Smart cement

Advances in digitalisation have led to the effective use of machine learning and artificial intelligence as part of the predictive and prescriptive maintenance at cement plants. Getting a plant's operating data to work for the company can result in enhanced efficiency and profitability through optimum equipment performance.

■ *by **CemAI**, USA*

In cement manufacturing, maintenance is essential for smooth, efficient and continuous operations to consistently deliver quality products. Historically accounting for 15-25 per cent of the total manufacturing cost, savings in maintenance go a long way in the overall profitability of the plant.

Advances in digitalisation, sensor technologies and maintenance practices have led to the effective use of machine learning (ML) and artificial intelligence (AI) as part of the predictive maintenance (condition-based) routines in cement plants. Complemented with prescriptive maintenance (data-driven), the opportunity to maximise availability and efficiency of equipment has reached a higher threshold, despite the ever-present limitations in resources.

The result is enhanced efficiency and profitability through optimum equipment performance through its lifecycle, reducing downtime and unscheduled shutdowns for repair. In addition, Industry 4.0 has spread to process optimisation with significant gains in energy efficiency and consistent throughputs.

Remote monitoring centres have proven effective in addressing alerts with plant personnel to identify the root causes so that actions can be agreed to and addressed preventively. The remote monitoring support aids the existing plant team(s)

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ML/AI role in predictive and prescriptive maintenance

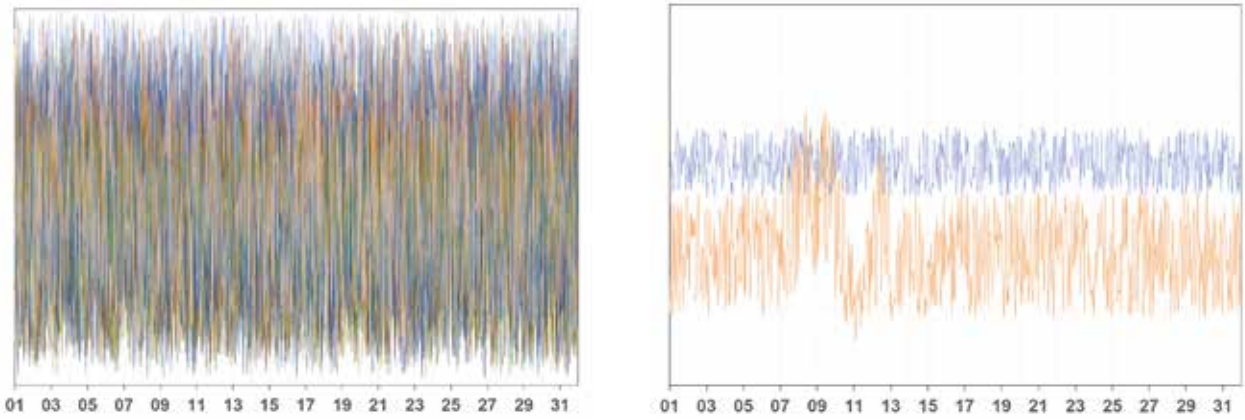
Existing measurement and control systems in a cement plant generate and use vast amounts of data and information. Raw data from existing sensors in a single-line plant, spanning quarry crushing, drying, raw milling, blending, pyroprocessing, fuel, clinker, finish mill, packing, storage, and distribution/loadout, can easily exceed one terabyte per year when all stored.

ML/AI has come to play a key role because the required computing power is now within reach to analyse all manufacturing data in real time. In other words, rather than being limited by past experiences and learning from indications of excursions post-event, by reviewing trends of certain signals leading to the event, AI can alert to what can become an excursion from normal before it happens: a predictive approach.

The ML/AI software, like an ever-available inspector, helps the maintenance and reliability teams by analysing the data from all signals in the plant 24h-a-day, seven-days-a-week, 365-days-a-year. "The monitoring can detect deviations within operating envelopes of equipment that do not reach the level of control room alerts," says Cesar Constantino, vice president of marketing and sales at CemAI. "It would be very difficult or too costly for any group of individuals to be able to monitor in a similar fashion."

