Increase productivity, reduce energy

Advanced Process Control (APC) can help steel manufacturers optimise their processes and work more efficiently. APC uses state-of-the-art Model Predictive Control (MPC) technology enabling customers to squeeze more value out of existing production processes, says Tarun Mathur*

TODAY'S steel manufacturer is facing a number of challenges that range from safeguarding competitiveness to meeting changing customer needs with flexibility and speed. These require steel plants to maximise operating performance, while maintaining quality and yield, and controlling maintenance and inventory levels. In addition, companies need to find ways of retaining expert human knowledge accumulated over many years, after the experts themselves come towards the end of their working lives. In this regard, automating certain processes not only ensures consistency of control, but also enables processes to operate smoothly in the absence of human operators, right around the clock. Advanced Process Control (APC) using model predictions is one of the ways to run the processes on autopilot mode with minimum intervention from operators.

Digitalisation: the power of partnership

To best realise the advantages of digitalisation, steel manufacturers require a partner with in-depth knowledge and experience of not only the available digital technologies, but also the industry's specific processes. This integration of OT and IT expertise ensures digitalisation projects do not simply look good, but provide efficient return on investment (ROI). When selecting a digital transformation partner, it is crucial to choose a company with domain, industry and process knowledge, preferably with many years' experience working with third-party and legacy integration. Specific capacities, such as the ability to apply cutting edge tools including cloud integration, advanced analytics, and artificial intelligence, together with proven development models including profitable methods of joint working are also critical.

Advanced Process Control

The concept of APC, and the ways in which it can be tailored to industry-specific processes – given the right level of knowledge and expertise – offers a great potential for a metals industry seeking solutions that provide tangible and guaranteed returns. Today, APC is fundamental to the success of certain processes within many industries, and is increasingly being applied today in steel production.

Although it is technically advanced and not without complexities, APC can be considered simply as the autopilot for driving the plant to an optimum state around the clock. It is traditionally based on Model Predictive Control (MPC), a technology with proven ability to provide control solutions using constraints, feed-forward and feedback to handle multi-variable processes that feature delays and processes with strong interactive loops. Using a plant model and objective functions, MPC can predict system behaviour some steps into the future – put simply, it produces a digital twin of any process and predicts the way it will act.

Based on this predictive functionality, APC is able to automatically adjust operational set points to ensure peak plant performance and productivity. Its ability to make frequent, small changes, avoids large corrections or over-compensation for changes in conditions, creating a stable process, before steadily and smoothly moving to and maintaining an optimal operating state (**Fig. 1**). In this way, APC is able to enhance quality, raise throughput and reduce energy use.

APC is already used in a variety of industries to facilitate operational change, offering significant ROI. In the cement industry, for example, APC has been used to optimise both horizontal and vertical grinding circuits to improve productivity. Given the similar process and equipment

* Global product manager for Metals Digital at ABB

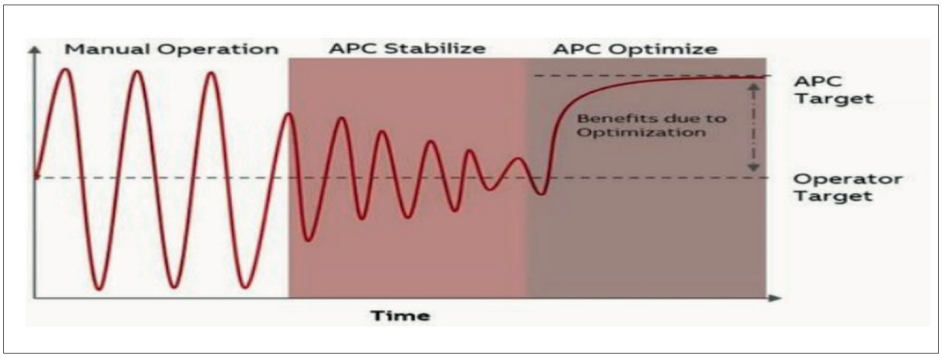

Fig 1. APC acts as the autopilot to an optimal operating state, first stabilising then optimising plant performance

used across both the cement and metals industries, such examples offer practical insight into the sort of savings APC could offer to steel producers in their own grinding processes.

