delivered through products, control systems, software and services.

combines IoT and cloud-based technologies with Schneider Electric's experts and services for business continuity. EcoStruxure Asset Advisor services offer the ability to anticipate and address issues before they become critical incidents, mitigating safety risks. This avoids unplanned downtime, operational losses and maintenance interventions.

In contrast, new economies have a different need. Such countries face high population growth, rising cement demand for infrastructure and housing and a need for greenfield capacity. Our involvement is in the supply of new equipment, commonly via the main contractor with whom we closely work to offer the full scope of solutions in electrical distribution, automation and software. Yet, while the cement industry has widely adapted to industry trends in process automation, energy management and laboratory management, cement manufacturers have been more careful in exploring the digital arena. There is a clear preference to omit fancy solutions and focus only on sensible investments that promise tangible benefits with a relatively quick return on investment.

***GC:* Do greenfield sites often take on Schneider Electric as the sole electrical equipment supplier?**

***PR:*** This is not particularly common, but there are some plants where this is the case, mainly for 'true greenfield plants.' By this I mean the first cement plant for a given producer in a country. If a producer builds a new plant but already has three or four, it will naturally gravitate towards systems it has used in the past, even if this is not the optimum solution. This is understandable. The producer already uses particular systems and its staff already understands how to operate them.

As the supplier, it is of course in our interest to supply the power management and automation systems across the entire plant. However, there are also advantages for the cement plant. If there is one electrical equipment supplier, the plant needs just one maintenance contract instead of several. It also needs to stock fewer parts. Both of these factors present cost savings. Digitisation with the software-agnostic solution from AVEVA will be possible, whoever is the electrical equipment supplier, should the plant decide to go down that route.

***GC:* How has the pandemic affected Schneider Electric over the past 15 months?**

***PR:*** We have been tested, like other companies, to different extents in different places at different times. Our global presence and our strong focus on digital, software and services have supported the resilience of our business. We have had to curtail client visits to almost zero. Throughout the pandemic, we were confident that the market would pick back up and we are seeing this now, even if the pandemic is not yet over. In financial terms, the company saw only a 4.7% reduction in 2020 revenues compared to 2019. This was not evenly shared across regions and businesses. Some market segments were more resilient (food) than others (transportation).

Cement proved to be quite resilient. Indeed, we have found that many producers have had the time to take stock over the course of the pandemic and think more deeply about their plant, process and business model. This has made the pandemic a fertile time for new projects, including total refurbishments of electrical systems in some cases. It is possible that some of these would not have been realised with a 'business as usual' scenario.

***GC:* What lessons will you take forward from the pandemic into the post-Covid era?**

***PR:*** On a personal level, I would say that I have never met as many clients as I have during the pandemic. Of course, I don't mean in person, but online. This is great for understanding their needs and understanding how we can help. Clients are more available for meetings too, because there is far less travel. I never realised how much time I lost commuting. Now I can meet with people in five different countries at the same time.

Before the pandemic I would always have told you that face-to-face contact is essential to business relationships, including the clichéd drink at the bar and the nice meal in the restaurant. But this is only one way to get to know a client. For example, on video calls I have been pleased to meet many of the spouses, children and even pets of our clients and, through these interactions, I see a new side to them. There is a greater openness in the relationship, and I hope this can continue in the post-pandemic business environment.

***GC:* Philippe Reveilhac, thank you for speaking with us today.**

***PR:*** You are welcome. It was great to talk!

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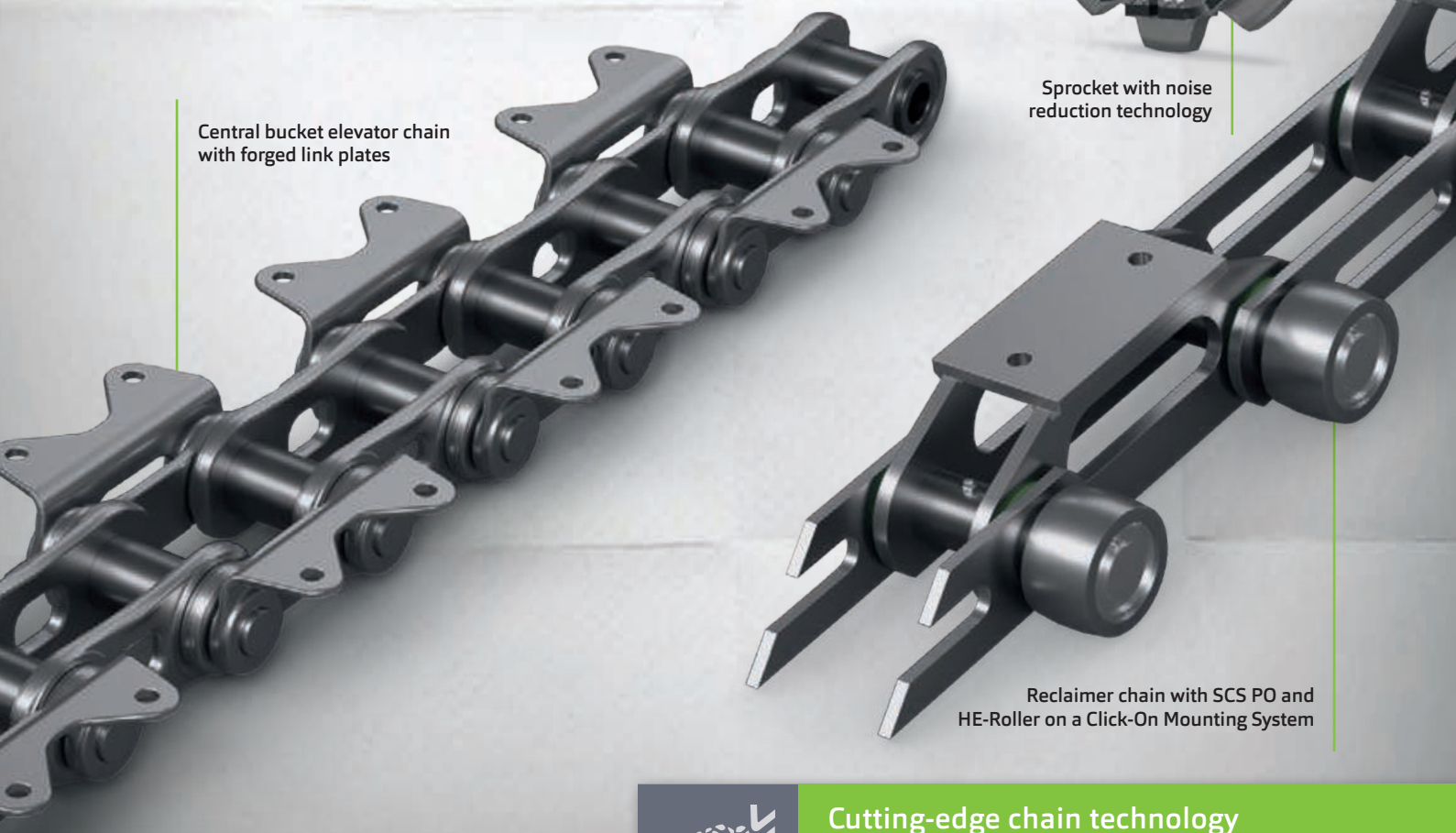

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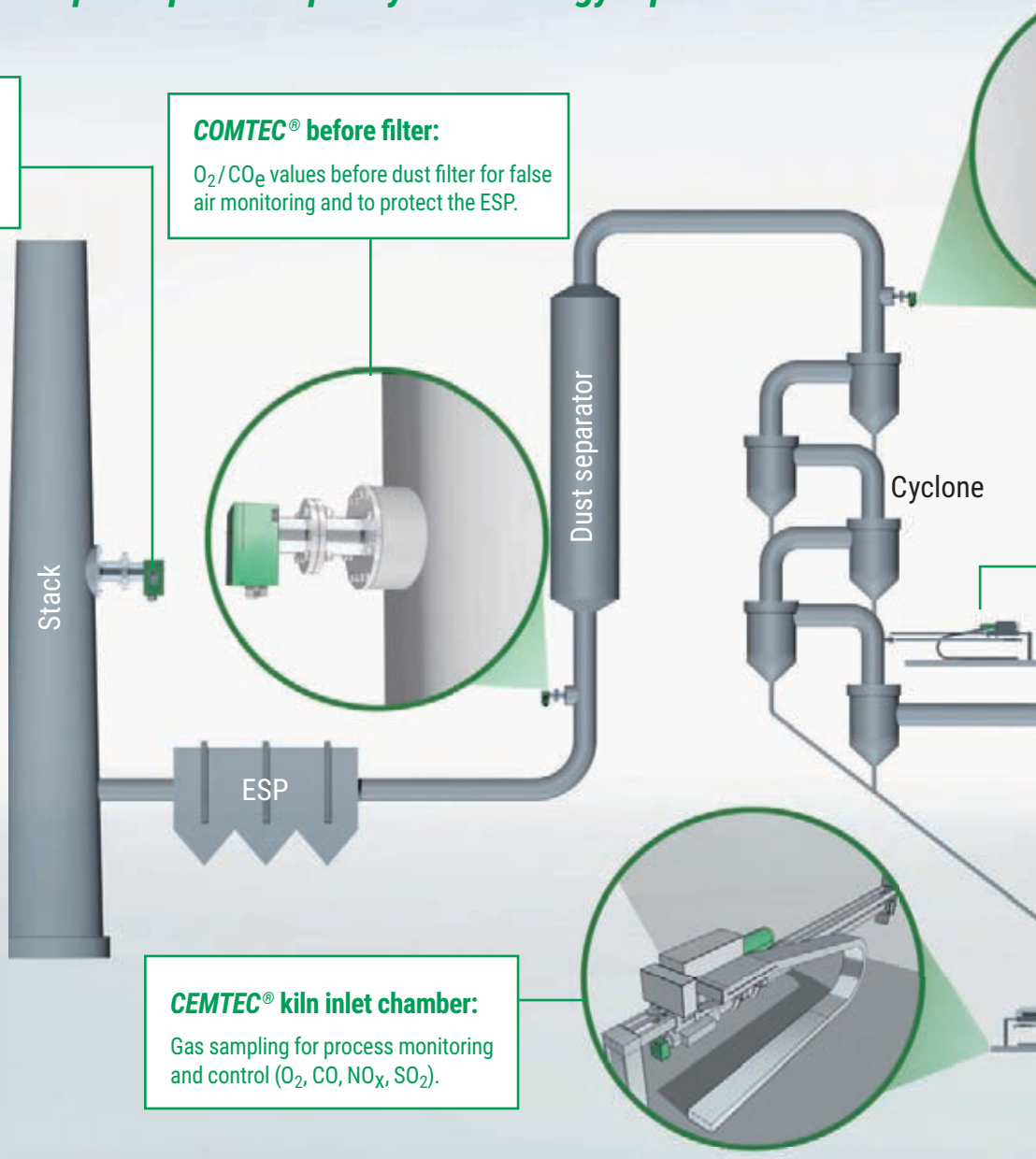


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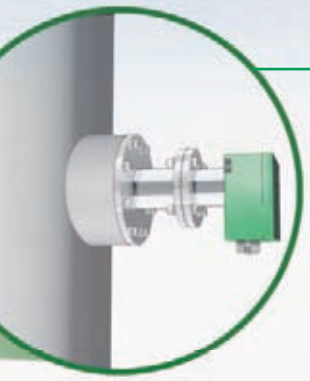

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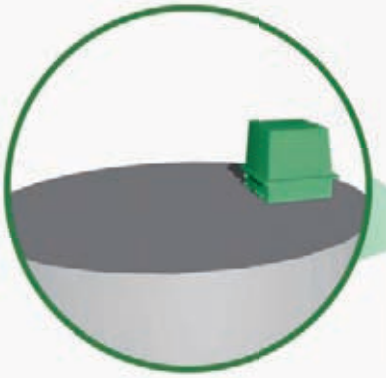

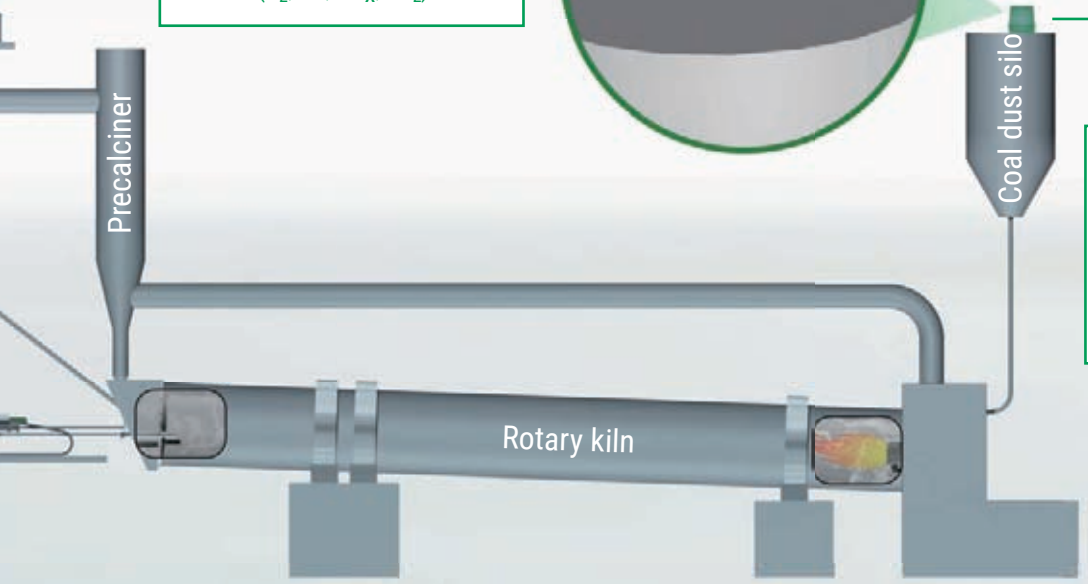


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*Konrad Doering, HeidelbergCement AG & Martin Liebau, ENOTEC GmbH*

# Reliable flue gas measurement: A prerequisite for lower emissions

HeidelbergCement and ENOTEC look at the use of the CEMTEC probe at the Burglengenfeld cement plant in Bavaria, Germany.

Between 2016 and 2018, HeidelbergCement modernised its plant in Burglengenfeld in Bavaria, Germany, at a total cost of Euro100m. This represented the largest single planned investment in the company's history. The modernisation was carried out to significantly reduce emissions, increase the use of alternative fuels to 80% and ensure consistent, high-quality cement. A prerequisite to achieve these goals is, among other things, to receive continuous and precise data of flue gas emissions from the new cement rotary kiln.

The conversion project included a new five-stage heat exchanger tower with calciner, a shortened rotary kiln, two new grinding plants for limestone (with significantly reduced specific power consumption) and a new fabric filter with a separation efficiency of almost 100%. The results of this modernisation were the reduction of emissions, including safe compliance with all limit values, the significant increase in energy efficiency and the reduction of $CO_2$ emissions due to the improved parameters, as well as consistent product quality.

## Ensuring consistent gas measurement

The intended increases to the secondary fuel feed and the additional calciner made the permanent availability of measurement data from a kiln inlet probe indispensable for the Burglengenfeld plant. The limestone and fuel feed, the fuel mix and the air supply are all controlled on the basis of the information it supplies. The $O_2$, $NO_x$ and CO content are recorded and controlled in detail, permitting high clinker quality (See below right).

"If you have a clear picture of what is happening at the kiln inlet chamber, you can establish a very good correlation with other process parameters and quickly draw conclusions and make improvements," says Valentin Hamar, head of the kiln and shift operation at the Burglengenfeld plant.

HeidelbergCement decided to use the robust and reliable CEMTEC rotary kiln inlet probe from ENOTEC GmbH. This measuring system for gas analysis was specially developed for extreme operating conditions such as those found at the kiln inlet. It can achieve continuous direct measurements of

**Right:** View of the Burglengenfeld plant from the south west. **Source:** HeidelbergCement.

**Left:** Overview of the CEMTEC system.

the gases in the kiln thanks to a patented rotating device and automatic cleaning. The CEMTEC probe comprises the water-cooled sampling probe itself, a compressed air tank, a re-cooler for the cooling water, a heat exchanger cabinet, a local control box and a control cabinet with built-in PLC.

The probe extracts the sample gas from the rotary kiln through its internal sintered metal filter tube. Dust build-up on the filter tube and sample gas inlet is regularly removed by a plunger - this means that the internal filter tube is regularly moved forward and back by two pneumatic cylinders to prevent raw meal caking at the tip of the probe. This is crucial for a reliable analysis, as hot caking at the sample gas inlet can lower the measured $O_2$ and CO by oxidation of the flue gas, and thus falsify the measured values.

All cyclic functions of the CEMTEC - plunging, rotation, purging, retraction and insertion

## Values measured and controlled with the help of the CEMTEC probe

**Oxygen ($O_2$):** In principle, the oxygen content is regulated by the air supply. Too much $O_2$ reduces the efficiency of the system and is therefore undesirable. On the other hand, too little $O_2$ creates reducing conditions that lead to rapid ageing of the refractory lining and poor clinker quality. Additionally, build-up and caking in the cyclones and the kiln inlet chamber can occur within a few hours. This is mainly caused by the sulphur in the raw material and chlorine in the secondary fuels in combination with too little $O_2$. The Burglengenfeld plant is thus able to prevent build-up in the process even without a separate $SO_2$ analysis measurement, as this can only occur with low $O_2$.

**Nitrogen oxides ($NO_x$):** The $NO_x$ concentration at the kiln inlet is a very important control parameter, as it can be related to the rotary kiln temperature and clinker quality. High $NO_x$ values, caused by too much excess air during energy input, will result in the deterioration of the clinker and reduces the efficiency of the plant. Low $NO_x$ values on the other hand, is a clear indication that the kiln is being fired too weakly and thus conversion of the material in the chamber is no longer possible. If this is not corrected in time, it can take several hours for the kiln to produce high-quality clinker once again. In a recent operational example from the Burglengenfeld plant, a problem in the kiln was detected quickly due to rising $NO_x$ values - together with other process parameters - at the kiln inlet. Without the values from the kiln inlet probe, this would have taken considerably longer.

