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### Also Inside:

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PID TUNING

# Overcoming loop tuning challenges

Proper control-loop tuning can improve production quality and throughput and minimize production-related waste.

**Damien Munroe,** *Control Station Limited*
**Ricardo Caruso,** *Aquarius Software Ltda.*

For years, it was necessary to steady a process before tuning software could be applied successfully. Because most industrial processes exhibit some degree of oscillatory behavior, the steady-state prerequisite meant tuning software could be applied only on loops that were already under reasonable control. In other words, tuning software routinely failed under the normal dynamic operating conditions for which software was needed in the first place. Recent advances in process modeling eliminate the steady-state requirement and allow proportional-integral-derivative (PID) controller tuning software to correct for the noisy, oscillatory behavior typical of industrial applications.

Articles about PID loop tuning are published regularly, and they routinely reference studies touting performance improvements and financial gains. Whether based on empirical research or anecdotal stories, they've made it clear that tuning PIDs can improve a production facility's performance significantly. With such overwhelming evidence, why does the manufacturing community need regular reminders?

Consider for a moment the findings published by the U.K.'s Energy Efficiency Best Practices Programme. Its "Invest in Control—Payback in Profits" guide credited PID tuning with economic gains that were both substantial and sustainable. Increases of 2% to 5% in production throughput, decreases of 5% to 15% in energy consumption, among other benefits were realized by the periodic PID tuning (see Figure 1). With benefits at those levels, one might expect manufacturers to race to the nearest supply house for tuning software.

For their part, automation vendors have produced an array of tools to simplify the tuning process and optimize PID control. From integrated auto-tuners to aftermarket products, there is an abundance of software options. Unfortunately, the devil has always been in the data. Typical process data from a typical plant is highly dynamic. It's noisy. It's oscillatory. Those attributes have caused more than one software program to crash on the rocks of failed tuning.

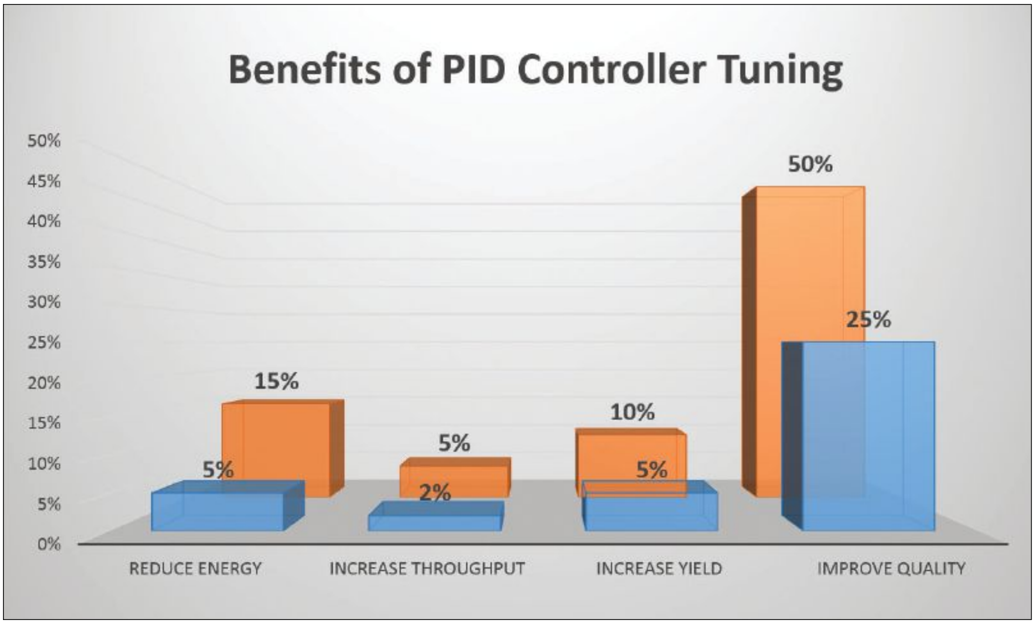
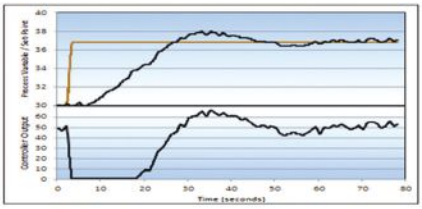