In one example, an Advanced Process Control solution for cement was installed on a grinding circuit that included a roller-press with static V-separator and single chamber ball mill, achieving an improvement in control with a 4% increase in production, a 3% saving in energy, and a 60% reduction in the standard deviation of the rate of returns (tph).

In the cement industry – which, like the steel industry makes use of sinter – APC can also be used to optimise raw mix proportioning in the sinter plant, as it already does for the raw mix entering the cement plant pyroprocess. With varying iron ore characteristics posing challenges to the production of a consistent steel product, using APC to balance the dosing ratio of base, limestone, dolomite and coke has the potential to minimise chemical variation before material enters the sinter machine.

Following the implementation of APC in a range of other industries – not only cement but also mining and pulp and paper – and working together with steelmakers, ABB has now developed APC applications for metals plants covering processes that pose clear and established challenges to steel plant operations.

Case study: *ABB Ability™ Advanced Process Control for metals*

ABB Ability™ Advanced Process Control for metals has already been implemented at one steelmaker to optimise the pellet plant dryer and indurating machine burners.

Optimising the pellet plant dryer

Pellet plant dryers face a range of operating challenges, including intermittent disturbances in feed rates, long process delays, and variations in the calorific value of the blast furnace gas (which makes temperature control difficult).

Temperature limits are, therefore, often not met, resulting in insufficient drying of the material, negatively impacting energy consumption and productivity. Moreover, control of the drying kiln with conventional PID controllers is unstable, mainly due to process delays.

At an Indian steel plant, ABB was tasked with maintaining the outlet temperature at the desired setpoint, irrespective of the above challenges. APC was implemented with dryer outlet temperature as the controlled variable and fuel flow as the manipulated variable. A model of dryer outlet temperature was developed based on plant data to include the fuel flow control valve and disturbance variables, such as feed rate. The model is used to predict the upcoming control performance, calculating setpoint corrections, which are then downloaded to Level-1 PID controllers.

APC now maintains the dryer temperature even with changes in feed rate and process delays, achieving a 10% reduction in the standard deviation of the temperature (**Fig. 2**). The implementation of APC has stabilised temperature conditions within the dryer, improving overall performance and productivity.

Controlling the indurating machine burners

Optimisation of the global steelmaker's indurating machines also posed a problem, due to the high interaction between control loops, as well as variation in feed rate, machine speed and bed height, which interferes with temperature control in the firing zone. This can result in fluctuations in the firing zone temperature up to +/- 30°C, making it difficult to maintain the burn-through temperature of the pellets.

To resolve these issues, it was necessary to stabilise the temperature profiles of eight burner zones (**Fig.3**). An offline model of burner zone temperature was developed, including fuel flow control valve and disturbance variables, such as bed height. The model was used to predict control performance in the near future, calculating setpoint corrections that were then downloaded to Level-1 PID controllers.

As a result, the customer has benefitted from a 15% reduction in the standard deviation of the temperature profile along the indurating machine burner zone (**Fig. 4**). This has helped ensure burn-out temperature is reached at the right location,

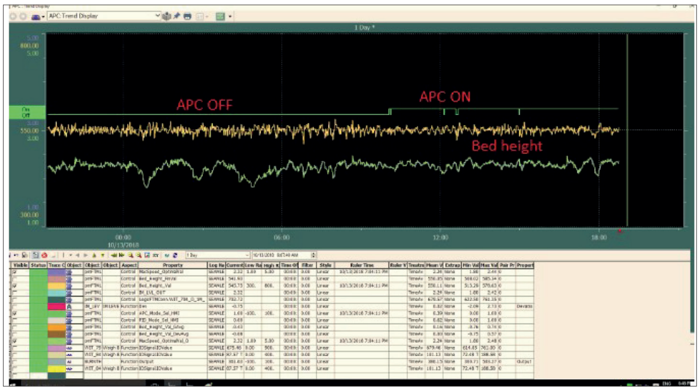

Fig 2. ABB Ability™ Advanced Process Control for metals helps maintain outlet temperature for the pellet plant dryer, stabilising the temperature and helping to optimise performance

