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CLPM: Delivering on the Promise of Plant-wide Optimisation

Petrochemical manufacturers experience unique challenges when it comes to maintaining effective regulatory control. As practitioners know that the dynamics of petrochemical processes are complex. From the volatility of batch reactions and rapid responses of pressure control to the highly nonlinear and the sluggish nature of temperature control, the range of both process dynamics and industry applications routinely push the common PID controller to its limits. Whereas an effectively tuned PID can enable safe and efficient production, a poorly tuned controller can inadvertently hamper quality and constrain production throughput. Innovations in process modeling technology have proven to simplify the tuning of individual PIDs. Only recently these innovations have been applied to simplifying controller optimisation on a plant-wide basis.

Proportional Integral Derivative (PID) remains the dominant regulatory control solution used by petrochemical manufacturers. Indeed, it is the control solution of choice across the process industries around the globe. Widespread adoption of the PID controller has been facilitated by its relative low cost and ease of configuration. These positive attributes notwithstanding, PID controllers must be tuned for their unique application in order to deliver the objective level of performance. Historically the tuning of PIDs – whether manually or with the help of software – has proven to be a challenge.

Regular tuning of plant PIDs is generally acknowledged as a best-practice that provides meaningful financial benefits. A study published in 2001 by the UK's Energy Efficiency Best Practices Programme found that manufacturers who frequently tuned their facility's PID controllers realised significant gains. Among the study's findings were increases in throughput of up to 5 per cent and reductions in quality related defects of as much as 50 per cent. Even though the potential gains are significant, the challenge of regularly tuning the PIDs of their complex processes has proven greater for most manufacturers.

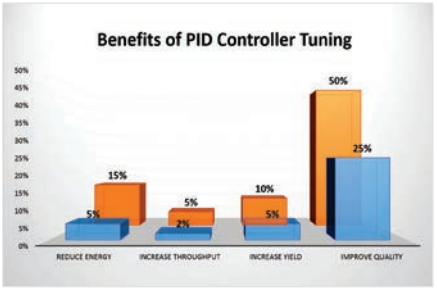

Figure 1: The UK's Energy Efficiency Best Practices Programme linked regular tuning of PIDs to significant economic gains. Improvements to both top-line and bottom-line performance were documented.

Software products for tuning PID controllers have been available for decades, promising a repeatable method and optimal results. As such, these tools sought to automate the process and correct the deficiencies inherent with manual tuning techniques. Unfortunately, early tuning software proved incapable of modeling the highly variable dynamics common in industrial process manufacturing. More specifically, they required practitioners to settle a process before performing the appropriate testing (e.g. step, bump, doublet). This steady-state requirement proved impractical for many petrochemical applications characterised by their noisy, oscillatory behavior.

In 2008, a major innovation in dynamic process modeling was introduced that enhanced the value proposition of tuning software. Non-steady state (NSS) modeling eliminated the need for a settled process prior to tuning the associated PID. With its unique ability to accurately model process dynamics using noisy, oscillatory – even long dead-time – process data, the innovation made it possible to improve the performance of loops that were previously viewed as 'off limits' for traditional tuning techniques due to their complexity or economic importance. Proof of the innovation's value to process manufacturers in general and chemical manufacturers was particularly quick in coming.

Mastering Real-World Dynamics

Evonik Industries is a leader in the global petrochemicals market with operations in over 100 countries. The company's facility located in Galena, Kansas (USA) manufactures an array of pharmaceutical intermediates, specialty chemicals and herbicides, and industrial solvents. Process complexity and poor controller tuning had resulted in excessive overshoot and persistent oscillations when the plant's controllers were operated in automatic during start up. In order to correct for these issues the plant's engineering staff routinely operated controllers in manual mode at the start of each batch. The outcome was an unnecessarily long cycle time and the loss of valuable production potential. It wasn't until they utilised software equipped with NSS modeling that the plant could establish effective, efficient control over its batch processes.