**Carbon monoxide (CO):** The CO has a certain relationship to $NO_x$. When CO rises, $NO_x$ automatically falls, as CO indicates incomplete combustion, causing the kiln temperature to also fall. At $NO_x$ values of approximately 1000-1200ppm, as operated at within the Burglengenfeld plant, the CO at the kiln inlet chamber is always below 1000ppm, which confirms reliable kiln operation. If CO increases without any change in $NO_x$, the operation of the kiln must be checked. Sometimes CO increases at the kiln inlet chamber are caused by falling, incompletely burnt calciner fuel.

- can be variably set via the Human Machine Interface (HMI) and adapted to the respective requirements of the combustion system. The sample gas is conveyed through heated sampling pipes to the gas analysis system cabinet after being dried and cleaned in an upstream sample gas conditioning unit.

The CEMTEC probe is the only device on the market that carries out all movements required for a continuous operation fully automatically, from the insertion and retraction, rotation by ±45°, plunging and pulse cleaning. All movements are powered by compressed air, so that a single supply method ensures a safe operation of the probe.

In the event of a failure of the compressed air supply, a 1000L compressed air tank provides a sufficient reserve to ensure the safe extraction of the CEMTEC out of the kiln. Additionally, in the event of a power failure, a battery-operated uninterruptible power supply in the control cabinet ensures that the probe retracts into a safe position. Furthermore, all parameters of importance for the probe, such as temperatures and pressures, are monitored in order to retract the probe from the process in case of emergency and thus prevent overheating.

## Reliable measurement data

The CEMTEC was installed by ENOTEC at the Burglengenfeld plant in March 2018. The installation was completed within a few days without any problems, so that the probe reliably supplied measuring gas from the first moment of ignition. In order to minimise the damage of falling material in the kiln inlet chamber, which is one of the biggest hazards for kiln inlet measurement, the short probe section that runs through the inlet chamber was additionally protected with a refractory lining, which quickly proved its worth in subsequent operation.

The probe operating personnel were trained just a few days after the first ignition of the rotary kiln. Due to the complete functional test of the probe beforehand at the ENOTEC factory and user friendly controls, they were able to take over the operation immediately. As the probe provided reliable measuring values from the first day onwards, it strongly supported the commissioning and optimisation of the kiln. "Due to the retrofitting, many values were new for us, but the CEMTEC values at the kiln inlet chamber are an enormously important indication of how the kiln is operating. They enabled us to quickly understand the modified kiln very well," explains Valentin Hamer.

After 12 months, a regular annual maintenance of the system was carried out, during which only the filter was changed and some wear parts replaced. Now, following more than two years of operation, the probe has reliably provided sample gas for 90% of the time, allowing the kiln to be continuously monitored and controlled. During one incident, in which the analysis did not seem plausible, the shift personnel, with the support of ENOTEC, were able to quickly verify that the data from the kiln inlet probe were correct. Shortly afterwards the cause of the problem was identified within the kiln itself.

## Concluding remarks

With the help of CEMTEC, HeidelbergCement was able to achieve all modernisation targets within a very short time. It is now easier to comply with the stricter limits for Germany's $NO_x$ and $NH_3$ emissions limits, which have been in force since 2019. Product quality could be maintained at a very high level despite the extensive construction project. In addition, the proportion of secondary fuels has been increased continuously and will reach the designated 80% in the near future.

"With its CEMTEC probe, ENOTEC provides one of the most reliable systems in the entire plant," says Norbert Beer, Master Electrician at HeidelbergCement. "The maintenance requirement is very low and simple. ENOTEC, through its direct communication and fast support, provides exactly the features that are expected from a mid-sized company - something that is often missed in larger enterprises."

**Below:** CEMTEC system installed on site.

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*Interview by Peter Edwards, Global Cement Magazine*

# Carbon Re: Lowering $CO_2$ emissions with AI

Representatives from Carbon Re discuss the development of their company's artificial intelligence (AI) driven approach to lower cement sector $CO_2$ emissions.

**Above:** A civil engineer by training, Sherif Elsayed-Ali is a co-founder and CEO of Carbon Re. He is an expert in the 'tech for good' space with over 13 years of leadership and management experience.

**Above:** Daniel Summerbell is a co-founder and Senior Vice President for Solutions at Carbon Re, as well as a researcher at the Institute for Manufacturing in Cambridge, UK, where he focuses on cost-effective environmental improvements for industry, particularly the cement sector.

***Global Cement (GC):* Please could you introduce Carbon Re?**

***Sherif Elsayed-Ali (SE-A):*** Carbon Re was formed in October 2020 to develop artificial intelligence solutions that help cement plant operators reduce fuel-derived $CO_2$ emissions. We believe that, while cement and concrete are essential for the future, the associated high levels of $CO_2$ emissions will not be an option.

Carbon Re is a company born out of the pandemic and I think that the past 12 months have been something of a wake-up call. There were many warnings about such a pandemic and yet humanity was badly prepared. Climate change is much the same. We have also been warned about climate change for a very long time, yet meaningful action is only just starting to take place. Carbon Re wants to help cement producers take steps to reduce their $CO_2$ emissions now, while helping them with their bottom lines too.

***GC:* What is the Carbon Re approach?**

***Daniel Summerbell (DS):*** Carbon Re is developing an approach that uses artificial intelligence (AI) to reduce $CO_2$ emissions from cement plant fuels. It is based on reducing the mass of $CO_2$ emitted per useful heating value ($kgCO_2/UHV$), essentially the $CO_2$ footprint of the heat that is actually delivered to and used by the process. For example, heat used to dry a wet fuel, for example biomass, is not considered. Neither is the fuel that heats the excess air, the amount of which can vary substantially between different types of fuel. You may have to run a lumpy refuse-derived fuel (RDF) with more air, for example, than a finely ground coal. By considering the $kgCO_2/UHV$ value we can objectively analyse the *actual* reduction in $CO_2$ of using a specific alternative fuel, rather than simply assuming that they lead to lower emissions.

By itself, $kgCO_2/UHV$ has the potential to get lost in the pantheon of cement process indicators and it can be fairly counter-intuitive. What combining $kgCO_2/UHV$ with AI does, however, is remove layers of complexity and allow


priorities to be identified and brought to the attention of plant staff. This way, Carbon Re can help cement plants to identify which of their familiar parameters should be improved, which will, in turn, lead to a lower $kgCO_2/UHV$.

***GC:* What stage is the development currently at?**

***DS:*** The approach is based on initial research performed at cement plants operated by Hanson UK, part of Heidelberg Cement. We are currently developing the approach for wider use and are negotiating agreements with producers around the world.

***GC:* What information is fed to the AI?**

***SE-A:*** Carbon Re's approach makes use of existing process parameters, including, but not limited to, $O_2$ levels, air flow rates, cement chemistry, fuel parameters, production rates and many more. Some of these have very clear relationships with $kgCO_2/UHV$ emissions. Others, for example time of day or the personnel working a particular shift, may also have relevant relationships with this indicator. However if the AI indicates that a particular parameter could be important, we can look in more detail to establish whether or not there is a relationship and if so, if it is causal. Of course, relationships between process parameters and $kgCO_2/UHV$ emissions will also vary from plant to plant.

What's clear is that the more data you have, the greater the opportunities to reduce $kgCO_2$/UHV. Thankfully, many cement plants are equipped with sensors that record vast quantities of data, more than can reasonably be acted upon by plant personnel. They can end up with long lists of priorities that may, or may not, be in a helpful order. Carbon Re's AI-based solution is a low-cost way to properly identify the best steps towards reducing fuel-derived $CO_2$ emissions from cement plants.

***GC:* How does the AI handle the incoming data?**

***SE-A:*** Our approach is led by our co-founder, Aidan O'Sullivan at University College London. It is based on deep reinforcement learning, an area of AI that has seen huge progress in recent years as the methodology behind things like DeepMind's famous AlphaGo.

***GC:* What does the plant have to install to make use of Carbon Re's system?**

***SE-A:*** Carbon Re's system is based in the cloud, so there is very little, if any, 'infrastructure' to install at the plant. The cloud-based system analyses the incoming data and identifies specific, quantified, recommendations for the operators, which it presents as a priority list on an intuitive browser-based dashboard. We use base AI models developed specifically for cement processes, with a layer of fine tuning for each individual plant.

***DS:*** The AI is intended to be used in the plant at three levels. The first is at the operator level. We imagine a situation where the AI indicates priorities for discussion, say at the plant's routine morning meeting. The relevant staff would discuss whether or not these are realistic and, if so, how to achieve them. The operator would then be set targets for the day. The following day, there can be feedback on how each of the changes affected the plant's performance with relation to $kgCO_2$/UHV. Did this have the desired result? If not, why not? The results are fed back to the AI and the system updates its knowledge base.

Perhaps there is a priority that couldn't be achieved. In this case, we start to look at the second level of use: Why couldn't the operator achieve the priority? Maybe they simply ran out of time... or could there be some underlying problem with the plant? Such issues can be reported to plant management via a second dashboard on a monthly basis. If a priority keeps being recommended by the AI, it shows that the priority has greater value to the plant from a $kgCO_2$/UHV perspective than we might perceive. It could even be as simple as a sticky valve. Such a 'small thing' might get lost at the bottom of a traditional list of priorities and it could take months to resolve. However, AI might show that fixing it now could bring unrealised benefits for the plant.


**Above:** Carbon Re's AI solution analyses relationships between diverse cement plant data, transforming it into actionable solutions that reduce costs as well as fuel-derived $CO_2$ emissions.

**Opposite:** With commitments to $CO_2$-neutrality now announced by most major cement producers, the next - and far more difficult - step is to identify and make use of opportunities for $CO_2$ reduction. AI can help.

Beyond this, the third level looks at potential to alter the plant itself. The AI might say, 'Keep parameter X constant at level Y.' It may be a winning recommendation in principle, but cement production is inherently unstable and it could be that the operator finds it impossible to actually keep parameter X in check. This could be due to a physical shortcoming or bottleneck that is not intuitively obvious to the staff.

The possibilities of the third level then become really exciting. If a digital twin model of the plant has been established, the staff can look at the problem far more deeply and forecast the effects of making physical changes. What will it be worth to the plant, both in terms of return on investment and $kgCO_2$/UHV? Too often such projects have return on investments that are fairly vague. In contrast, the Carbon Re approach informs the project manager of the potential benefits of a given project in a far more comprehensive manner. Appropriate actions become clearer.

***GC:* Could the AI control the plant?**

***DS:*** We have deliberately stepped away from the AI controlling the plant at this stage. The level of complexity this would add is enormous and we are not sure that the sector is ready for this approach just yet.

***GC:* It seems that the Carbon Re's approach can unmask previously unknown correlations. What are some of the more surprising ones?**

***DS:*** It turns out that where you burn your fuel has a major influence on $kgCO_2$/UHV, which had not been picked up on by the overall metric previously. For example, in one plant we found that if you increase the amount of secondary recovered fuel (SRF) in the main burner past a certain point, you actually have to burn more coal to heat the

**Above:** Cement production is a complex process and no two plants are alike. Carbon Re's AI solution can be tuned for each plant and continues to adapt as it learns more about how it behaves.

material up so it will burn. This is a case of increasing alternative fuel use not bringing a net $CO_2$ benefit. In fact, it can make the situation worse!

***GC:* What benefits would a typical plant expect to see when it uses Carbon Re's AI solution?**

***DS:*** We expect that a typcial plant would be able to achieve a 16-19.5% reduction in fuel-derived $CO_2$ emissions, which would represent around 5-8% of the total. How this translates to cost is hard to assess, as fuel prices vary and, as we have established, the relationships between $kgCO_2$/UHV and fuel are non-linear. We have also been working on a grinding optimisation AI-led system that can reduce the cost of the energy needed to grind materials within the plant by up to 8%, which could provide the basis for an entire separate article.

***SE-A:*** Highly-qualified AI experts are thin on the ground. Even the largest and most ambitious cement producers would struggle to develop a functional and effective AI system in-house. Therefore, our aim is to be the provider of that AI expertise for the cement sector. We want to bring both environmental and cost benefits to producers around the world.

***GC:* What is the timescale for commercial use?**

***SE-A:*** We are working, as discussed, with our early adopting partners right now in a number of locations around the world, including in North America, the Middle East and Asia, as well as countries in Europe. We hope to launch a commercial product to the general market in early 2022.

***GC:* Do you think that the rapidly-rising price of emitting $CO_2$ under the EU Emissions Trading Scheme will encourage uptake of this solution in Europe in particular?**

***DS:*** While EU ETS prices have risen dramatically, they are now consistently over Euro40/t, there are still quite a lot of free allowances available to cement producers. This dampens the effect of rising prices at present. However, as the number of free allowances comes down, EU ETS prices will go from being an area of concern to a serious financial consideration, as well as those affected by the recently-announced Carbon Border Adjustment Mechanism (CBAM).

So, in reponse to the suggestion that Carbon Re's solution is necessarily a Euro-centric concept, I don't agree. This is because the solution allows you to both reduce $CO_2$ emissions and cost, be it from optimising efficiencies in the fuel mix, air flow, less maintenance or any one of many other parameters.

I do agree that, in the longer term, Carbon Re's approach will go from providing an incremental improvement to becoming an essential add-on for a cement plant. We want to become established now and embed our solution in the decision-making process, so that we can help cement producers get over that transition.

***GC:* What are the biggest hurdles to implementation in the coming years?**

***SE-A:*** As you just touched on, we want to implement this solution across the world, not just in one place. This means that we will have to apply the system across different sized producers that work to different regulatory requirements in different languages using different measurement units, that work with different types of fuel to make different types of cement for different markets. This will challenge our approaches for sure but it's something we look forward to working on as we grow.

***GC:* What is the greatest opportunity for the company over the next few years?**

***SE-A:*** There is increasing action by governments to reduce $CO_2$ emissions, as demonstrated by China's commitment to $CO_2$ neutrality by 2060, the EU's commitment to zero $CO_2$ by 2050 and the recent policy changes from US President Joe Biden. The use of emissions trading schemes will only grow globally and pressure from the public and investors is now clearly geared towards sustainable investment and business practices. As cement is essential for future growth, this will require low- or zero-$CO_2$ cement and concrete products. We can facilitate this transition, while improving cement producers' bottom lines too. We look forward to helping them.

***GC:* Thank you for your time today, gentlemen.**

***SE-A/DS:*** You are very welcome indeed!

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*Luc Rudowski, thyssenkrupp Industrial Solutions AG*

# polysius® pure oxyfuel: Best in class technology for $CO_2$ capture and storage

thyssenkrupp Industrial Solutions introduces its polysius® pure oxyfuel system.

Cement production releases large quantities of $CO_2$. Around a third results from the combustion of fossil fuels, such as coal or petroleum coke, while 35-44% is released by the calcination of limestone, depending on its quality.

Luc Rudowski, Head of Innovation at thyssenkrupp Industrial Solutions, Business Unit Cement Technologies, says, "Reducing $CO_2$ emissions in cement production is one of the most important challenges facing the industry today. As part of our #grey2green journey, we are developing technologies and solutions for sustainable cement production without losing sight of plant profitability and productivity."

## Oxyfuel – pure oxygen replaces air

Oxyfuel technology replaces ambient air in the clinker production process with pure oxygen introduced into the front zone of the cooler. As nitrogen content is no longer present in the system, the $CO_2$ concentration in the kiln exhaust gas can be increased to 100%. This much higher $CO_2$ concentration serves as the basis for the downstream separation, utilisation and / or storage.

However, the advantage of reducing the exhaust gas to a virtually pure $CO_2$ stream means that there is too little gas in the preheater to operate the cyclones. In the first-generation oxyfuel process, this necessitated a complex gas recirculation system from the preheater exhaust to the cooler involving heat exchange, dust removal and condensation.

Dr Georg Locher, Head of Research & Development at thyssenkrupp Industrial Solutions, says, "With the second-generation polysius® pure oxyfuel process, exhaust gas recirculation can be eliminated, resulting in considerable savings in investment and operating costs, and making polysius® pure oxyfuel the best-in-class technology for $CO_2$ capture. Another advantage is that existing kiln plants can also be retrofitted with this process. By using the polysius® pure oxyfuel process, our customers profit from optimised operating costs, while freeing our communities and the environment from high $CO_2$ emissions."

Four European cement manufacturers, Buzzi Unicem-Dyckerhoff, HeidelbergCement, Schwenk Zement and Vicat, plan to investigate the industrial-scale use of oxyfuel $CO_2$ capture technology in cement production in a demonstration plant. To this end, the research company CI4C - Cement Innovation for Climate was established. The aim is to capture 100% of the $CO_2$ and use it with the help of renewable energies to produce so-called 'refuels,' $CO_2$-neutral synthetic fuels such as kerosene for the aviation industry.

Dr Markus Sauer, Senior Proposal Manager at thyssenkrupp Industrial Solutions, said, "The research company CI4C and thyssenkrupp are currently investigating the use of our polysius® pure oxyfuel technology in a demonstration plant. Working with our long-standing customers, we would be delighted if we could demonstrate the efficiency of our technology for the first time on an industrial scale. By using this technology, the cement industry could significantly reduce its process-related $CO_2$ emissions and thus make an important contribution to climate protection."

**Below:** thyssenkrupp Industrial Solutions is working on various technological solutions to reduce the impact of cement production, while maintaining plant profitability and productivity.

*Dr Kathrin Weber, Kai Beimdiek, Dr Ulrich Zielinski, Ansgar Schnell & Carlos Matus, Refratechnik Cement GmbH*

# Extend the service life of your kiln with veneering

Hot spot in the lining and general overhaul is still three months away?