The drivers of this technological advancement can be illustrated (see Figures 1a and 1b), for example, with 50 simulated and normalised signals to plot within their acceptable operating envelopes, each being a 1min average, for a month. A plant can have hundreds or thousands of these signals. Expert maintenance engineers, either at the plant or remotely, receive help from the AI programmes which can appreciate signals of what could be an actionable alert – without a dedicated person committed to look for these deviations which can occur even when the data is within operating conditions.

Figure 1a (left): 50 signals all overlapping in time and 1b (right): displaying two signals from the 50 in Figure 1a



Source: CemAI

Prescriptive maintenance results

Cement plant maintenance, reliability and process experts can filter and select the particular alerts that the ML/AI predictive approach captures to prioritise those that have the most positive impacts for any given plant process. Remote monitoring centres have proven effective in addressing alerts with plant personnel to identify the root causes so that actions can be agreed to and addressed preventively. The remote monitoring support aids the existing plant team(s).

The connotation of "smart" in the predictive and prescriptive approach stems from ML/AI digital models that capture the equipment hierarchies and process dependencies. This is critical and vital because alerts can be triggered when the relative behaviour between operating equipment signals is not in alignment with the historic record of how those processes have been measured and documented through the sensor signal history at each plant.

In turn, AI alerts are not only the result of a signal's deviation from prescribed min and max but a deviation relative to other signals even if all are within the operating envelope. Accordingly, maintenance action can take place when any prevented failure remains easy to fix and before it has escalated to an extent that impacts other components or other interconnected pieces of equipment.

By keeping equipment operating in its useful life for longer periods, the efficiencies translate into profitability for the plant. The following example is instructive: "Considering a 0.83Mta kiln with a target in mind to avoid kiln stops, a robust maintenance management system can pull run factors from 83 to 90 and, depending on market conditions and under several assumptions, can equate with millions of dollars in savings."[1]

Predictive and prescriptive maintenance practices, coupled with the existing plant maintenance, could 1. further develop the maintenance culture of the plant and sustain year-on-year high reliability factors throughout the plant, and 2. effect positive change when stops are due to maintenance-related causes to reduce costs in power, fuel and lost production.

"The gains fit instances where there are ample improvement opportunities for raising reliability factors and even more so when plants have already reached best-in-class status with reliability factors hovering at 95+," says Mr Constantino. "At such high levels, it requires bolting on these new practices to be able to continue to improve and maintain the gains."

Start using ML/AI for predictive maintenance fast

CemAI was created by cement professionals for the cement industry and has tuned a service that relies on data from existing infrastructure. The system also connects the plant with a remote monitoring centre that complements expertise and facilitates the plant's response to alerts.

The quickest installations take place when plants have existing and operating historians permitting data flows to the ML/AI system. Three months for start-up is typical in these circumstances. Results are quantified, documented and summarised for technical and management reviews as an ongoing continuous improvement activity.

Real Time Optimisation (RTO)

The frontier of digitalisation is advancing at today's cement plants as real-time optimisation of process emerges in tandem with ML/AI-based predictive and prescriptive maintenance. In enlightened cement manufacturing operations, the data revolution has supplied distinct operating variables for the physical assets in production.

Optimising efforts include defining operating models and feeding optimising software modules historical machine data so system behaviour can be learned and the most impactful variables identified and understood. All this learning is directed at maximising throughput, minimising energy consumption, and maintaining product quality. Product quality is the defining constraint to the successful use of optimising techniques under Industry 4.0.

Conclusion

The cement plant's operating data is now available – get it working for your company. On a risk management decision branch basis, to neglect to employ predictive and prescriptive maintenance is outside the mainstream of current cement manufacturing. Process optimisation is also in vogue and insights obtained from its application are impacting the evolution of plant operations. The AI/ML tools are available, indicated and must be strongly considered for any 2024 budgeting. ■

REFERENCES

[1] ALSOP, PA (2019) *The Cement Plant Operations Handbook. Seventh Edition*. Dorking, UK: Tradeship Publications Ltd, 338p.