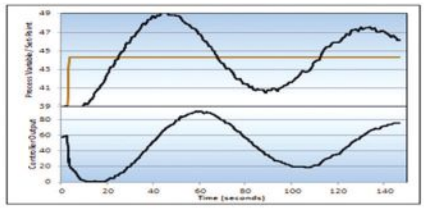

**Figure 1: The "Energy Efficiency Best Practices Programme" associated significant economic gains from regular PID tuning. The study found average reductions in energy consumption ranging from 5% to 15%. All images courtesy: Control Station Inc.**

## Calming the process

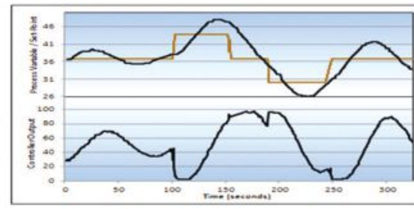
Tuning PID control loops begins with the calculation of a process model using step test data. While debates about the merits of first-order



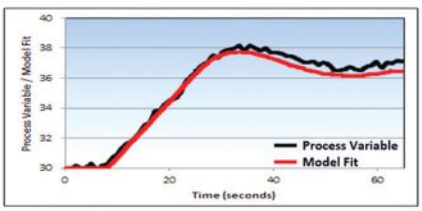

Step test with the process started in a steady-state condition and ended in a steady-state condition.



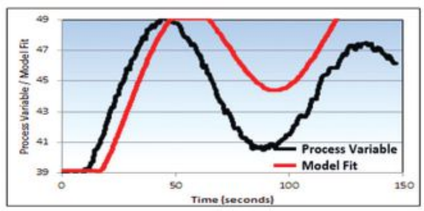

Step test with the process started in a steady-state condition but ended in transition.



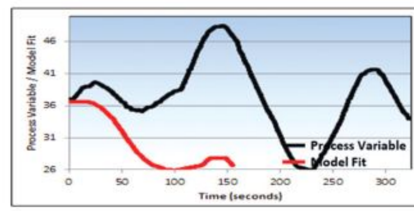

Doublet test with the process started in transition and ended in transition.




Integrating model correctly applied. Value for Gain is marginally off from the optimal value.




Non-integrating model applied incorrectly. Model impacted by incorrect Gain and Dead-Time values.




Controller action calculated incorrectly. Values for Gain and Dead-Time notably off.

**Figure 2: Traditional tuning tools accurately model the dynamics of a process when testing both begins and ends in a steady-state condition. As non-steady conditions typical of everyday plant operations are introduced, traditional tuning tools struggle to calculate an accurate model.**

versus higher-order modeling continue to rage, nearly all vendors agree on the need for a steady or quiet process before their prescribed tuning procedure is initiated. The irony of that requirement strikes at the heart of the matter. A steady-state requirement has no place in an overwhelmingly transitional world (see Figure 2).

Practitioners look to software to tune PID loops that exhibit challenging, highly variable dynamics. But software has historically required practitioners to steady a loop's behavior before the software can function properly. When it comes to tuning loops, most would argue that steadying a process is the hard part. If achieving a steady state condition was easy—let alone feasible—manual tuning methods would more or less suffice. What's more, by requiring users to do the hard part of tuning, the value of software is justifiably called into question.

Whether in spite of or in response to this irony, process modeling and controller tuning technology have advanced. In particular, a select group of automation companies have resolved the conundrum created by the steady-state requirement. In so doing, they've made it possible for tuning software to finally deliver on its original promise.

**Tuning PID control loops begins with the calculation of a process model using step test data.**

## Advances in modeling

Numerous automation vendors offer PID tuning solutions equipped with a feature called "non-steady state" (NSS) modeling for use with either their programmable logic controllers or their distributed control systems (DCSs). The innovation first entered the automation scene in 2008, and it has grown steadily, albeit quietly since then. The innovation eliminates the steady-state requirement, finally allowing users to improve control over their noisy, oscillatory, and even long dead-time processes (see Figure 3).

Consider the implications of NSS modeling. First, it eliminates the burden of steadying a process. Software equipped with NSS requires bump test data that includes controller output and process variable signals distinct from any apparent noise in the process. That factor alone dramatically reduces the time and effort involved with tuning a plant's PID control loops, which means no more tinkering with a loop's control or curbing other upstream and potentially interactive processes.