Time is money. This mantra applies to every manufacturing industry. The production of cement clinker is a complex system with many pitfalls. The three main components, the kiln, the raw meal and the refractory material, must be kept in harmony. Any small disturbance of one component can have a major impact on the whole system. If the kiln does not run smoothly, the risk of the refractory material being damaged over a short timeframe increases. If the composition of the raw meal is variable, not only can off-spec clinker be produced but the refractory lining can also be damaged. Once the refractory material is affected, it loses its protective effect and the kiln shell can overheat and deform. High consequential costs arise. Costs for refractory material only make up a minor part of the operating costs, but they form the basis for a running kiln and thus for a properly maintained cement plant.

It is even more frustrating when refractory damage occurs only shortly before a planned overhaul. Bringing forward the planned stop is only possible in rare cases, as logistics will often not be in place. The fuel tanks are not empty and neither refractory material nor installation personnel are on site.

In this situation, a quick repair to bridge the gap until the planned shutdown of the kiln is required. Refratechnik Cement offers a cold repair technique that allows refractory damage to be fixed rapidly and easily: Veneering technology. This involves the application of thermochemically-resistant and flexible refractory concretes to the worn lining in a fast gunning process that enables the kiln to be restarted quickly. Short downtimes and a less complex installation process keep the costs low compared to the installation of new monolithic products or classic new brick laying.

**Below:** Veneering can help bridge the gap between unexpected refractory damage and the plant's next scheduled shutdown.

## The possibilities of veneering

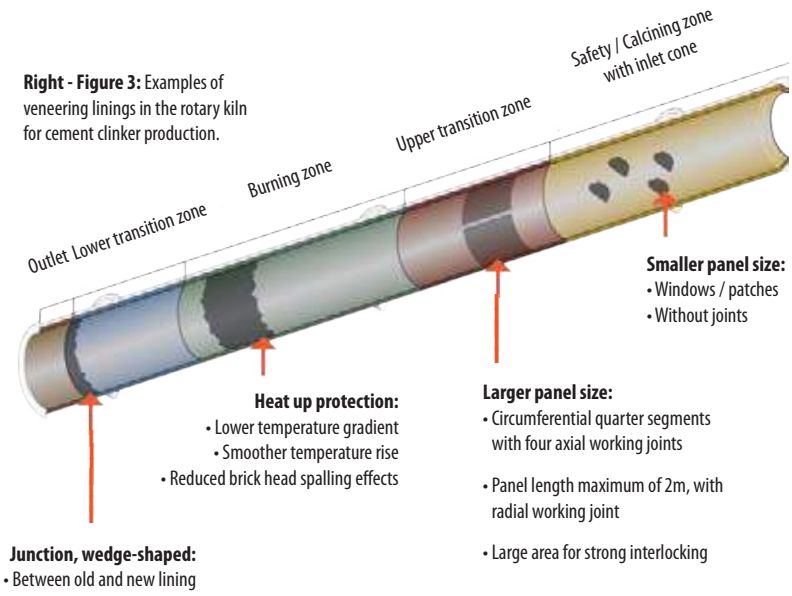
There are various possible applications of veneering, from the repair of small hot spots to the repair of the lining around a full kiln circumference (Figures 1 & 2). Lost bricks can be replaced entirely, or, in case of insufficient lining thickness after brick spalling phenomena, veneering concrete can be installed on top. This can be useful if the kiln comes down prematurely a few weeks before the scheduled overhaul.

The time until the planned shutdown and the size of area to be repaired are key to deciding whether veneering is suitable. The plant operator can decide between a more durable, but initially also more time-consuming and expensive brick laying repair or a faster and cheaper veneering solution.

Besides emergency repair, veneering also offers other areas of application (Figure 3). The use of a protective layer when the rotary

**Far Left - Figure 1:** Veneering of a hot spot on a kiln with a diameter greater than 5.0m.

**Left - Figure 2:** Veneering a protective layer across an entire kiln circumference. Kiln diameter greater than 5.0m.




**Right - Figure 3:** Examples of veneering linings in the rotary kiln for cement clinker production.

kiln is restarted, so-called 'heat-up protection,' established itself as a suitable solution. Lining that has already seen a campaign or a certain period of production is often infiltrated with various salts and has lost its flexibility, making it particularly susceptible to thermomechanical loads. In this case, the application of a heat-up protection reduces the thermal gradient and allows a smoother temperature rise in the lining until a protective coating has formed. Brick head spalling can thus be reduced, especially during the critical heating up phase.

Veneering can also be used to easily adjust the height compensation between an old and new lining to prevent abrasion or blockages caused by the raw meal passing through. Specially-shaped bricks, conical parts of the rotary kiln for example, can also benefit from veneering, as their production is often associated with long delivery times. A timely gunning with veneering material can signficantly extend their lifespan and reduce the warehouse costs of storing these special shapes for long periods.

## How is veneering used?

Veneering is a fast method of gaining lining thickness in a worn section to reach the upcoming overhaul. The installation of veneering is possible using the casting, wet gunning or dry gunning process. However, the dry gunning method is particularly suitable due to its easy handling and short processing time. The equipment for dry gunning is available in many cement plants and allows the veneering concrete to be transported over long distances to all static areas, as well as to the rotary kiln.

Aluminosilicate concretes of the $Al_2O_3$-$SiO_2$ system, for example Refra-mullite 60 EDG Z AR are used in the static areas and the calcining zone of the rotary kiln. For a non-basic veneering lining an average service life of 12 months in the calcining zone was realised.

In the areas of the rotary kiln that are subject to increased thermal and thermochemical stress, basic concretes with a thermal expansion coefficient very similar to that of basic bricks are recommended, for example Refra-MgO 90 SG or Refra-MgO 82 SG. Dozens of plants have successfully installed basic veneering concretes. The installation mainly took place between upper and lower transition zone where we met the individual targets regarding lifetime of several weeks or months.

## Does the coating have to be removed?

Depending on the kiln area where a repair is necessary, the removal of the coating is always a key question in terms of safety and the duration of the downtime. The more coating to be removed, the

longer the kiln downtime. What does this mean for the veneering process? All areas of the kiln that are accessed by the installation personnel must be safe: either the coating has to be removed or common appropriate safety precautions, such as a protective cage, tunnel or scaffolding, must be taken. The lining itself, to which the veneering concrete is to be applied, must always be free of coating. New, as well as old, veneering layers have to be treated like coating in terms of safety and the same protective measures must be taken.

Before the veneering installation starts, the residual thickness of the bricks must be determined. The veneering thickness is usually 30-120mm. Up to this thickness no additional anchoring is necessary in most cases. Form-work is not required. Before installation, the area must be cleaned using suitable methods (sweeping, vacuuming, blowing off, etc.). Smooth refractory surfaces can be roughened by sandblasting. Dust, loose clinker, loose adhesions and brick heads as well as layer-like spalling material must be removed to achieve the best possible surface.

For veneered linings, no specific drying and heat-up are necessary. The kiln can be put back into operation in line with the standard heating up procedure. The exact installation instructions have to be discussed in each case individually and depend on the refractory concrete used, the installation method, the type of damage, and the surface of the lining. Appropriate processing guidelines have been drawn up by Refratechnik Cement in close cooperation with international customers and installation companies considering work and installation safety, as well as the best possible interlocking between the existing worn lining and the gunned veneering material.

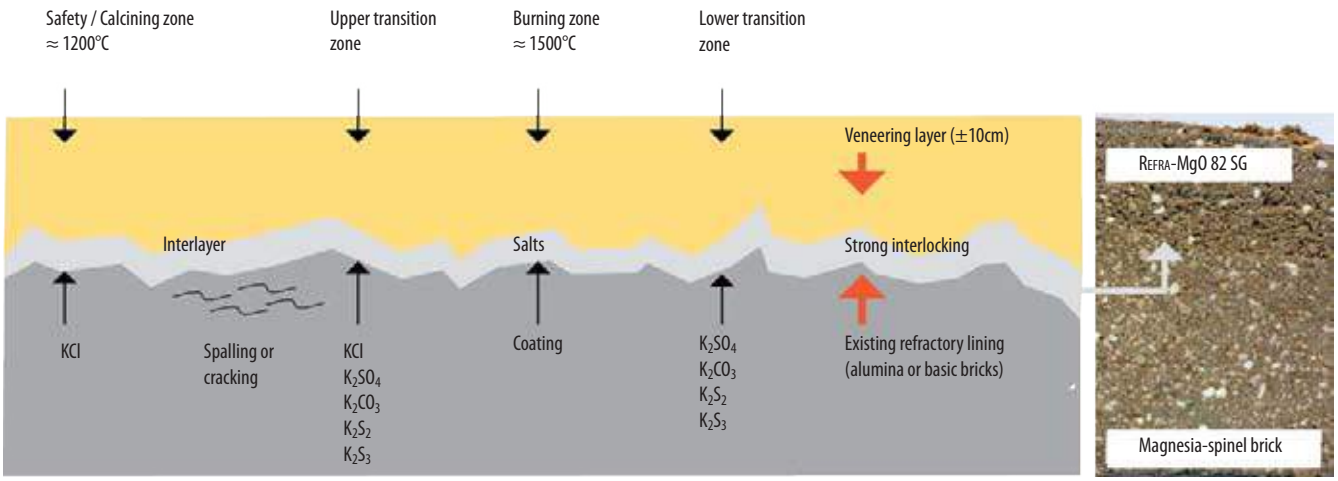
A veneering lining in static areas of a cement plant is usually more durable and less demanding. In dynamic areas of the rotary kiln, however, numerous factors influence the adhesion and thus the durability. The gunning process of the veneering material onto a worn, rough surface does not initially present a significant challenge. Nevertheless, it is important to achieve a very good form closure and bonding strength between the old refractory lining and the veneered refractory concrete in all parts of the rotary kiln.

Different wear factors of the old lining in each zone play a significant role for the quality of adhesion (Figure 4). Besides an insufficiently cleaned surface and loose layers, especially high alkali chloride, alkali carbonate and alkali sulphate/sulphide salt loads in the area of the worn surface can have an impact on the interlocking.

Refratechnik Cement's veneering concretes are specially designed and developed to meet these requirements. They are characterised by a safe gunning behaviour, rapid hardening even at low processing temperatures, high adhesion without anchoring and a very good interlocking with the worn surface. In most cases, these well-balanced settings and properties contribute to optimised application behaviour and thus also support the cement plant operator in extending the service life of the refractory lining until the planned shutdown.

## Your challenge, our solution

Thanks in particular to its quick installation, veneering enables a quick return to production and thus low production losses. Although veneering is not a substitute for new brick laying, it is a small, inexpensive, and, above all, effective repair measure that can reduce follow-up costs when used in a targeted manner. This is Refratechnik's answer to unplanned kiln stops. To ensure the full benefit of the veneering concept, strategic stocks at warehouses are already established. Furthermore, the company is working on optimising the refractory linings in all areas of the plant, for example, by preparing basic refractory concretes, especially for use in static areas, in order to withstand the increasing thermal and thermochemical loads and to reduce alkali-based wear.




**Below - Figure 4:** From the safety zone to the lower transition zone: Illustration of the contact/worn surface area between an existing refractory lining and the gunned veneering layer. Wear factors, which are different for each kiln zone, can have an impact on the interlocking.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*Interview by Peter Edwards, Global Cement Magazine*

# In discussion: Heinz Telser, RHI Magnesita

RHI Magnesita's Heinz Telser speaks to *Global Cement* about the company's history, the current demands placed on refractories by the global cement sector, changes brought about by the Covid-19 pandemic and the company's next steps in the digital world.

***Global Cement (GC):* Please could you introduce RHI Magnesita?**

***Heinz Telser (HT):*** The roots of RHI Magnesita reach back into the first half of the 19th Century. Famous refractory companies, including Didier, Veitscher and Radex were combined in the 1990s under RHI AG. Almost 200 years of history and the merger between RHI and Magnesita shaped the company of today and made it the market and technology leader in the refractory industry.

RHI Magnesita's headquarters is located in Vienna, Austria. It is active across 30 production sites, five research and development hubs and more than 70 sales offices. There are more than 12,000 employees who serve the industry with refractory products and solutions around the globe.

***GC:* How important is the cement sector to RHI Magnesita?**

***HT:*** The cement industry is a very important sector for RHI Magnesita, accounting for around 10% of our annual revenue. The sector contributes a significant volume to our production plants in Brazil, USA, Mexico, Europe, India and China. Because of the importance of this sector, the company has a dedicated structure and organisation, with all the support functions, exclusively to serve the cement industry. We serve more than 1500 customers in more than 100 countries. They deserve a strong and reliable service.

**Below:** RHI Magnesita's headquarters in Vienna, Austria.

***GC:* What main product lines does the company provide to the cement sector?**

***HT:*** RHI Magnesita can proudly call itself a full product and service provider. This covers all of the refractory product groups and services that are required to install refractories in the different kiln configurations. This includes the product, engineering, installation and digital tools to optimise and monitor the refractory performance. Our portfolio includes many value-added solutions that go far beyond simply the supply of grade refractories.

***GC:* Which world regions are most important at the moment?**

***HT:*** Different regions have different market dynamics and volumes, which need different sales and service approaches. China and India, the number one and two in cement production, require an intense set up, and we pay attention by adding production, research and development, and sales capacity into these regions. However, this does not mean that we neglect other areas. We need to be present in all markets to serve our customers and increase our activities, especially those in which we are not well represented or have a low market share.

***GC:* What are some recent cement sector refractory consumption trends?**

***HT:*** Although refractories represent a very small proportion of a cement plant's operating expenditure, in recent years we have seen a trend towards more 'price-convenient' refractory grades. This is where customers focus just on the cost-per-tonne value that they spend on refractories.

However, this value is not the most important one. The specific refractory costs and total costs of

**Left:** Heinz Telser has worked for RHI Magnesita since 2001 and has held several different roles in the company's cement and lime business sector. He has been Head of Marketing & Technical Excellence of the business unit Industrial since the merger of RHI and Magnesita in 2017. Here he is seen installing the company's ANKRAL LC bricks, basic bricks that are produced from recycled refractory bricks. They represent one of the company's approaches to reducing its $CO_2$ emissions.

ownership should be more in focus. Buying cheap runs the risk of premature failures and unplanned interruptions during operation. This is why RHI Magnesita has developed its Refractory Optimisation Model, which combines premium products and services that add value and, at the end of the day, have a positive cash effect for our customers.

***GC:* How has RHI Magnesita been affected by the Covid-19 pandemic?**

***HT:*** The protection of employees was of highest priority for us and our customers. We implemented measures in our offices and production sites very quickly to protect our employees and operations. Luckily, we were able to keep our production sites working and producing for our customers. All of us had to face very challenging situations, for example in the supply chain and transportation, but several task forces tried to manage the situation as well as possible. Regarding installations, work had to be stopped in some countries due to local regulations. Of course, we respected all the rules and restrictions. But where our customers needed local support, we tried to give it, but this was not possible in all cases, due to travel restrictions.

Interaction shifted from the real world towards online meetings, remote assistance and webinars. During the last year we have carried out several online training courses and webinars in different regions for our clients. So, although not physically present, we had very intense customer interaction.

***GC:* Which aspects of pandemic-era business will RHI Magnesita keep once 'normality' resumes?**

***HT:*** It is clear that we won't travel to the same extent as we did before Covid. That's good, as we have another big problem to tackle, $CO_2$ emissions. RHI Magnesita can also be of assistance in this regard by providing modern equipment and tools. RHI Magnesita has also stepped into a cooperation with Microsoft to drive digitalisation, where remote assistance is one important aspect.

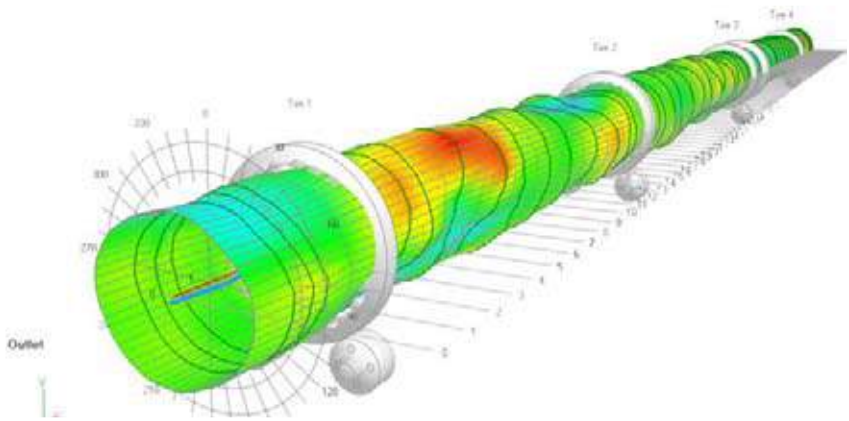
We are currently extending this service, using Augmented Reality (AR)-glasses, remote assistance on smart phones, carrying out virtual kiln inspections and even virtual material inspections at our production plants. These developments were in the pipeline anyway, but got a real boost during this era.

***GC:* How are cement client demands different from those made by other sectors you serve?**

***HT:*** The demands placed on refractories are very different across different industrial sectors. In the steel, non-ferrous and glass sectors we face melts and slags that attack the refractories, while in cement we have gaseous phases that infiltrate the refractory material. The most refractory-intense part of the process is the rotary kiln. This is, of course, a rotating process, which is the second main difference between the cement sector and the others that we serve. The mechanical stresses on refractory bricks in this area are enormous. The kiln rotates at 3-4rpm continuously, for nearly a whole year at a time. The refractory bricks therefore have to simultaneously withstand thermal, chemical and mechanical stress.

***GC:* How are the cement sector refractory needs changing at present?**

**Below:** RHI Magnesita is investing in plant modernisation and digitalisation around the globe.



**Above:** With the Refractory Optimisation Model RHI Magnesita offers services to improve the performance of refractories. A Mechanical Kiln Audit can help to monitor the condition of the kiln, to initiate timely maintenance measures and consistently prolong the service life of the lining.