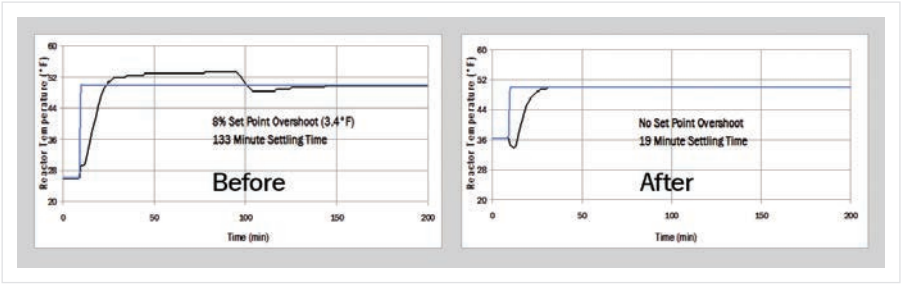

Figure 2 – Traditional tuning software had failed repeatedly to model Evonik's batch dynamics accurately, forcing plant staff to operate controllers in manual mode during start-up and resulting in a combination of overshoot and long settling times. The NSS modeling innovation made it possible to tune the highly variable process, eliminating overshoot and reducing settling time by ~85 per cent.

"We experimented with other tuning software packages to see if they could accurately model our batch dynamics," noted John Gaines, Production Manager at the Kansas Plant. "In order for the tools to work properly, they required us to settle out our process and conduct bump tests starting from a steady state. In the world of batch processes, that requirement is simply not realistic and it forced us to control the process manually."

Improvements in the plant's PID control were immediate and exceeded the maximum increase in production throughput that had been previously published by the Energy Best Practices Programme. Using software equipped with the NSS Modeling Innovation, Evonik engineers accurately modeled the process' dynamics and tuned the associated loops for a combination of zero overshoot and minimal settling time. Using the new parameters, the plant operated the process in closed-loop during startup for the first time. More importantly, engineers documented a 9.3 per cent reduction in production cycle time. Even so, the performance gains were only realised after engineers had singled out the bad acting PIDs. What's more, gains were limited to individual control loops and not yet realised plant-wide.

Taking Innovation to New Levels

For years, manufacturers across the petrochemical industry have been pushing automation technology suppliers to move beyond single loop optimisation. In response, Control Loop Performance Monitoring (CLPM) technologies were introduced to the market at the start of the new millennium. The ability of CLPM technologies to capitalise on everyday set point changes and output changes to automatically produce process models, however, was only introduced during the last decade. Like traditional tuning software, early CLPM solutions with this capability required steady-state conditions in order to produce meaningful models and actionable information. The same noisy, oscillatory data that limited the effectiveness of early PID controller tuning software also constrained the efficacy of CLPM technologies.

The first integration of NSS modeling with a CLPM solution was completed in 2013. With its ability to accurately model noisy, oscillatory data, the innovation allowed accurate plant-wide modeling of the complex dynamics common to petrochemical processes. This advancement allows CLPM solutions to fully capitalise on the considerable number of closed-loop set point and open-loop output changes that occur daily at a typical plant. Additionally, select CLPM solutions can aggregate the analysis from all models associated with a given PID control loop, providing a more complete assessment of a given loop's dynamics and more relevant recommendations for controller optimisation. For the first time, control loop optimisation is truly possible on a plant-wide basis. For manufacturers of all types, this is welcome news. (See Figure 3)

Figure 3 - Select CLPM solutions automatically capture both closed-loop set point changes and open-loop output changes, calculating models of the associated process dynamics. Aggregated modeling data offers a comprehensive view of a given control loop's behavior and it provides the basis for tuning values suitable for controlling that same range of behavior.

Understanding the Oil Sands

Petrochemical companies located in the tar sands of Canada apply a unique process in their extraction of crude oil. The Athabasca oil sands are known as a rich source of both heavy crude and bitumen. Indeed, the Government of Alberta has concluded that the oil sands of Canada represent a full 70% of the world's proven natural bitumen reserves. In order to process the crude oil contained in oil sands it must first be separated from the partially consolidated sandstone and loose sand that surrounds it. Steam-assisted gravity drainage (SAGD) is a common method for separating oil from earth. The process involves the drilling of horizontal wells into a known oil reservoir. Steam is injected via one well in order to reduce the oil's viscosity and to cause it to drain downward into a second well where it is collected and pumped out for refining.

A single SAGD facility is generally comprised of several steam generating units, a water separation area, and up to a half dozen extraction pads. Such a facility employs approximately 1000 PID control loops in the regulation of continuous oil extraction and processing. In the best of times the supervision of such a production facility is challenging. That challenge is exacerbated when the price of oil is depressed and fewer staffs are available to oversee the production process. Technologies like CLPM enable these plants to proactively monitor their critical control systems. They improve staff efficiency by identifying changes