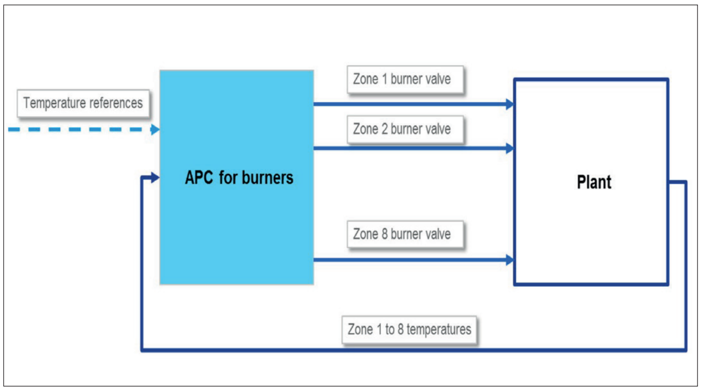

Fig. 3. Multi-variable APC directly controls the burner valves in order to stabilise the temperatures in the burning zones.

improving the quality of the pellets. It has also reduced temperature variation, leading to a reduction in fuel consumption in the burners.

Typical savings, based on on-site results from over 300 references worldwide, include:

- 2%-3% increase in output.
- 1%-2% reduction in fuel consumption.
- 2%-3% reduction in electricity consumption.
- 10%-20% reduction in quality variation.
- 10%-20% reduction in refractory consumption.

Considered together with ongoing results from the metals implementation discussed above, we can expect similar improvements for metals customers.

Conclusion

Given the ever-challenging conditions in the steel market, intelligent plants that remove ambiguity and eliminate guesswork represent the future of the industry, by placing every aspect and detail within the control of skilled operators. APC is an essential part of that intelligent plant – indeed, it is the intelligence that makes a plant smart. By accurately modelling process conditions using Model Predictive Control – and ultimately AI and other advanced technologies – APC is able to predict and respond to multi-variable conditions in a way that is beyond any human operator. In doing so, it is a vital tool for those human operators in maintaining peak productivity and performance consistently.

As APC technology continues to evolve, the potential of AI with reinforcement learning neural networks, as well as edge and cloud technology, is now being explored to provide a set of Advanced Process Control and analytics services for monitoring, predictive analytics and closed-loop control. However, this can only be truly successful where the partnership between those undertaking these complex processes, and those supplying APC expertise is based on a deep and common understanding of the challenges and requirements of specific industries.

APC technology is built on the three core pillars of digitalisation – a unified, connected, data-led ecosystem; smart algorithms, deep analytics and AI to translate data into actionable insights; and with deep domain knowledge, such a solution offers the paradigmatic shift in operating performance needed by today's steel industry in order to survive and prosper. ■

References

1. Zhou, Y. and Hu, L., "The Digital Revolution will Transform the Steel Industry", World Economic Forum, 25 June 2019: https://www.weforum.org/agenda/2019/06/the-digital-revolution-will-transform-steel-and-metals-companies

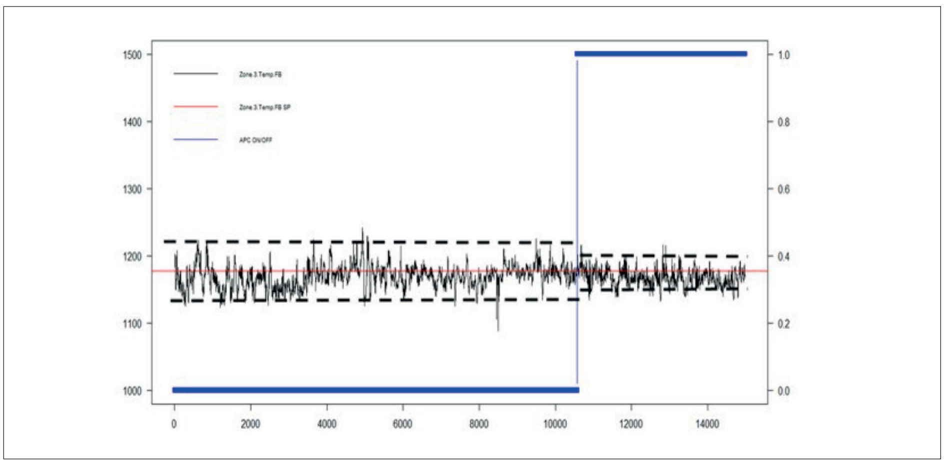

Fig 4. Advanced Process Control for metals successfully reduced the standard deviation in temperature profile of the indurated machine burners