***HT:*** The use of alternative fuels, already well established in many markets, for example Europe, is expected to rise in countries like China and India over the coming years. With this will come a change in the volatile chemical components inside of the kiln, particularly an increase in alkali salts, like chlorides and sulphates. These infiltrate the refractories, filling up pores and lowering the mechanical strength of the bricks. Sulphates predominantly attack basic (magnesia based) bricks, and alkali salts attack non-basic (alumina-based) bricks.

In sold out markets, kiln utilisation needs to be high and supported by an optimised lining design and mechanical kiln maintenance.

On the alumina side, RHI Magnesita produces its special impregnated alumina bricks and SOL-bonded mixes. In the latter a sol-gel binding system is applied which makes them able to withstand high chemcial stresses.

On the basic brick side, we have successfully launched our Spinosphere technology. This is a revolutionary and innovative new concept for magnesia bricks, where we have not seen any major new developments for decades. In the past, refractory suppliers for magnesia bricks, which are installed in the most critical area of a rotary kiln, always had to compromise between thermal-resistance and mechanical strength.

With our new ANKRAL X-series, as we call this product line, we don't have to compromise anymore. This product line can withstand highest thermo-mechanical stresses in the most critical kiln zones. Since the product launch, we have collected many excellent performance references. After establishing our Spinosphere hub in Europe, we now invest in transferring this special technology to our production sites in China and Brazil.

***GC:*** **How else is RHI Magnesita changing its service offering?**

***HT:*** We see a clear trend towards waste minimisation and the circular economy. We have invested a lot of money and research activities and finally were able to develop magnesia bricks based on (recycled) secondary raw materials, without technical compromises compared to the original product. Our ANKRAL LC series – LC stands for Low Carbon dioxide emissions - is the result of a circular economy solution, which we offer to our customers, taking back the used bricks from the rotary kilns and processing and purifying the secondary raw material in a patented process to produce basic refractory bricks. These then go back into customers' kilns.

Recycling bricks is one approach, but there are many more services and tools available. We would like to offer much more than just refractory materials to our customers. We want to be a solution provider to our customers and offer packages in order to improve and optimise refractory performance, enabling predictive maintenance beyond experience-driven decisions and which finally enable our clients to keep their kiln utilisation high.

***GC:*** **What is the biggest threat to the continued success of RHI Magnesita over the next five years?**

***HT:*** Refractory production is a raw material intensive industry and the availability of raw materials are of highest importance. We have seen, just a few years back, that the supply chain can be disrupted. Since we have a high backwards integration and a global production network, we are in a much better situation than many of our competitors, but also not immune against interruptions in the supply chain.

***GC:*** **What is the biggest opportunity over the same time period?**

***HT:*** We are very confident that, with the current set up and actions in place, we are fit for the future. Digitalisation and sustainability are megatrends also within our customer's industry and this requires special solutions and further developments. RHI Magnesita invests massively in resources and expertise. This starts with modernisation and digitalisation in our production plants and ends with customised services at our client's site. Many very interesting and promising solutions are in the making and will be launched within the next five years.

This opens a huge opportunity for us, to bring our service and solution to a new level. In some regions we will be a full-service provider to our cement customers, offering the whole package of installed material, circular economy and automated refractory optimisation tools.

***GC:*** **Heinz Telser, thank you for your time.**

***HT:*** You are most welcome.

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*Prasunjit Sengupta, SKG Refractories Ltd, India*

# A solution to the mechanical instability of refractory linings in large diameter kilns

The mechanical instability of the refractory lining in the calcination zone of cement kilns is often problematic, especially in older kilns and those with large diameters. Here Prasunjit Sengupta, from India's SKG Refractories, looks at how to solve this issue.

The mechanical instability of the refractory lining in the calcination zone of cement kilns is often problematic, especially for older kilns and kilns with large diameters. It is often found that the bricks in the calcining zone simply fall down (Figure 1), leading to a shutdown, even when the bricks have been installed expertly. There are many reasons behind the mechanical instability of the refractory lining and associated disintegration, each of which contributes to some degree.

**Thermal expansion of kiln shell:** During the running of the kiln the shell is heated up. In a modern kiln, the shell reaches 200°C, which causes it to expand. The problem is that the steel expands much more than refractory bricks. The thermal expansion coefficients of steel and 45-50% $Al_2O_3$ brick are 11.5 x $10^{-6}$/C and 3.5 x $10^{-6}$/ C respectively. In a kiln where Ø = 4m operating in an ambient temperature of 25°C, the expansion of the kiln shell circumference is:

$2\pi$ x 2.0m x (200°C-25°C) x 11.5 x $10^{-3}$ = 25.2mm

The expansion of the refractory ring is:

$2\pi$ x 2.0m x (200°C-25°C) x 3.5 x $10^{-3}$ = 7.7mm

The shell therefore expands 17.5mm more than the refractory ring in contact with the shell, which causes loosening of the bricks. The greater the diameter of the kiln, the greater the difference. A kiln with Ø = 6m, under the same conditions, would be as much as 26.4mm. Once the bricks in a ring are loosened, a gap forms and they can fall. The shell is then exposed to higher temperatures, causing more expansion and further collapses. Reducing the shell temperature and / or using refractory linings with higher thermal expansion coefficients can help maintain a stable lining.

**Refractory thermal conductivity:** When in operation, heat flows from the centre of the kiln through the refractory lining and through the shell to the atmosphere. The higher the thermal conductivity of the lining refractory, the higher the shell temperature and the greater the expansion. Bricks that have high thermal conductivity and low thermal expansion, for example those with high silicon carbide content, are therefore not suited to the calcination zone.

A question may arise about the suitability of basic bricks with high thermal conductivity in the lining of rotary kilns. Basic bricks are used in the burning and transition zones where operating temperatures are much higher. The coating formation on refractory lining in these areas insulates the shell from becoming overheated. The thermal expansion of basic refractories is much higher than aluminosilicate refractories, which reduces the difference in expansion between the shell and brick ring, keeping the lining tight. Moreover, the coating formation over refractory lining holds the brick lining together and ultimately contributes to the mechanical stability of basic brick lining.

During running of the kiln, different alkali salts vaporise and penetrate inside the brick pores where they are deposited. This causes slow densification and a gradual increase in the thermal conductivity

**Right - Figure 1:** Bricks can fall down from the ring of the calcining zone in large-diameter kilns, even when expertly installed.

of the refractory. This kind of densification of the lining may increase the shell temperature and aggravate expansion problems.

**Diameter-related stability factor**: Refractory bricks are lined in the kiln dry, without mortar. They remain in place because of their key shape design (Figure 2) and cannot come out of the ring. However, as the diameter of the kiln increases, the key effect reduces. Figure 2 shows a single brick in the lining. Its dimensions are defined as:

A = The side in contact with the shell;
B = The side in contact with the kiln feed;
H = The length of the brick;
R = Radius of the kiln shell.

The number of bricks (N), required to construct a ring based on A is:

$$N = 2\pi R/A$$

N can also be defined in terms of B:

$$N = 2\pi (R-H) / B$$

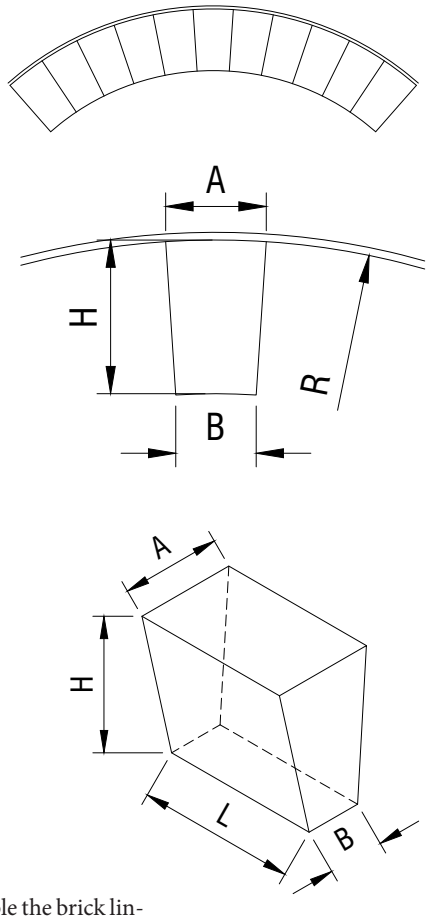
It therefore follows that:

$$2\pi R/A = 2\pi (R - H) / B \text{ or } R / A = (R - H) / B$$

$$B = A - AH / R$$

The factor, (AH/R) is known as the stability factor (SF) of a lining. The lower the SF, the closer the value of 'B' to 'A' and the lower the stability of the brick in the constructed ring. There are some practical difficulties that prevent A and H rising beyond certain limits, meaning that SF depends upon R, decreasing as R increases. The SF values for some common brick sizes according to ISO and VDZ convention are shown in Table 1. The SF value can only be used to compare the stability of linings within a particular shape system. Although the SFs of the VDZ system are low compared to the ISO system due to the lower value of A, it is compensated by the larger number of joints and the lower weight of individual bricks.

If the kiln is old and the shell has deformation and flatness at some points, the R at that point tends towards infinity. Accordingly, the SF tends towards zero, with bricks very liable to fall. If just one brick falls from the lining ring, the stability of the adjacent bricks in the ring is disturbed, causing a domino effect.




**Above - Figure 2:** Typical arrangement of brick lining in a rotary kiln.

A = The side in contact with the shell.
B = The side in contact with the kiln feed.
H = The length of the brick.
R = Radius of the kiln shell.

**Friction coefficient:** Each brick in a ring is in close and tight contact with the others. The four surfaces of a brick in a ring offer frictional resistance to sliding. The higher the friction coefficient ($f_r$), the more stable the brick lining will be. $f_r$ can be measured as shown in Figure 3. Two kiln refractory bricks, A and B, are placed on each other and the contact angle *a* is gradually changed to *b*, the point at which brick B starts to slide. $f_r$ = tan b. The higher its value, the higher the stability of the lining.

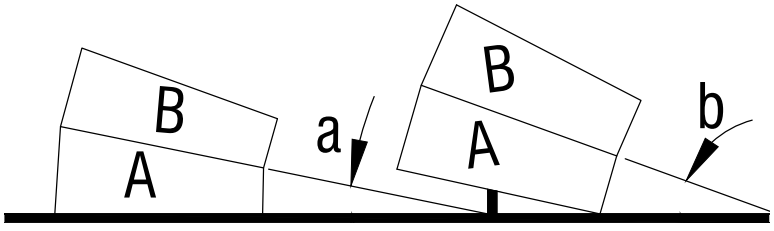
**Contact area per unit mass of the individual brick (CAPUM):** In a lining, the brick tends to come out of the ring because of the gravitational pull, when the bricks reach the upper half of the kiln's rotation. As discussed briefly with relation to the VDZ standards, the force placed on an individual brick will be greater as its mass increases. A heavier brick is therefore more likely to come out of the ring.

On the other hand, the contact surfaces of an individual brick, with other bricks in contact, offers resistance to sliding of the bricks. Therefore the contact area per unit mass (CAPUM) is an important factor that determines the ease of sliding

| Ø (m) | ISO shape, Size - 198 x H x A/B | SF x 100 |
|---|---|---|
| 4.0 | 198 x 200 x 103/90 | 1.03 |
| 4.5 | 198 x 200 x 103/90 | 0.91 |
| 5.0 | 198 x 220 x 103/92 | 0.90 |
| 6.0 | 198 x 250 x 103/90 | 0.85 |
| 7.0 | 198 x250 x 103/96 | 0.73 |

| Ø (m) | VDZ shape, Size - 198 x B x A/C | SF x 100 |
|---|---|---|
| 4.0 | 198 x 200 x 76.5/66.5 | 0.76 |
| 4.5 | 198 x 200 x 76.5/66.5 | 0.67 |
| 5.0 | 198 x 220 x 75/68 | 0.66 |
| 6.0 | 198 x 250 x73.5/69.5 | 0.61 |
| 7.0 | 198 x 250 x 76.5/66.5 | 0.54 |

**Left Below - Table 1:** Stability Factors for ISO (top) and VDZ (bottom) refractory linings at different kiln diameters.




**Below - Figure 3:** Sliding of bricks on changing contact angle can be used to calculate the friction coefficient.

| Shape | Brick quality | CAPUM ($cm^2/kg$) |
|---|---|---|
| ISO (198 x 220 x 103/92) mm | 60% Alumina | 1300.2/11.040 = 110 |
| VDZ (198 x 220 x 75/68) mm | 60% Alumina | 1185.8/8.097 = 140 |

**Above - Table 2:** Comparison of CAPUM for ISO and VDZ shape bricks in a 5m-diameter kiln.

when bricks are at the top of the kiln. The higher the CAPUM value, the higher the resistance against sliding and the higher the stability of the brick in the lining. Table 2 shows the comparison made of the CAPUM values between the ISO and VDZ shapes of the same quality brick for a same diameter kiln. These values suggest that VDZ lining bricks are more stable than ISO shape bricks because of their 27% higher CAPUM value.

**Thermal shrinkage:** There is a common misconception that the refractory, if it shrinks during use at high temperatures, forms a gap to adjacent bricks, allowing them to fall. However:

**1.** This phenomenon could only occur in the calcination zone where the operational temperature is a maximum of 1100°C. However, the alumino-silicate refractories used in the calcining zone are fired above 1100°C and the brick does not shrink at that temperature.

**2.** During the operation of the kiln, the whole brick does not remain at the operating temperature of the calcining zone, but a temperature gradient is established across the brick hot face, at a temperature of 1100°C and the cold face in contact with the kiln shell, at a temperature of about 200°C. Even if shrinkage occurs at the hot face, most of the brick will remain at a far lower temperature.

**3.** The shrinkage of the refractory in service happens either due to liquid phase formation as a result of reactions with the material it is in contact with or because of phase changes at high temperature. In both cases the reagents are solids, ensuring very slow reaction kinetics and a long time before there can be significant damage via this mechanism.

## A solution

SKG Refractories Ltd is a major producer of refractories and refractory solution provider for the cement and lime industry in India. It manufactures and supplies refractories of all kinds to major cement manufacturers in India, as well as to its neighbours and export markets in the Middle East and Africa.

SKG Refractories has put forward a solution to brick falls that can occur in the calcining zone of larger-diameter and older cement kilns. This involves modifying the brick design with tongue-and-groove arrangements (Figure 4). This structure holds the bricks together in the ring much more tightly and prevents them from sliding. Moreover this design is more forgiving to lining installation defects and also to the quality of bricks. Bricks with higher thermal conductivity and/or low thermal expansion coefficients can also can be used in this modified design, which means that highly alkali-resistant bricks with high silicon carbide content can be used safely.

## Case-study

Bricks with the tongue-and-groove design in 45AR alkali-resistant alumino-silicate quality were used to line a 4m long section of the calcining zone of a 5.5m-diameter kiln at an Indian cement plant. The bricks were made as per the ISO system and were machine laid. A combination of brick sizes were used, 622 of 220mm x 198mm x 103/95mm and 422 of 220mm x 198mm x 103/91mm. No difficulty was encountered when machine lining the modified bricks. After 17 days, the conventional bricks adjacent to the tongue-and-groove bricks fell down. However, the tongue-and-groove bricks were stable. The kiln has since run for four months using the tongue-and-groove bricks without any issues. It is expected that this modified design will totally eliminate the problem of unstable linings in the calcining zone and will open up the option to use bricks with different properties to improve the campaign life further in this area.

**Below and Below Right - Figure 4:** Lining of the tongue-and-groove bricks in the calcination zone.

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## US: Cemex to supply Houston Grand Parkway

Cemex USA has won a contract to supply 153,000m$^3$ of concrete and 90,700t of cement for the latest phase of construction of the Houston Grand Parkway. The cement and concrete will help build the road's I-1 and I-2 sections. The ring road around Houston is the longest of its kind in the US. Cemex USA will provide a portable central mix plant for the project.

Texas regional president Scott Ducoff said "Cemex USA is proud to be part of an iconic infrastructure project in our headquarters city of Houston, and one that will help ease traffic and improve local travel for commuters." He added "Completing the Grand Parkway is a significant endeavour and opportunity for us to continue to innovate how we efficiently and effectively deliver our best-in-class materials to meet the demands of inspiring projects such as this one."

## Egypt: Mountain View contract for Lafarge Egypt

Developer Mountain View has awarded a 300,000m$^3$ concrete supply contract to Lafarge Egypt, part of Switzerland-based LafargeHolcim. Mountain View will use the concrete to build its Mountain View iCity in East Cairo. The investment in the project totals US$12.7m. The producer has also signed a memorandum of understanding with the Egyptian National Research Centre to undertake initiatives aimed at enhancing construction.

## UK: Highways England to upgrade concrete roads

Highways England has pledged Euro460m to upgrade nearly 1000km of concrete motorways and other major roads in England. Many were built in the 1960s and 1970s, when traffic volumes were considerably lower. Some of the concrete pavements will be repaired and others replaced entirely, depending on the level of wear. The project, to take place in several stages, is scheduled to last until 2025.

## Belgium: SigmaRoc buys B-Mix and Casters Beton

SigmaRoc has bought the Belgian concrete producers B-Mix (comprising B-Mix Beton NV, J&G Overslag en Kraanbedrijf BV and TOP POMPING NV) and Casters Beton NV from Groep Janssens NV for a combined sum of Euro13m. B-Mix is located in Tessenderloo and Caster is located in Gent. Between them, they operate ready-mix concrete production assets with a capacity of 250,000m$^3$/yr. SigmaRoc says that the acquisitions have been funded using the proceeds of its December 2020 equity funding round.

## US: R-Tec launches New World Concrete

R-Tec Creations has launched New World Concrete, a 'single-stone Portland pozzolan concrete.' The company classifies it as a 'super-ultra-high-performance concrete,' due to its high compressive strength. It is intended for use in hurricane and earthquake-affected areas.

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## Hungary: A TEC to supply alternative fuel flash dryer to Királyegyháza plant

Lafarge Hungary, part of LafargeHolcim, has awarded a contract to Germany-based Loesche subsidiary A TEC for the supply of an alternative fuel (AF) flash dryer for the 1.0Mt/yr kiln line at its Királyegyháza cement plant in Baranya county. The supplier says that the dryer will use residual hot gas from the chlorine bypass system in conjunction with a satellite burner to fire the material in the kiln.