Now consider critical loops where steadying the process is viewed as a nonstarter. Those are usually the loops deemed too financially important or too technically challenging to be subjected to a software program's steady-state criteria. With a similarly distinct bump test, the per-



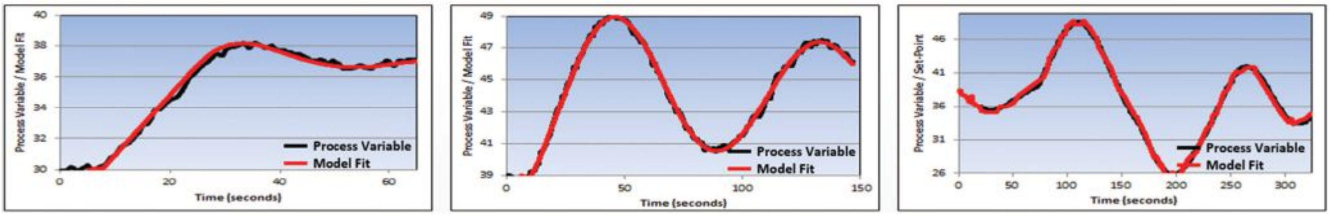




**Figure 3: Tuning software equipped with non-steady-state (NSS) modeling eliminates the steady-state requirement and has been shown to accurately model highly variable dynamics typical of industrial process manufacturing. These are graphs of NSS models applied to the tests shown in Figure 2.**

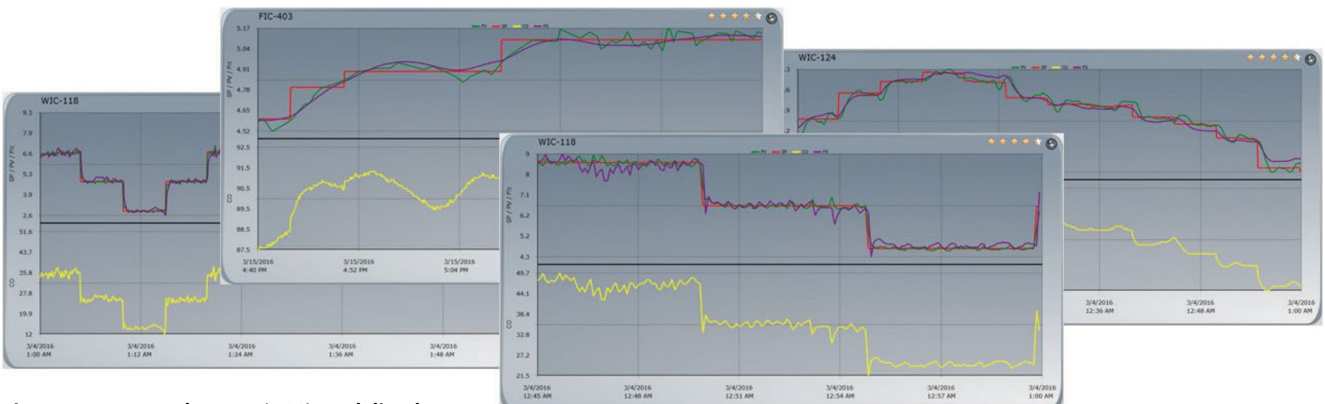



**Figure 4: Non-steady-state (NSS) modeling has enabled manufacturers to improve control of complex loops and to realize meaningful financial gains. Its recent integration within control loop performance monitoring (CLPM) solutions is creating new opportunities for plantwide process optimization.**

formance of these loops can finally be improved with the application of NSS modeling.

## Overcoming loop tuning challenges

**Tuning a plant's regulatory controllers can improve production quality and throughput.**

Finally, consider processes characterized by exceptionally large dead-time or time constant values. It may be understandable that a requirement for steady-state to steady-state testing would exceed the patience of most operational staff members, but that shouldn't be the case with software. For a variety of reasons, exceptionally slow systems consistently foil the modeling capabilities of traditional tuning software products.

NSS modeling is proprietary. It functions equally well using open-loop as it does using closed-loop process data. More importantly, it generates accurate models across the full range of industrial applications—think non-integrating loops such as temperature and pressure, as well as integrating processes such as level, concentration, and even pseudo-integrating processes such as batch temperature.

As shared by others, the performance improvements and financial gains achieved by tuning PID controllers can be significant (see Figure 4). Tuning a plant's regulatory controllers can improve production quality and throughput. It can reduce energy consumption and production-related waste. The effects enhance a plant's top-line revenue potential along with its bottom-line profitability. Given the competitive nature of manufacturing, those benefits are meaningful.

Fortunately, tuning software's biggest deficiency has been addressed. With the ability to accommodate noisy, transitional, and oscillatory data, tuning software can finally be applied with positive effects to loops that were previously too challenging.

***Damien Munroe** is general manager of Control Station Limited, Roscrea, Ireland.*

***Ricardo Caruso** is services manager of Aquarius Software Ltda., São Paulo, Brazil.*