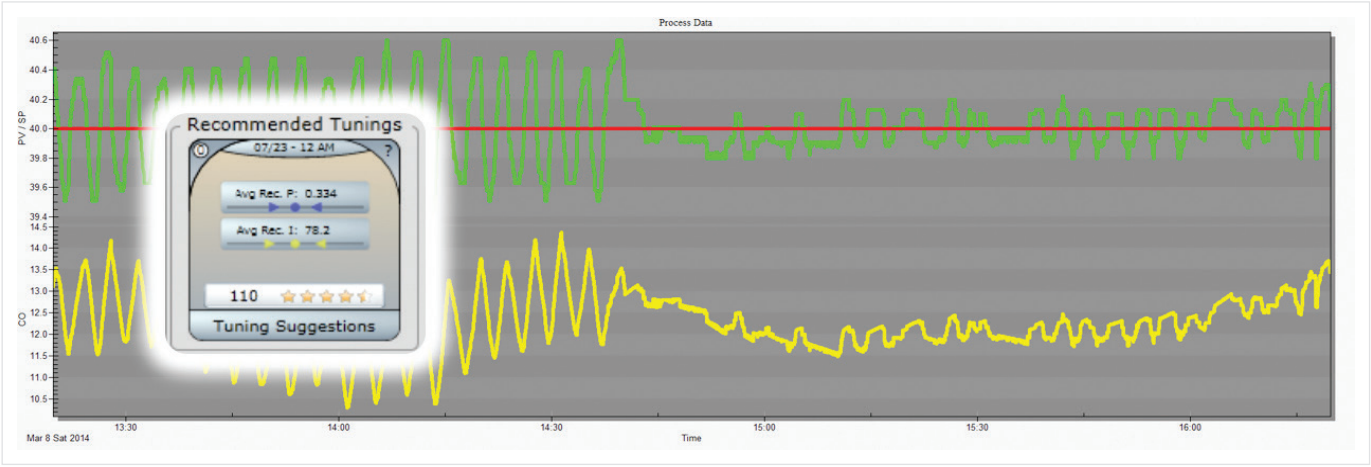

Figure 4 – PlantESP's TuneVue™ feature aggregates process model data and recommends PID tuning parameters. Shown above is the trend from a SAGD plant. The control loop's performance can be seen to improve dramatically based on use of CLPM solution's tuning recommendation.

that can affect performance – changes that are routinely overlooked. More importantly CLPM technologies actively monitor performance, recommending adjustments for maintaining optimal plant-wide control and production.

Large Scale Modeling and Tuning

An independent oil producer located near Fort McMurray, Alberta first implemented CLPM technology in 2014 to improve production efficiency across its extraction facilities. The producer understood that a transition from reactive controller corrections to proactive PID optimisation would lead to lower overall production costs. In order to achieve its goal, however, the CLPM technology would need to go beyond providing standard process analytics and find meaningful opportunities for improvement; it would need to recommend specific adjustments to regulatory control using little more than everyday set point changes as the basis for its optimisation.

The benefits and computational challenges associated with NSS modeling are significant when applied to CLPM technology and plant-wide monitoring. In comparison, the effectiveness of the optimisation routines of traditional process modeling and tuning products are severely constrained by the noisy, oscillatory conditions typically present in plants. Now consider that one SAGD facility utilises a total of 995 PIDs to regulate control. During a span of 121 days, because of its use of NSS, the CLPM technology successfully identified and modeled a total of 323,612 closed-loop set point changes and open-loop output changes. That can be equated to nearly 3 model fits per loop each day and nearly 1 million model fits across the plant each year. While the processing requirements were truly significant, the benefits were equally meaningful.

The benefits of CLPM matched the goal established by the producer. In addition to identifying mechanical challenges such as valve stiction along with isolating issues linked to loop interaction, the CLPM solution found numerous opportunities for PID controller tuning. Many of the recommendations surprised production staff as they believed the associated PIDs were already tuned optimally. Using aggregated model data and analysis of tuning parameters, however, the CLPM solution visually clarified how the existing tuning parameters had failed to provide adequate control under normal operating conditions. Once the new parameters were implemented the engineers saw immediate improvements. The transition from reactive to proactive loop management was completed. (See Figure 4)

Simplifying Plant-wide Optimisation

Petrochemical manufacturers are faced with unique challenges in the control and optimisation of their production processes. The complex dynamics associated with typical petrochemical processes require innovation solutions. Specifically, those solutions have needed to address the noisy, oscillatory conditions which petrochemical manufacturers view as the 'real world'. Fortunately, there are now CLPM solutions equipped with NSS modeling that can overcome these challenges. Unique capabilities for modeling and tuning have simplified controller optimisation on a plant-wide basis. ■

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