The project also includes the installation of a new AF receiving, handling and dosing system for a second AF flow, firing directly into the kiln burner. A TEC says that it will commission the project in the second quarter of 2021 after the end of the plant's winter shutdown.

## India: Major UltraTech order for Aumund

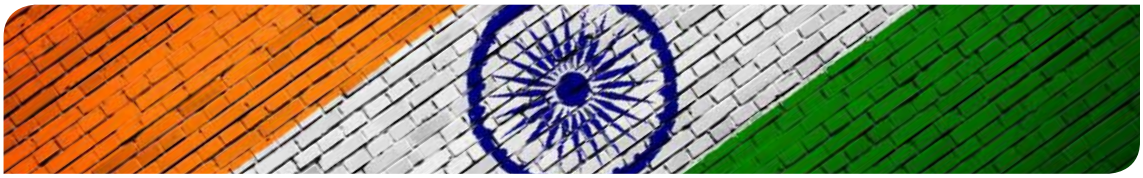
UltraTech Cement has selected Aumund to supply conveyors, elevators and feeders for its 'Project Spring' expansion project, which aims to increase its capacity from 117Mt/yr to130Mt/yr.

The expansion project includes three integrated cement production units in Madhya Pradesh, Rajasthan and Chhattisgarh, each with capacities of up to 10,000t/day. For these kiln lines, Aumund India will supply clinker cooler extraction conveyors as well as the transfer conveyors to the clinker silos. Six cement grinding plants in various locations in India are also part of the capacity expansion plans.

Aumund will supply six pan conveyors, 11 Samson material feeders and 68 bucket elevators including up to 157m-high kiln feed bucket elevators, up to 2200t/hr roller press recirculation bucket elevators and clinker and cement handling bucket elevators, among other products. The order is one of the largest to date for Aumund India.

## India: Gebr. Pfeiffer to supply Deccan coal mill

Germany-based Gebr. Pfeiffer has won a contract to supply a vertical roller mill for grinding coal to Deccan Cement's Bhavanipuram cement plant in Andhra Pradesh. Gebr. Pfeiffer India will be responsible for processing the order and supervising production and installation at the plant's 3500t/day kiln line. The mill will be the company's second from the supplier. It chose an MPS 250 BK mill, which can also grind petcoke or a mixture of coal and petcoke. Commissioning is scheduled for before mid-June 2022.



## Germany: ScrapeTec launches PrimeTracker

ScrapeTec has announced the launch of PrimeTracker, a belt tracker designed to tackle misalignment. The supplier says that the tracker differs from other products of its kind in using free rotation, thereby avoiding abrasion and damage from sliding over the belt surface. The tracker is able to swing and tilt while remaining in full contact with the belt.

## Germany: SMART Box for Flender and Schaeffler

Flender and Schaeffler have launched the Schaeffler Modular Adaptable Returnable Transport (SMART) Box, a packaging system for bearings. Flender says that the reusable box reduces waste by replacing disposable packaging.

## Uzbekistan: IKN cooler for Qizilqumsement

Germany-based IKN has secured a contract for process integration and equipment design for a new kiln line at Qizilqumsement's Qizilqumsement cement plant. The supplier's remit includes the pyroprocessing line, preheater, kiln and cooler including ID fan, kiln drive and burners. It plans to use a six-stage preheater, the region's first. Commissioning is scheduled for 2022.

## Russia: Smikom buys Eurocement

Holdings company Smikom has won the auction to buy Eurocement from Sberbank. RBC News has reported the value of the deal as Euro2.1bn. Smikom, formerly known as BaselCement, will acquire a 100% share of Cyprus-based GFI Investments, which controls Eurocement Group. The final terms of the deal are still being agreed, according to sources quoted by the Russia-based media group. Neither Sberbank nor Smikom have commented on the matter.

Sberbank acquired a 100% stake in GFI Investment in November 2020 following an increase in its debts in mid-2020. An electronic auction process for the company then started in February 2021.

Eurocement is the largest cement producer in Russia. It operates 10 plants domestically and abroad.

**Source:** Eurocement website.

## Greece: Titan improves EBITDA in 2020, while sales stay flat

Titan Cement's consolidated earnings before interest, taxation, depreciation and amortisation (EBITDA) rose by 7% year-on-year to Euro286m from Euro267m in 2019. Sales remained level year-on-year at Euro1.61bn and net profit after taxes and minorities (NPAT) fell by 97% to Euro1.50m from Euro50.9m. The group attributed the profit slump to one-off charges, namely the full write-off of the Euro46.6m goodwill of subsidiary Titan Cement Egypt and the derecognition of Euro17.3m of accumulated deferred Egyptian tax assets. If not for these, the group says its consolidated NPAT would have increased by 28% to Euro65.4m.

Cement sales were 17.1Mt, up by 1% from 17.0Mt. The group called the impacts of the coronavirus outbreak 'less severe than expected.' Ready-mixed concrete sales rose by 3% to 5.4Mm$^3$ from 5.2Mm$^3$.

Construction activity continued under coronavirus lockdown in most of the group's countries of operation. As a result, sales remained resilient across all markets. US sales fell by 2% to Euro938m from Euro952m due to negative currency exchange effects. Greece and Western Europe sales rose by 1% to Euro247m from Euro245m. Southeastern Europe sales rose by 3% to Euro938m from Euro952m and Eastern Mediterranean sales rose by 1% to Euro152m from Euro150m.

Group executive committee chair Dimitri Papalexopoulos said "In 2020, we delivered strong financial performance while taking care of our employees and those around us, ensuring high-quality, uninterrupted customer service and accelerating progress towards our digital and sustainability aspirations. In the face of uncertainty caused by Covid-19, we remained confident in our business model. We adapted to shifting market conditions and continued to pursue operational excellence while laying the groundwork to capture future growth." The group anticipates a positive market trend in all regions in 2021.

## Poland: Lafarge starts Małogoszcz renovations

Lafarge Poland has begun the demolition of part of its 2.0Mt/yr Małogoszcz cement plant in Świętokrzyskie voivodeship. The work proceeded with the company taking down one of the plant's 120m-high chimneys. Industrial director Stanislaw Sobczyk said that the new Małogoszcz cement plant would 'rise like a Phoenix from the ashes' of the old. The plant's two chimneys were a local landmark and appeared on the logo of the former Małogoszcz Cement Company.

## Germany: Opterra consults on Wössingen quarry expansion

Opterra has started a public consultation process regarding the expansion of the limestone quarry for its integrated Wössingen cement plant in Baden Württemberg. The move follows the quarry at Lugenberg reaching its approved eastern perimeter. The subsidiary of Ireland-based CRH plans to find a location for a new quarry to open from around 2030. The company also wants to conduct exploratory drilling in the region for additional limestone deposits.

## Switzerland: Protestors cleared from Holcim Mormont quarry

Police cleared 150 squatters from the site of a planned expansion to LafargeHolcim subsidiary Holcim Schweiz's Mormont quarry in Vaud in March 2021. Reuters News has reported that officers made 34 arrests. The squatters claimed to be protesting in the interests of biodiversity protection and reducing $CO_2$ emissions.

## France: Hoffmann Green Cement's revenue falls by a fifth

Hoffmann Green Cement's consolidated net revenue fell by 19% year-on-year to Euro504,000 in 2020 from Euro620,000 in 2019. Its net loss was Euro6.12m, up by 41% from Euro4.34m. Loss in earnings before interest, taxation, depreciation and amortisation (EBITDA) more than doubled to Euro4.13m from Euro1.85m. During the year, the group began construction of its second cement plant, in Vendée, France.

Co-chairs Julien Blanchard and David Hoffmann said "We are happy with what we achieved at Hoffmann Green in 2020, in spite of the pandemic. We signed numerous technical and commercial collaboration contracts with key players in the construction sector such as Groupe GCC, KP1, Cemex and Eiffage Génie Civil, taking our order book to over 190,000t to date." They reconfirmed the target of a 3% French cement market share by 2025/2026, adding "The commercial dynamic continues at the beginning of 2021 with the signing of contracts with Ouest Réalisations for the construction of housing, and EdyCem to develop low carbon footprint concretes."

Blanchard and Hoffmann called 2020 'the year of increasing production volumes,' adding that the group expects environmental legislation to bolster demand across the regions that the company serves.

## Greece: Titan speeds up sustainability targets

Titan Cement group has accelerated its efforts towards sustainability, with new environmental, social and governance (ESG) targets. The targets include an updated $CO_2$ emissions reduction target of 35% by 2030 compared to 1990 levels, zero workplace fatalities and a cement industry top-three lost time injury frequency rate, increased female leadership participation and 70% supplier sustainability in line with the producer's own ESG standards by 2025. It also set a water consumption target of 280L/t of cementitious material produced and 50% certified Zero Waste to landfill production by 2025.

## UK: Construction R&D spending rises by 8%

Business consultant Catax has reported an 8% year-on-year rise in the UK construction sector's research and development spending in 2020 to Euro432m from Euro401m in 2019.

## UK: New Dunbar plant manager

CRH subsidiary Tarmac has appointed Chris Bradbury as the plant manager at its integrated Dunbar cement plant in East Lothian, Scotland. He previously worked at Tarmac's Tunstead plant in Derbyshire. Bradbury began working in the cement industry as an apprentice in 1994 and has held many roles at plants both in the UK and in Nigeria and the Philippines.

**Source:** Tarmac.

# GLOBAL CEMENT NEWS: *EUROPE*

## Ireland: New finance director for CRH

CRH has appointed Jim Mintern as group finance director with effect from 1 June 2021. He will also join the company's board of directors at the same time. He succeeds Senan Murphy, who will retire.

Mintern, aged 54 years, is a chartered accountant and holds a Bachelor of Commerce degree from University College Dublin. He has over 30 years of experience in the building materials industry, nearly 20 years of which have been with CRH.

## Switzerland: LafargeHolcim expands sustainability role

LafargeHolcim has expanded Chief Sustainability Officer Magali Anderson's role to Chief Sustainability and Innovation Officer. The new role additionally includes leadership of the group's research and development strategy and organisation. Anderson will also oversee external innovation collaborations with the academic world. The group says that the combination of sustainability and innovation aims to increase impact across both areas.

## UK: MPA welcomes Cement Admixtures Association

The Mineral Products Association (MPA) has announced the accession of a new affiliate member, the Cement Admixtures Association (CAA). The CAA represents admixture producers that supply construction and civil engineering in the UK. It was a founding signatory of Construction Industry Sustainable Construction Strategy in 2008.

## Peru: New plant announced

Cementos Interoceanicos has contracted Switzerland-based Satarem to establish a 1.0Mt/yr cement plant in Puno. The Gestión newspaper has reported that Satarem intends to buy a 30% stake in the producer. The scheduled completion date for the work, which also includes setting up two new lime plants, is mid-late 2022. The total estimated cost of the project is US$158m.

## Dominican Republic: Domicem starts work on new line

Domicem, a subsidiary of Italy's Colacem, has begun work on a second line at its Sabana Grande de Palenque cement plant in San Cristóbal province. Ansa News has reported the cost of the project as US$120m. When commissioned in late 2022, the line will produce cement for export.

The news comes shortly after Cemex Dominicana announced that it would restart production from a mothballed 0.5Mt/yr kiln line at its San Pedro de Macorís plant by the close of 2021.

## Peru: US$200m Yura plant expansion

Yura plans to upgrade its Arequipa cement plant at a cost of US$200m. The planned upgrade will increase the plant's clinker production capacity to 8000t/day from 5000t/day. The La República newspaper has reported that the sustainability-enhancing expansion involves the installation of a new vertical roller mill, packing, storage and dispatch equipment and a 4.3km raw materials conveyor. General manager Ramón Pizá called the modernisation a 'vote of faith' in Peru.

## US: Californian cement sector to be $CO_2$ neutral by 2045

The California Nevada Cement Association (CNCA) has published a plan for the Californian cement industry to meet its target of carbon neutrality by 2045. The plan consists of three pathways, namely: a reduction in process emissions including by alterations to clinker factor and type of additives; an increase in alternative fuel substitution rates; and a switch to renewable energy. The association said that the aims are achievable by close stakeholder coordination, constructive public policy engagement and a situational approach based on a flexible portfolio of pathways.


## US: LafargeHolcim completes Firestone purchase

Holcim Participations, part of Switzerland-based LafargeHolcim, has completed its acquisition of Firestone Building Products from Bridgestone. The group said that the acquisition marks a milestone in its transformation into a global innovative and sustainable building materials and solutions leader. The group said that the early conclusion of the deal came about due to 'smooth collaboration' with Bridgestone.

LafargeHolcim CEO Jan Jenisch welcomed Firestone Building Products' 1900 employees to the group, saying "Together, we will lead this iconic company's next era of growth to become the global leader in flat roofing systems. As we expand its leadership in the US to Europe and Latin America, I want the world to know that 'Nobody Covers You Better than Firestone'."

## Colombia: Green loan for Argos

BBVA has granted a US$45.1m loan to Grupo Argos subsidiary Cementos Argos. The loan includes a pricing adjustment mechanism which links its interest rate to the producer's environmental, social and corporate governance performance rating. The company said that the choice of financing arrangement aims to promote a greater commitment to sustainability management and compliance with socially- and environmentally-responsible practices that ensure the construction of a greener future. The transaction is the first of its kind in Colombia and constitutes Grupo Argos' debut in sustainable financing.

## Guatemala: Upgrades for Cemex plant

Cemex Latam Holdings plans to install a new 1000t/day horizontal ball mill and support infrastructure, including a dust collector and 3000t silo, at its Puerto de San José grinding plant in Escuintia, Guatemala. Central America Data has reported the value of the work as US$16m.

## Brazil: Corumbá plant upgrade

Votorantim Cimentos has announced plans to upgrade cement production at its 0.2Mt/yr integrated Corumbá cement plant in Mato Grosso do Sul. The Correio de Corumbá newspaper has reported the value of the planned work as US$2.85m. The investment will improve the plant's grinding line, modernise an electrical substation system, improve its mining operations and optimise energy consumption via a number of approaches.

## Colombia: Argos sales fall

Cementos Argos' full-year consolidated net sales in 2020 were US$2.52bn, down by 4% year-on-year from US$2.62bn in 2019. The group's cement volumes declined by 9% to 14.7Mt from 16.1Mt. The company's net profit for the year was US$21.8m, down by 36% from US$34.1m. Volumes, sales and earnings before interest, taxation, depreciation and amortisation (EBITDA) declined in all three of the group's regions.

## Mexico: GCC rename approved

Shareholders of the former Grupo Cementos de Chihuahua have approved a name change at an exceptional general meeting. The company will now trade as GCC. The company's chief financial officer, Luis Arias, said "We changed the name to GCC to better reflect our 2025 vision: to be the best cement company in North America with the proper balance of people, profit and the planet. It unifies our brand in multiple countries, mirrors the stock ticker and reflects how the market best knows us."

Jacob Winskell, Global Cement Magazine

# Cement in North America

*Global Cement* revisits the United States, Mexico and Canada, three countries with very different cement industries. All three of which, however, are long-established, growing and exploring new horizons in sustainable cement production.

The United States, Mexico and Canada occupy the northern 20.1 million km$^2$ - roughly half - of the Americas.[1] The countries gained their independence in the seventeenth, eighteenth and nineteenth centuries respectively. The US and Mexico are presidential republics and Canada is a parliamentary democracy and constitutional monarchy. The continent's 494m people mostly speak English (266m) and Spanish (156m), corresponding to 54% and 32% respectively, with French-speaking minorities numbering 11.2m (2%) in Canada and the US.[2] The US has the region's highest gross domestic product (GDP) per capita at US$65,300, followed by Canada with US$46,200 and Mexico with US$9,950 per capita.

The 494m North Americans' cement demand is mostly met by the total 195.8Mt/yr-capacity cement industries of the US, Mexico and Canada. Figure 1 (below) shows the division of ownership by type of producer for each country's cement industry, by production capacity.

**Country Data**

**US**

| | |
|---|---|
| GDP: | US$19.4tn |
| Area: | 9.83m km$^2$ |
| Cement capacity: | 117Mt/yr |
| Population: | 328m |
| Per-capita cement capacity: | 385kg/yr |

**Mexico**

| | |
|---|---|
| GDP: | US$1.15tn |
| Area: | 1.97m km$^2$ |
| Cement capacity: | 60.2Mt/yr |
| Population: | 128m |
| Per-capita cement capacity: | 466kg/yr |

**Canada**

| | |
|---|---|
| GDP: | US$1.65tn |
| Area: | 9.99m km$^2$ |
| Cement capacity: | 18.6Mt/yr |
| Population: | 37.6m |
| Per-capita cement capacity: | 485kg/yr |

**Below - Figure 1:** North American cement capacity by country, showing shares of production by type of ownership.

**Source:** *Global Cement Directory 2021.*




A total of 158.5Mt/yr, 81% of North American domestic cement production capacity, is in the hands of multi-plant companies such as **LafargeHolcim**, the region's leading producer. The Switzerland-based group's 26 North American integrated cement plants and two grinding plants command 41.2Mt/yr of capacity - 20% of the regional total. LafargeHolcim is the only producer present in all three countries.

This type of producer is further split between foreign multinationals like LafargeHolcim and domestically-based groups, for example **Cemex** in Mexico. Cemex's 26 North American integrated cement plants have a capacity of 30.2Mt/yr, making it the second-largest producer regionally. Germany-based **HeidelbergCement** is third-largest, with 19.9Mt/yr across 19 plants. Foreign ownership accounts for 87% and 77% of cement production capacity in the US and Canada respectively, while the figure for Mexico is 28%.

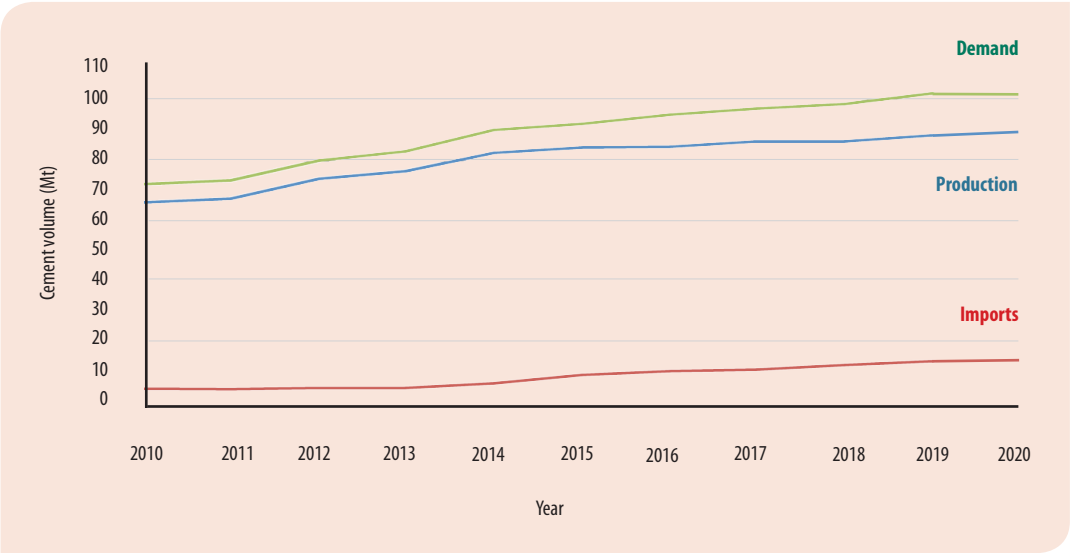
## The US

The 50 US states' 328m-strong population is served by a 117Mt/yr-capacity cement sector - the world's third-largest. Its network of 94 integrated cement plants extends over 34 federal states. Texas leads production with 16.2Mt/yr of capacity, 13% of the national total, followed by California with 13.6Mt/yr (11%) and Missouri with 10.2Mt/yr (8%). **Martin Marietta** reported that Texas delivered 'robust underlying demand' during the fourth quarter of 2020. US Portland and masonry cement production totalled 89.0Mt in 2020, up by over 1% year-on-year from 88.0Mt in 2019 and corresponding to a capacity utilisation rate of 76%. Producers exported 1.0Mt of cement and clinker during the year, in line with the 2019 figure. Apparent cement and clinker consumption also remained level in 2020 at 102Mt. Cement and clinker imports increased by 3% to 16.4Mt from 15.9Mt.[3] Figure 2 (below) plots the ten-year trends in cement demand, production and imports nationally.

### Cement production

There are 25 active players in US integrated cement production in May 2020, eight of them US-based. Of these, Texas-based **Eagle Materials** is the largest, with 4.2Mt/yr of capacity across the five cement plants which it owns outright, in addition to 50% stakes in the 1.7Mt/yr Kosmos Cement plant in Kentucky - acquired from Cemex in August 2020 - and the 1.4Mt/yr Texas-Lehigh Cement plant in Texas. In mid-2020 the company split its heavy materials and light materials businesses. North Carolina-based **Martin Marietta** owns the TXI Cement plant chain, with one 2.4Mt/yr plant in Texas and 0.2Mt/yr and 0.1Mt/yr plants in California. The 1.3Mt/yr and 1.0Mt/yr Continental Cement plants in Missouri and Iowa belong to **Summit Materials**. The remaining five native US producers operate single cement plants, the largest of which is **Salt River Materials**' 1.1Mt/yr Clarkdale cement plant in Arizona. Salt River Materials is currently installing a fly ash beneficiation plant at a power plant in nearby Utah to produce useable ash for the Clarkdale plant. Single-plant producers command 4.1Mt/yr of a total of 14.9Mt/yr US-owned cement capacity; foreign companies own 102Mt/yr, giving an 87:13 split in the latters' favour. All five of the top US cement producers are based overseas.

Switzerland-based **LafargeHolcim** operates 14 cement plants nationally, with a total integrated capacity of 22.1Mt/yr. Two grinding plants bring its installed capacity in the US to 23.4Mt/yr. The company owns the country's largest cement plant, the St Genevieve, Missouri, plant, and controls the largest share in the Southern and Midwestern cement markets. In October 2020, LafargeHolcim subsidiary Holcim US opened a 10MW solar power plant at its Hagerstown, Maryland, cement plant in partnership with Greenbacker Renewable Energy Company. The producer said that the installation will supply 25% of the plant's energy needs, cutting 12,400t/yr of $CO_2$ emissions. Operations CEO Jamie Gentoso said "We hope to install enough renewable energy to power all of our plants and give back to the surrounding communities by 2026; this new solar array is just the




**Left - Figure 2:** US cement demand, production and imports, 2010 - 2020. **Source:** USGS.

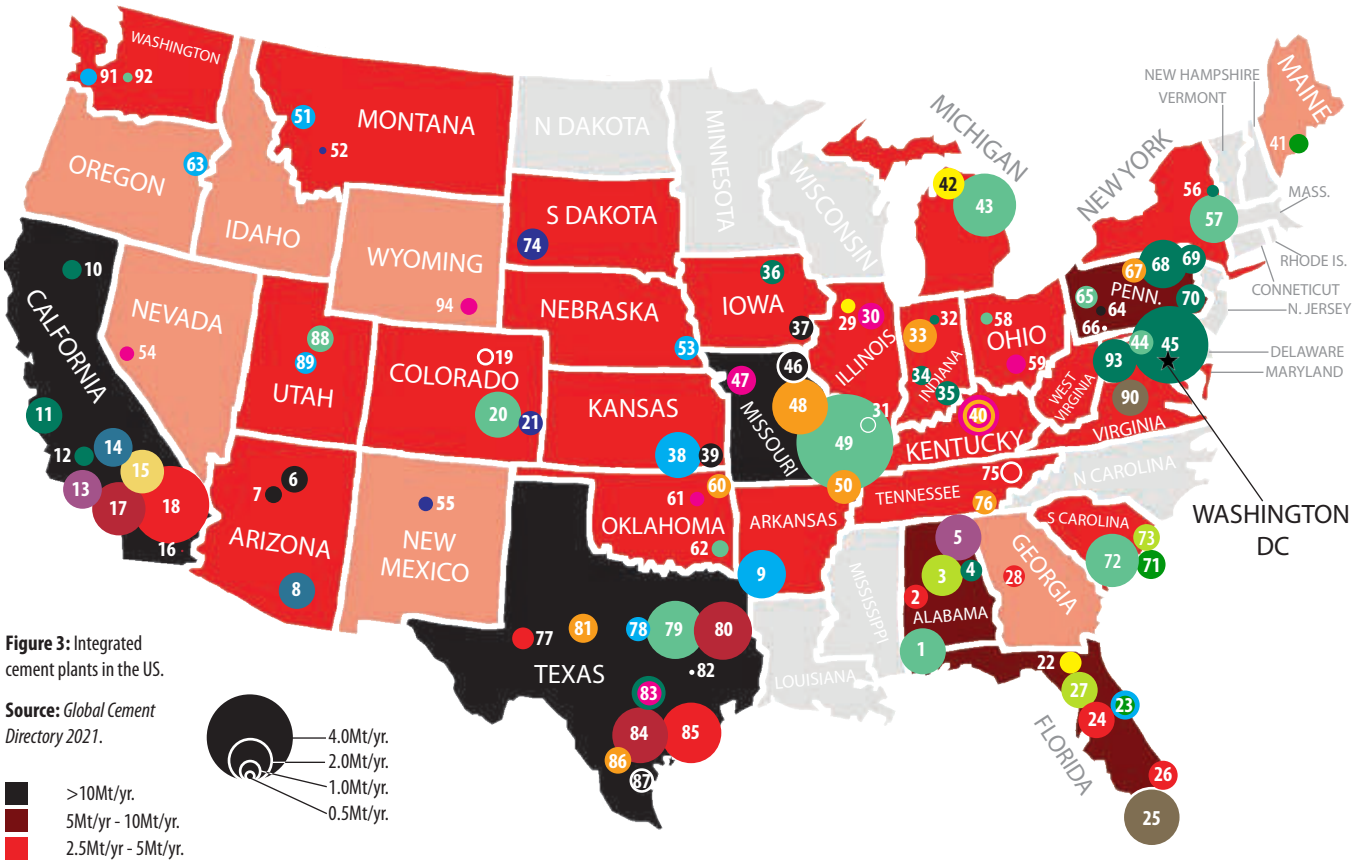



**Figure 3:** Integrated cement plants in the US.

**Source:** *Global Cement Directory 2021.*

**ALABAMA - 7.4Mt/yr**
1. LafargeHolcim, 1.9Mt/yr.
2. Cemex, 1.0Mt/yr.
3. Cementos Argos, 1.7Mt/yr.
4. Lehigh (HC), 0.9Mt/yr.*
5. National (Vicat), 1.9Mt/yr.

**ARIZONA - 3.3Mt/yr**
6. Salt River Materials, 1.1Mt/yr.
7. Drake, 0.7Mt/yr.
8. CalPortland (Taiheiyo), 1.5Mt/yr.

**ARKANSAS - 2.0Mt/yr**
9. Ash Grove (CRH), 2.0Mt/yr.

**CALIFORNIA - 13.6Mt/yr**
10. Lehigh (HC), 0.8Mt/yr.
11. Lehigh (HC), 1.5Mt/yr.
12. Lehigh (HC), 0.8Mt/yr.
13. National (Vicat), 1.6Mt/yr.
14. CalPortland (Taiheiyo), 1.6Mt/yr.
15. Mitsubishi, 1.8Mt/yr.
16. TXI (Martin Marietta), 0.1Mt/yr.
17. TXI (Martin Marietta), 2.2Mt/yr.
18. Cemex, 3.2Mt/yr.

**COLORADO - 3.5Mt/yr**
19. Cemex, 0.6Mt/yr.
20. LafargeHolcim, 1.9Mt/yr.
21. GCC Rio Grande (GCC), 1.0Mt/yr.

**FLORIDA - 8.7Mt/yr**
22. Suwannee (Votorantim), 0.9Mt/yr.
23. American (50% Elementia, 50% CRH), 1.2Mt/yr.
24. Cemex, 1.5Mt/yr.
25. Titan Florida (Titan), 2.4Mt/yr.
26. Cemex, 1.2Mt/yr.
27. Cementos Argos, 1.5Mt/yr.

**GEORGIA - 0.9Mt/yr**
28. Cemex, 0.9Mt/yr.

**ILLINOIS - 2.3Mt/yr**
29. St Marys (Votorantim), 0.6Mt/yr.
30. Illinois (EM), 1.1Mt/yr.*
31. LafargeHolcim, 0.6Mt/yr.

**INDIANA - 3.6Mt/yr**
32. Essroc (HC), 0.4Mt/yr.
33. Buzzi Unicem, 1.4Mt/yr.
34. Lehigh (HC), 0.8Mt/yr. (Upgrade)
35. Essroc (HC), 1.0Mt/yr.

**IOWA - 2.0Mt/yr**
36. Lehigh (HC), 1.0Mt/yr.
37. Continental (SM), 1.0Mt/yr.

**KANSAS - 2.9Mt/yr**
38. Ash Grove (CRH), 1.9Mt/yr
39. Monarch, 1.0Mt/yr.

**KENTUCKY - 1.7Mt/yr**
40. Kosmos (BU/EM), 1.7Mt/yr.*

**MAINE - 0.8Mt/yr**
41. CDN Dragon Products (55% Elementia), 0.8Mt/yr.

**MICHIGAN - 3.9Mt/yr**
42. St Marys Cement (Votorantim), 1.3Mt/yr.
43. LafargeHolcim, 2.6Mt/yr.

**MARYLAND - 4.2Mt/yr**
44. LafargeHolcim, 1.0Mt/yr.
45. Lehigh (HC), 3.2Mt/yr.

**MISSOURI - 10.2Mt/yr**
46. Continental (SM), 1.3Mt/yr.*
47. Central Plains (EM), 1.2Mt/yr.
48. Buzzi Unicem, 2.3Mt/yr.
49. LafargeHolcim, 4.0Mt/yr.
50. Buzzi Unicem, 1.4Mt/yr.

**MONTANA - 1.3Mt/yr**
51. Ash Grove (CRH), 1.0Mt/yr.
52. GCC, 0.3Mt/yr.

**NEBRASKA - 1.0Mt/yr**
53. Ash Grove (CRH), Louisville, 1.0Mt/yr.

**NEVADA - 0.6Mt/yr**
54. Nevada (EM), 0.6Mt/yr.

**NEW MEXICO - 0.6Mt/yr**
55. GCC Rio Grande (GCC), 0.6Mt/yr.

**NEW YORK - 2.5Mt/yr**
56. Lehigh (HC), 0.5Mt/yr.
57. LafargeHolcim, 2.0Mt/yr.

**OHIO - 1.3Mt/yr**
58. LafargeHolcim, 0.5Mt/yr.
59. Eagle Materials, 0.8Mt/yr.

**OKLAHOMA - 2.3Mt/yr**
60. Buzzi Unicem, 1.0Mt/yr.
61. Central Plains (EM), 0.6Mt/yr.
62. LafargeHolcim, 0.7Mt/yr.

**OREGON - 1.0Mt/yr**
63. Ash Grove (CRH), 1.0Mt/yr.

**PENNSYLVANIA - 6.7Mt/yr**
64. Armstrong, 0.4Mt/yr.
65. LafargeHolcim, 0.8Mt/yr.
66. Lehigh (Cementir), 0.1Mt/yr W.*
67. Buzzi Unicem, 1.0Mt/yr.
68. Essroc (HC), 2.0Mt/yr.
69. Keystone (HC),1.2Mt/yr.
70. Lehigh (HC), 1.2Mt/yr.

**SOUTH CAROLINA 4.5Mt/yr**
71. Giant (Elementia), 1.2Mt/yr.
72. LafargeHolcim, 2.2Mt/yr.
73. Cementos Argos, 1.1Mt/yr.

**SOUTH DAKOTA - 1.3Mt/yr**
74. GCC Dakotah (GCC), 1.3Mt/yr.

**TENNESSEE - 1.8Mt/yr**
75. Cemex, 0.8Mt/yr.
76. Buzzi Unicem, 1.0Mt/yr.

**TEXAS - 16.2Mt/yr**
77. Cemex, 0.9Mt/yr.
78. Ash Grove (CRH), 1.0Mt/yr.
79. LafargeHolcim, 2.4Mt/yr.
80. TXI (Martin Marietta), 2.4Mt/yr.
81. Buzzi Unicem, 1.2Mt/yr.
82. Lehigh (Cementir), 0.1Mt/yr W.
83. Texas-Lehigh (EM/HC), 1.4Mt/yr.
84. TXI (Martin Marietta), 2.3Mt/yr.
85. Cemex, 2.5Mt/yr.
86. Alamo (BU), 1.1Mt/yr.
87. Capitol, 0.9Mt/yr.

**UTAH - 2.0Mt/yr**
88. LafargeHolcim, 1.1Mt/yr.
89. Ash Grove (CRH), 0.9Mt/yr.

**VIRGINIA - 1.5Mt/yr**
90. Roanoke (Titan), 1.5Mt/yr.

**WASHINGTON - 1.1Mt/yr**
91. Ash Grove (CRH), 0.7Mt/yr.
92. LafargeHolcim, 0.4Mt/yr.

**WEST VIRGINIA - 1.8Mt/yr**
93. Essroc (HC), 1.8Mt/yr.

**WYOMING - 0.7Mt/yr**
94. Mountain (EM), 0.7Mt/yr.

*BU - Buzzi Unicem; EM - Eagle Materials; HC - HeidelbergCement; SM - Summit Materials; W - white cement.

beginning." LafargeHolcim became a founding member of the MIT Climate and Sustainability Consortium in January 2021 and in February 2021 announced an upcoming carbon capture and storage (CCS) study with Schlumberger New Energy at an unspecified North American cement plant.

Essroc, Keystone Cement and Lehigh Cement, part of **HeidelbergCement**, hold a total of 17.4Mt/yr of integrated and a further 1.0Mt/yr of grinding capacity across 16 sites extending from Pennsylvania to California. The group invited bids for its 3.1Mt/yr-integrated capacity Californian assets in December 2020, targeting US$1.5bn. In February 2021, it identified five unnamed assets to sell, beginning in early/mid-2021.

Mexico-based **Cemex**'s 12.6Mt/yr-capacity subsidiary Cemex USA's eight integrated cement plants are mostly situated in states bordering the group's home country and the Gulf of Mexico. The company is conducting a CCS study with Oak Ridge National Laboratory and UK-based Carbon Clean at its 3.2Mt/yr Victorville, California, cement plant. Italy-based **Buzzi Unicem**'s 10 cement plants command 11.3Mt/yr of integrated capacity, while Ireland-based **CRH**'s 11 plants total 10.1Mt/yr.

In other US news, **Vicat** subsidiary National Cement Company of Alabama completed the installation of a new 5000t/day clinker line at its 1.9Mt/yr Ragland plant ahead of schedule in February 2021. **GCC**'s Black Hills cement plant in South Dakota has been 50% wind-powered since early 2021. **Votorantim Cimentos** is reportedly seeking to expand its US assets, having merged its subsidiaries St Marys Cement and McInnis Cement in the US and Canada.

The Covid-19 outbreak changed the patterns of US cement consumption from March 2020, but did not produce the 2% decline for which the Portland Cement Association (PCA) had prepared the industry. Rather, consumption remained level year-on-year in 2020. Summit Materials' organic cement volumes fell by 5% year-on-year, reducing its cement sales by 7% to US$271m despite a 2% price rise. Eagle Materials' nine-month cement sales rose by 34% year-on-year to US$211m in 2020 from US$157m in 2019. The company recorded net earnings of US$273m compared to a loss of US$1.54m in 2019. Meanwhile, Martin Marietta recorded full-year net sales of US$4.73bn, the same as in 2019, noting a 12% year-on-year increase in cement shipments to 1.1Mt in the fourth quarter of 2020. The general picture painted by the disparate results is one of recovery. Buzzi Unicem named the US as its only area of sales growth in 2020.

The PCA forecasts 1% growth in 2021, driven by residential construction. In March 2021, it welcomed the American Rescue Plan Act's US$350bn extra funding for state and local governments. Beyond the current crisis, the US cement sector will depend on President Biden and Congress seeing infrastructure spending as a continued investment worth making. Since January 2021, the industry is back in the global fight against climate change following the US's re-entry to the Paris Climate Accord. The sector will benefit from continued federal spending as the country shifts to higher environmental regulations.

**Below - Figure 4:** Integrated cement plants in Mexico. States are colour-coded by production capacity.

**Source:** *Global Cement Directory 2021.*

## Mexico

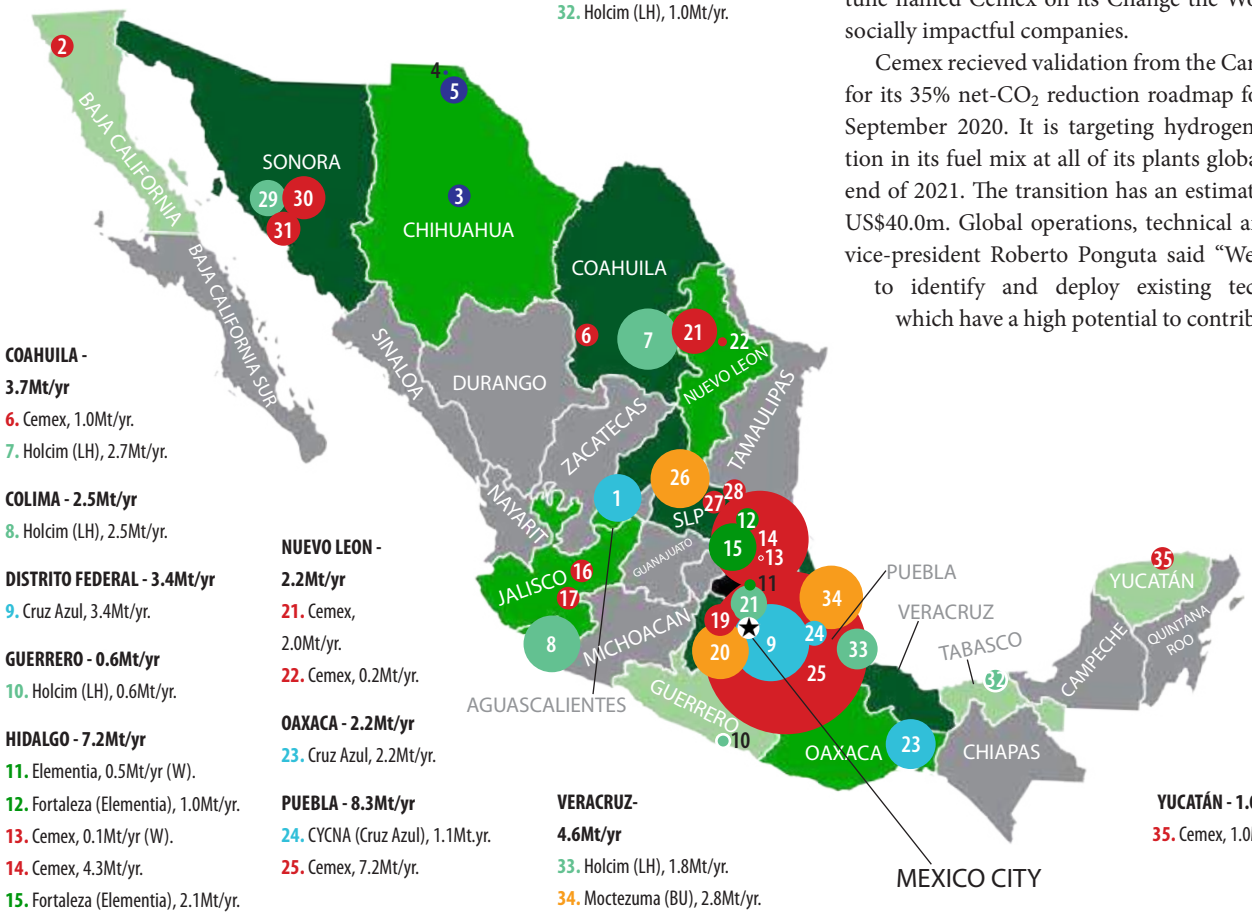
Mexico's population in 2019 was 128m, up by 2% year-on-year from 126m in 2018. The domestic cement industry centres around a 60.2Mt/yr-capacity network of 35 integrated cement plants spanning the entire length of the country (Figure 4). Production in 2019 was 40.0Mt, down by 13% year-on-year from 46.0Mt in 2018 and corresponding to a capacity utilisation of 66%. Figure 5 shows annual production levels between 2013 and 2019. Domestic consumption fell by 10% year-on-year in 2019 due to a crisis compounded by money shortages.[4] Homebuilding contracted following a subsidy cut. At the same time, the government cancelled construction of the Texcoco Airport and reduced roadbuilding, and various commercial projects also folded. It was under these circumstances that the Covid-19 pandemic broke in Mexico in March 2020. We will look at recent events in the cement industry through each of the country's seven producers in turn.

The world's fifth-largest cement producer, Cemex, controls 17.6Mt/yr (43%) of Mexican cement capacity across its nine integrated cement plants in the country. The company was able to resume production at its 7.2Mt/yr integrated Tepeaca, Puebla, plant on 5 October 2020 following its suspension for alleged failed payments to the city of Cuautinchán. In February 2021, the company announced plans to recommission its mothballed 1.0Mt/yr-capacity CPN cement plant in Hermosilla, Sonora state, at an investment cost of US$15.0m. Due for completion in the second quarter of 2021, the recommissioning will generate 130 jobs, according to Cemex. When operational, the CPN plant will produce cement for export to the US states of California, Arizona and Nevada. In December 2020, the company launched its Vertua low and net-zero $CO_2$ concrete range in Mexico. Cemex also looked south in 2020, expanding its stake in Colombia-based Cemex Latam Holdings to 93% from 73%. The company redoubled its corporate social responsibility efforts during the Covid-19 pandemic, building mobile hospitals at a rate of two weeks per facility in Mexico. In September 2020, Fortune named Cemex on its Change the World list of socially impactful companies.

Cemex recieved validation from the Carbon Trust for its 35% net-$CO_2$ reduction roadmap for 2030 in September 2020. It is targeting hydrogen substitution in its fuel mix at all of its plants globally by the end of 2021. The transition has an estimated cost of US$40.0m. Global operations, technical and energy vice-president Roberto Ponguta said "We continue to identify and deploy existing technologies which have a high potential to contribute to our

>6Mt/yr.
3Mt/yr - 6Mt/yr.
1.5Mt/yr - 3Mt/yr.
<1.5Mt/yr.
0Mt/yr.

4.0Mt/yr.
2.0Mt/yr.
1.0Mt/yr.
0.5Mt/yr.




**AGUASCALIENTES - 2.1Mt/yr**
1. CYCNA (Cruz Azul), 2.1Mt/yr.

**BAJA CALIFORNIA - 1.0Mt/yr**
2. Cemex, 1.0Mt/yr.

**CHIHUAHUA - 2.4Mt/yr**
3. GCC, 1.0Mt/yr.
4. GCC, 0.2Mt/yr.
5. GCC, 1.2Mt/yr.

**COAHUILA - 3.7Mt/yr**
6. Cemex, 1.0Mt/yr.
7. Holcim (LH), 2.7Mt/yr.

**COLIMA - 2.5Mt/yr**
8. Holcim (LH), 2.5Mt/yr.

**DISTRITO FEDERAL - 3.4Mt/yr**
9. Cruz Azul, 3.4Mt/yr.

**GUERRERO - 0.6Mt/yr**
10. Holcim (LH), 0.6Mt/yr.

**HIDALGO - 7.2Mt/yr**
11. Elementia, 0.5Mt/yr (W).
12. Fortaleza (Elementia), 1.0Mt/yr.
13. Cemex, 0.1Mt/yr (W).
14. Cemex, 4.3Mt/yr.
15. Fortaleza (Elementia), 2.1Mt/yr.

**JALISCO - 2.0Mt/yr**
16. Cemex, 1.0Mt/yr.
17. Cemex, 1.0Mt/yr.

**MEXICO - 3.0Mt/yr**
18. Holcim (LH), 1.6Mt/yr.
19. Cemex, 1.4Mt/yr.

**MORELOS - 2.5Mt/yr**
20. Moctezuma (BU), 2.5Mt/yr.

**NUEVO LEON - 2.2Mt/yr**
21. Cemex, 2.0Mt/yr.
22. Cemex, 0.2Mt/yr.

**OAXACA - 2.2Mt/yr**
23. Cruz Azul, 2.2Mt/yr.

**PUEBLA - 8.3Mt/yr**
24. CYCNA (Cruz Azul), 1.1Mt.yr.
25. Cemex, 7.2Mt/yr.

**SAN LUIS POTOSI - 4.6Mt/yr**
26. Moctezuma (BU), 2.6Mt/yr.
27. Cemex, 1.0Mt/yr.
28. Cemex, 1.0Mt/yr.

**SONORA - 5.0Mt/yr**
29. Holcim (LH), 1.6Mt/yr.
30. Cemex, 1.9Mt/yr.
31. Cemex, 1.5Mt/yr.

**TABASCO - 1.0Mt/yr**
32. Holcim (LH), 1.0Mt/yr.

**VERACRUZ - 4.6Mt/yr**
33. Holcim (LH), 1.8Mt/yr.
34. Moctezuma (BU), 2.8Mt/yr.

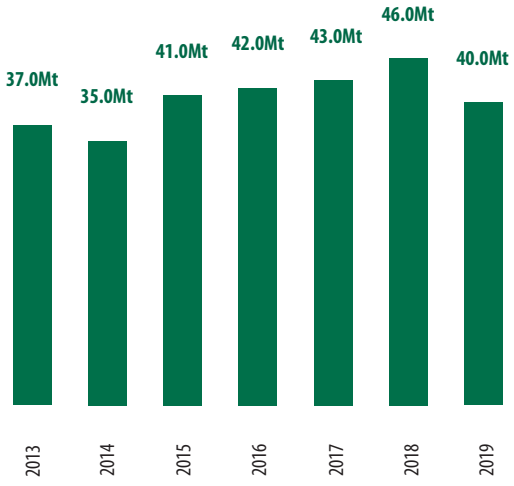
**YUCATÁN - 1.0Mt/yr**
35. Cemex, 1.0Mt/yr.

sustainability goals." He added "Hydrogen is a key lever." The company announced a partnership with Switzerland-based Synhelion to develop the use of solar power as an alternative to fuel in cement kilns in October 2020.

The group's Mexican cement volumes grew by 6% year-on-year in 2020 amid a 2% global consolidated volume rise to 63.8Mt from 62.7Mt in 2020. Its net sales fell by 1% to US$13.0bn from US$13.1bn and its earnings before interest, taxation, depreciation and amortisation (EBITDA) rose to US$2.46bn, up by 3% from US$2.38bn, with 'significant' improvements in both indicators in the fourth quarter of 2020. The group's medium-term strategy, Operation Resilience, consists of US$280m in cost reduction and optimisation of the company's portfolio by strategic divestments, towards European and US markets.

Three other Mexico-based producers participate in domestic integrated cement production. **GCC** changed its name from Grupo Cementos de Chihuahua on 30 March 2021. It is the only producer active in the northern state of Chihuahua, where all three of its total 2.4Mt/yr-capacity Mexican integrated cement plants are located. Along with Cemex, **LafargeHolcim** and **Cemento Cruz Azul**, its operations were impacted by a natural gas shortage in Chihuahua, Coahuila, Nuevo León and Sonora.

GCC's EBITDA rose by 6% year-on-year to US$308m in 2020 from US$292m in 2019. Net sales increased by under 1% to US$939m from US$934m and Mexican sales rose by 3%. During the year, the group achieved a 9% reduction of its $CO_2$ emissions from 2005 levels.




**Left - Figure 5:** Mexican cement production, 2013 - 2019.

**Source:** Instituto Mexicano del Cemento y Concreto.

**Bottom - Figure 6:** Integrated cement plants in Canada. Provinces are colour-coded by capacity.

**Source:** *Global Cement Directory 2020.*

>5Mt/yr.
2.5Mt/yr - 5Mt/yr.
1.25Mt/yr - 2.5Mt/yr.
<1.25Mt/yr.
0Mt/yr.

4.0Mt/yr.
2.0Mt/yr.
1.0Mt/yr.
0.5Mt/yr.

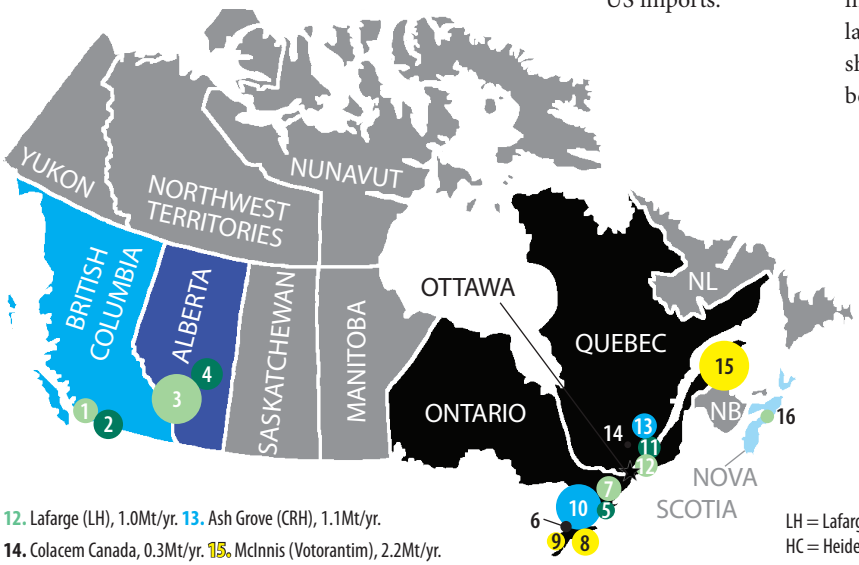
**BRITISH COLUMBIA - 2.4Mt/yr**
1. Lafarge (LH), 1.1Mt/yr.
2. Lehigh Hanson (HC), 1.3Mt/yr.

**ALBERTA - 3.6Mt/yr**
3. Lafarge (LH), 2.2Mt/yr.
4. Lehigh Inland (HC), 1.4Mt/yr.

**NOVA SCOTIA - 0.6Mt/yr**
16. Lafarge (LH), 0.6Mt/yr.

**ONTARIO - 6.4Mt/yr**
5. Essroc (HC), 0.8Mt/yr.
6. Federal White, 0.5Mt/yr.
7. Lafarge (LH), 1.1Mt/yr.
8. St Marys (Votorantim), 1.2Mt/yr.
9. St Marys (Votorantim), 0.8Mt/yr.
10. Ash Grove (CRH), 2.0Mt/yr.

**QUEBEC - 5.6Mt/yr**
11. Ciment Québec (HC), 1.0Mt/yr.




12. Lafarge (LH), 1.0Mt/yr. 13. Ash Grove (CRH), 1.1Mt/yr.
14. Colacem Canada, 0.3Mt/yr. 15. McInnis (Votorantim), 2.2Mt/yr.

LH = LafargeHolcim.
HC = HeidelbergCement.

The third Mexican producer is **Cemento Cruz Azul**, operator of 8.8Mt/yr of integrated capacity across four cement plants in Mexico. The company was the victim of plant seizures by insurgents at three of its plants in Puebla, Oaxaca and Aguascalientes. The insurgents were 'cooperativists' with alleged links to organised crime. Production continued, as did the on-going upgrade of the 2.2Mt/yr-capacity Oaxaca cement plant. The occupiers, however, did not abide by the owners' rigourous safety standards. On 10 July 2020, two workers fell to their deaths from a crane in Oaxaca. The disaster led to Cemento Cruz Azul's reassertion of control, first over its subsidiary Cementos y Concretos Nacionales (CYCNA)'s Puebla and Aguascalientes cement plants in September 2020, then of the Oaxaca plant in October 2020, with the help of police. The fight for Oaxaca ended in 18 injuries and five arrests. It subsequently emerged that during its tenure at the latter plant, the cooperative stole a total of 10,000t of cement from the company for illegal resale.

Fourthly, **Elementia** and its subsidiary Cemento Fortaleza control three integrated cement plants with a total capacity of 3.6Mt/yr, all in the central state of Hidalgo. The parent company expanded its geographical footprint in September 2020 by comissioning a new 0.3Mt/yr grinding plant in Yucatán.

**LafargeHolcim**'s subsidiary Holcim Mexico controls 11.8Mt/yr of capacity across its six plants and **Buzzi Unicem**'s subsidiary Cemento Portland Moctezuma operates 7.9Mt/yr between three plants.

Following the outbreak of Covid-19 in March 2020, the Mexican National Cement Chamber (CANACEM) suspended all cement dispatches in the country from 3 April 2020, followed by all cement production from 10 April 2020.

Despite this setback, Mexico's cement producers recorded 2020 as a year of steady growth. Elementia performed particularly strongly, increasing its consolidated Mexican net sales by 15% year-on-year to US$278m from US$241m. Group consolidated cement volumes rose by 4% to 5.3Mt from 5.1Mt.

## Canada

The Canadian cement industry consists of 16 integrated cement plants with a total production capacity of 18.6Mt/yr. The plants are clustered around the 37.6m-strong population's main urban centres near the US border. Cement deliveries to the rest of the country are seasonal. At 485kg/yr, the nation has North America's highest per-capita cement capacity, and as such is an important exporter. It maintained its exports to the US at 5.0Mt in 2020 - 33% of US imports.

### Cement production

**LafargeHolcim** leads cement production with five plants of 6.0Mt/yr total capacity. **Votorantim** has three plants with a capacity of 4.2Mt/yr. **HeidelbergCement** also has three plants with a capacity of 3.5Mt/yr and **CRH** two, combined capacity 2.5Mt/yr. CRH reported a year-on-year fall in cement volumes in Canada, particularly in the first half of 2020.

2021 saw the completion of two CCS installations, at HeidelbergCement subsidiary Lehigh Cement's Edmonton cement plant in Alberta and Lafarge Canada's Richmond cement plant in British Columbia.

### Conclusion

The North American cement industry was unified in its resilience to 2020's coronavirus-induced collapse in demand. As lockdowns end, the coming year should unleash demand across the continent, to the benefit of cement plants in US, Mexico and Canada.

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## India: Dalmia Cement starts new line at Bengal plant

Dalmia Cement has commenced commercial production of cement at the new 2.3Mt/yr production line of its Bengal Cement Works cement plant in Midnapore, West Bengal. The new line brings the plant's total capacity to 4Mt/yr.

CEO Ujjwal Batria said "To ensure that demand is met in a sustainable manner, we have deployed the latest machinery and technology at our Bengal Cement Works unit and will be aiming to produce 100% blended cement. This step is also in line with our commitment to become carbon negative by 2040." He added, "Post the lockdown-led demand disruption, the cement sector has continuously witnessed buoyancy across the country. This is largely led by revival in demand from the infrastructure and urban housing sectors, along with the demand from individual homebuilders and the government's rural housing schemes, especially from the east and central regions."

## Tajikistan: Mohir Cement starts plant

Mohir Cement has commenced operations following an official opening ceremony at its new 0.6Mt/yr integrated cement plant in Jalolidinni-Balkhi district. Local press has reported that the plant will produce M400 and M500 grades of Portland cement for export to Afghanistan and Uzbekistan.

Earlier it was reported by local press that Tajik cement plants produced 4.2Mt of cement in 2020. Cement exports for the year were 1.3Mt. Uzbekistan imported 764,000t, while Afghanistan imported 505,000t and Kyrgyzstan imported 42,000t. The Tajikistan Ministry of Industry and New Technologies has predicted a 46% increase in cement exports to 1.9Mt/yr by 2023.

## Russia: Upgrade for Angarskcement

SibCem subsidiary Angarskcement has replaced air ducts with local air blowers in its raw materials and clinker grinding units. The producer made the modification to the units' three horizontal slurry tanks.

Managing director Dmitry Kireev said, "The programme to reduce the consumption of compressed air in the slurry section of the raw materials and clinker grinding facility will continue." He added, "It is important for us to reduce the costs of energy resources consumed by slurry basins, since they directly affect the cost of the products manufactured by the plant."

## Cambodia: Conch plans new plant

China-based Conch International Holding subsidiary Conch KT Cement has announced plans for a new 2.0Mt/yr integrated cement plant in Kampong Speu Province. The Phnom Penh Post newspaper has reported the cost of the proposed plant as US$263m. It will generate up to 500 jobs, according to the producer. The company also operates the 2.0Mt/yr Ratanak Mondol cement plant in the province, which began operation in mid-2018. It says that the new plant will lower domestic cement prices, reducing the demand for imports.

## Taiwan: Taiwan Cement income up as revenue slips

Taiwan Cement's revenue fell by 7% year-on-year to US$4.02bn in 2020 from US$4.32bn in 2019. Net income grew by 4% to US$881m.

Senior vice president Edward Huang said "In 2020, Taiwan Cement made achievements in many aspects. In addition to our sound financial performance, we also committed to the Global Cement and Concrete Association (GCCA)'s Climate Ambition aspiring to deliver carbon neutral concrete to society by 2050. Even though challenges such as Covid-19, global economic volatility and climate change remain in 2021, Taiwan Cement is well-prepared as we continue to see stable profits in the cement industry, expand our waste treatment and energy businesses and move towards our carbon emissions reduction targets."

## China: Production picks up in first two months of 2021

The Chinese construction industry has reversed a downward trend in 2020 to increase its value-added output by 46% year-on-year in the first two months of 2021. The Ministry of Industry and Information Technology recorded a 61% year-on-year rise in cement production to 240Mt over the two month period.

Both of these figures represent large increases compared to the first two months of 2020, when China was in the midst of the first coronavirus-related lockdowns. The country always reports January and February cement data as a single figure due to the Chinese New Year holiday.

**Above:** Construction of Metro line in Jiaxing, China, March 2021.
**Credit:** Dave Colman / Shutterstock.com.

## Vietnam: Production rises again

Members of the Vietnam Cement Association (VICEM) produced 22.5Mt of cement in the first quarter of 2021, up by 2% year-on-year from 22.1Mt in the first quarter of 2020. The Việt Nam News newspaper reported that production in March 2021 was 8.3Mt, down by 4% from 8.0Mt in March 2020. Full-year production totalled 100Mt in 2020.

## Philippines: Awards for Republic

Republic Cement, a subsidiary of Ireland's CRH, has won the Quarry Operations award at the 2021 Presidential Mineral Industry Environmental Awards in Quezon City for its work in sustainably supplying limestone to its Bulacan and Batangas cement plants. The Batangas quarry also won the Safest Quarry award, while the Bulacan quarry won the Best Mining Forest Programme in the Non-metallic category. The company's Iligan quarry won the Platinum Achievement for Quarry Operations award.

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## Nigeria: Dangote sales rise 16% in 2020


Dangote Cement has recorded sales of US$2.52bn in 2020, up by 16% year-on-year from US$2.18bn in 2019. Earnings before interest, taxation, depreciation and amortisation (EBITDA) increased by 21% to US$1.17bn from US$965m. Total cement sales volumes rose by 8% to 25.7Mt from 23.7Mt and Nigerian cement sales rose by 13% to 15.9Mt from 14.1Mt. Highlights for the year included the start of clinker exports from the Apapa terminal and the commissioning of the Onne cement terminal in Nigeria. The group also commissioned a gas power plant in Tanzania.

## Nigeria/South Africa: Lafarge Africa's profit nearly doubles

Lafarge Africa, the subsidiary of LafargeHolcim that runs the group's assets in Nigeria and South Africa, has announced that its profit grew to US$80.8m in 2020, nearly double the US$40.7m that it made in 2019. The company reported that the improvement was the result of optimisation of unproductive assets, which improved its recurring earnings before interest and tax (EBIT) margin from 16% to 20%.

An illustration of the effects of the changes implemented by the company are reflected in the disparity between its profit and its revenue, which 'only' grew by 8.3% year-on-year. It increased to US$605m in 2020 from US$558m a year earlier. The company added that revenues increased due to higher cement sales, which rose by 9.1% year-on-year. These more than offset a 25.5% fall in aggregate sales. Concrete sales also fell.

## Iraq: Lucky starts commercial production

Lucky Cement began commercial cement production at its 1.2Mt/yr integrated Samawah cement plant in southern Iraq on 10 March 2021. The plant was built by the Chinese cement plant manufacturer Sinoma, with key equipment from Italian and German suppliers. The plant's captive power plant, from Wärtsilä, was assembled and tested in 2020. The plant also has two waste heat recovery systems.

The plant brings Lucky Cement's overseas installed cement production capacity to 4.1Mt/yr. The company also operates the 1.7Mt/yr Basra grinding plant in Iraq and a 1.2Mt/yr integrated cement plant in the Democratic Republic of Congo.

## Palestine: Jericho Cement plans 1.1Mt/yr plant

Jericho Cement Company plans to establish the first cement plant in Palestine by 2022. The planned 1.1Mt/yr plant will cost US$85m. Funding will come from a group of companies and the Palestinian Investment Fund. The plant is expected to cost US$85m.

Palestine currently imports cement, mainly from Jordan and Israel. Its economy contracted by 12% in 2020 but the IMF expects it to grow by 8% in 2021. "The cement plant is one of the most important steps toward achieving self-sufficiency," said Muhammad Mustafa, head of the Palestinian Investment Fund.

## Togo: CimCo on schedule for September start

CimCo says that its 2.5Mt/yr Lomé cement plant in Maritime Region will open by September 2021, following a total investment of US$118m. Agence Ecofin reports that work on the project is 65% complete. The producer said that the plant will create 500 direct jobs and a further 1000 indirect jobs.

Germany's Intercem Engineering is supplying a 1000t/hr truck unloading station, a 25,000t storage facility for additives, a 1000t/hr truck loading station, two 50,000t clinker silos, four Rotopacker machines from Haver & Boecker, eight truck loading stations and 10 truck scales. Intercem Engineering is also responsible for the installation of a Gebr. Pfeiffer MVR 6000 C-6 that will form the backbone of the plant. It will produce a wide range of cements, from CEM-I to CEM-IV. The mill has a drive power of 6400kW to produce CEM I at 370t/hr with a fineness of 3800cm$^2$/g according to Blaine.

The plant had originally been scheduled to start production in the first quarter of 2021, but appears to have been delayed by the Covid-19 pandemic.

These pages give *Global Cement Magazine*'s monthly review of global cement prices - in US$ for easy comparison. Some price information is only available to subscribers to *Global Cement Magazine*. Subscribe on Page 72. In this issue subscribers receive information from: The Gambia, India, Burkina Faso, Nigeria, South Africa, Senegal and Zambia.

Prices are for metric tonnes unless otherwise stated. US$ conversions from local currencies are correct at the time of original publication.

**India:** Fuel prices used by Indian cement manufacturers have continued to increase in price so far in 2021. Internationally-sourced coal has increased in price from US$49/t in September 2020 to US$88/t in February 2021, although it then fell to US$84/t in March 2021. Petcoke prices reached US$160/t in March 2021 from US$107/t in September 2020.

**Cuba:** Cuba is facing a shortage of cement, which has led to cement theft and a rampant black market. The government normally sells cement at state-run stores for US$6.60/bag (50kg), but there is little or no supply. Resellers are reportedly selling cement at US$10/bag in non-state stores, with some people prepared to pay as much as US$40/bag.

**India:** With the prospects of rising demand and ongoing input cost inflation, market analysts report that cement prices in India were likely to increase by an average of US$0.13/bag (50kg) in April 2021. Elara Securities said that in South India, Maharashtra, Delhi, Rajasthan, Bihar, Madhya Pradesh, Uttar Pradesh and West Bengal, cement firms may attempt price rises as high as US$0.40/bag.

**EU ETS:** The cost of $CO_2$ emissions permits has continued to rise in April 2021, with another record high of Euro44.14/t on 6 April 2021. As at 8 April 2021 the value was Euro43.38/t, a week-on-week rise of 3.4% from Euro41.95/t on 30 March 2021, an 11.0% month-on-month rise from Euro39.07/t on 8 March 2021 and an 86.6% year-on-year rise from Euro23.25 on 9 March 2020. The price has not dipped below Euro30/t since 9 December 2020 and has remained above Euro40/t since 9 March 2021.

**Egypt:** Ordinary Portland Cement prices as at 9 April 2021: Arabian Cement Co (Al Mosalah) = US$58.75/t; Minya Portland Cement (Minya) = US$55.55t; Minya Portland Cement (El Maelim) = US$53.67/t; El Nahda Cement (Al Sakhrah) = US$53.83/t; Wadi El Nile Cement = US$54.92/t; Lafarge (Al Makhsous) = US$56.19/t; Arish Cement (Alaskary) = US$54.28/t; Sinai Cement (Sinai) = US$54.28/t; Suez Cement (Al Suez) = US$58.11/t; Helwan Cement (Helwan) = US$58.11/t; Misr Beni Suef = US$57.34/t; El Sewedy Cement = US$58.43/t; Titan Beni Suef = US$53.00/t; Misr Cement Qena (Al Masalah) = US$53.83/t; Al Watania Company for Cement in Beni Suef = US$56.51/t.

White cement prices as at 9 April 2021: Sinai White Cement (Alabid Elnada) = US$159.64/t; Sinai White Cement (Super Sinai) = US$157.08/t; El Menya Cement (Super Royal) = US$152.61/t; El Menya Cement (Royal Elada) = US$155.17/t; Menya Helwan Cement (Alwaha Alabiad) = US$154.85/t.

Blended cement prices as at 9 April 2021: Cemex (A.one) = US$48.08/t; Helwan Cement (Al Waha) = US$50.00/t; El Sewedy Cement (Sewedy Tashtibat) = US$49.36/t.

Sulphate-resistant cement prices as at 9 April 2021: Minya Portland Cement (Asec Sea Water) = US$57.02/t; El Sewedy Cement (El Sewedy Al Mukawem) = US$59.70/; Al Watania Company for Cement in Beni Suef = US$57.15/t.

**China:** All-China 42.5 grade cement spot prices from sunsirs.com: 4-5 April 2021 = US$74.28/t; 6 April 2021 = US$74.43/t; 7-9 March 2021 = US$74.71/t.

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# 113.85 grams of 'banter' please...

**Peter Edwards** Editor, *Global Cement Magazine (peter.edwards@propubs.com)*

In the town I grew up in, there was a sweet-shop on my route home from school. It was run by Geoff, an eccentric chap who sold sweets the 'proper' way, by weight from behind a counter. He was straight-talking and uncomplicated. When UK shops were, in his words, 'forced to adopt' the metric system in January 2000, he just relabelled everything with the same price, per 113.85 grams rather than per 1/4 lb.

During a typical day, lots of people would drop in to talk to Geoff, while also picking up their favourite tipple. Sometimes my mates and I would just go there to chat rather than actually buy anything. He'd gently tell us that what we'd just learned at school was a load of old rubbish, while entertaining us with riddles and anecdotes. The shop closed in 2011 after 103 years in business. Geoff would be keen to point out that he only ran it for 49 of them.

The shop run by Geoff may have been a sweet shop, but it was also a Third Place, as defined by the US sociologist Ray Oldenburg in his 1989 book *The Great Good Place*. In it, Oldenburg coined terms for three types of social environment: The First Place is the home and the people you live with. The Second Place is the work environment, where the people and rules are different. They can be formal and even confrontational at times, but they also provide social interaction and the chance for new friendships. Of course, the Second Place also provides money to pay for the First Place, as well as the things in it.

The Third Place is the 'Great Good' one referred to in Oldenburg's title. He defines them as 'anchors' of the community. They include, but are not limited to: community centres, local shopping streets, public parks, places of worship, cinemas, public libraries, pubs / restaurants / coffee shops, barbers, bookshops and record stores, as well as hobby clubs of all descriptions. The definition has since expanded to include the online world, for example gaming communities.

Academics have since attempted to define the characteristics of Third Places, revealing several main themes. Third Places are neutral territory, away from work and the home. A related characteristic is that they act as societal levellers, where everyone is theoretically equally welcome and heard. Crucially, the main activity in a Third Place is to meet people and converse, usually in a jovial and informal way, 'banter' to use an English term. Buying a record, drinking a coffee or getting your hair cut is secondary to the social outlet provided by the space.

After this point, Third Place characteristics become blurrier. 'Regulars' are a common feature of many, whether they prop up a bar or spot weights for each other. These 'old faces' are balanced by a steady stream of new ones. Some may stay only a short while, others much longer. To ensure a fresh supply of new people, the cost to enter the Third Place needs to be fairly low.

Oldenburg's overriding point is that Third Places expose people to new contacts, who will likely have different views on: music, beer, hairstyles, sports, politics, religion, child-rearing, how to make the perfect bolognese... anything. They provide unexpected and stimulating conversation, which inform the future beliefs and behaviours of the individuals involved. Oldenburg argues that Third Places are essential to healthy political discourse and society in general.

As we look down the list of characteristics, however, it appears that many Third Places have been under threat for some time, even before the onset of the pandemic. Local shops are under attack from out-of-town facilities and online shopping. Religious attendance is on a downward trend across many mature economies. Public facilities, including youth-clubs, drop-in centres and libraries, have faced the axe since the late 2000s financial crisis, if they were even present in the first place. Independent restaurants and bars have been blighted by Covid-19, with many unsure if they will even survive.

The temporary, although very trying, closure of many Third Places (and Second Places) during the pandemic will be reversed. However, we should be wary of the long-term decline in public social space. Otherwise, our physical lives risk becoming entrenched in ever decreasing social circles in which we only ever come into contact with those that we already socialise with. The effects of online polarisation, regardless of your stance on politics, Covid-19 or the latest celebrity twitter storm, indicates that this would be damaging to individuals and to society as a whole.

So here's to our Third Places. Let's do whatever we can to keep them going now to ensure they do not become another victim of the pandemic. After this is all over, we will all need our 113.85g of banter!

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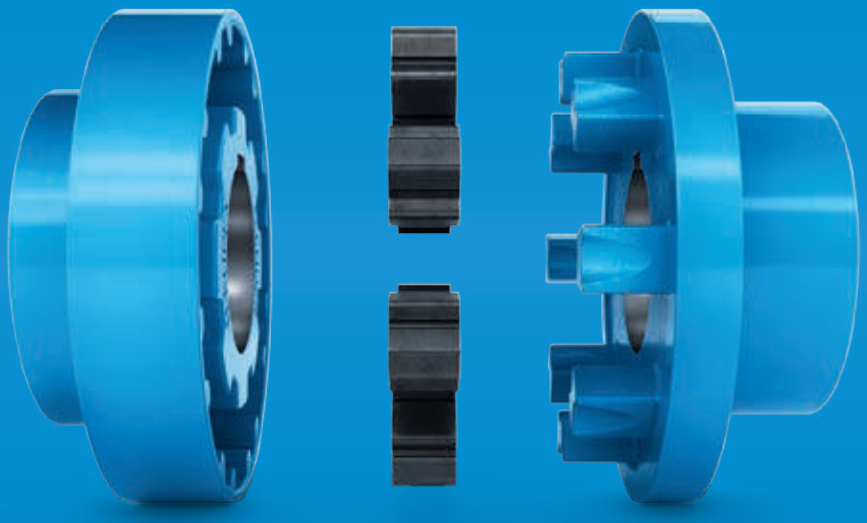

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