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Embedded APC tools reduce costs of the technology

Control projects can be more easily justified for smaller plants

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Advanced process control (APC) techniques often show significant improvement over regulatory PID functions in both continuous and batch processes, with potentially huge returns.[1,2,3,4] Historically, APC projects have required very specialized skill-sets and experienced resources to implement and maintain—limiting use of the technology to only very large refineries or petrochemical plants that could justify such an expense. New embedded APC tools offered by some automation suppliers are starting to change that. Ease-of-use features designed into these tools aim to make APC blocks almost as easy to use as a PID loop.

Lower APC implementation costs have enabled smaller manufacturers to take advantage of the technology.[5] But is the technology ready for mainstream control engineers—those who make their living working in the guts of our control systems? Is it time to add new tools to every process control engineer's toolbox? Recent advances in embedded APC technologies are impacting the process control industry and how its practitioners do their work.

Past obstacles to APC implementation. Many leading companies recognize that APC applications can produce significant improvement in control of complex processes, particularly those with long dead- or lag-times, interacting loops, highly constrained operations or inverse response. Model predictive control (MPC) techniques developed in the early 1970s have been successfully applied to these kinds of processes with excellent results.

A worldwide survey conducted by Qin and Badgewell showed that, of the roughly 2200 installations surveyed, over 82% of all APC applications were implemented in the refining and petrochemical industries, and the majority of these applications were in large facilities of the major refiners.[6] One must question whether other industries and smaller refineries do not have similar control problems that could benefit from these techniques. The most likely reason for this disparity is the historical cost to implement and maintain the APC functions.

Traditional APC technology is usually implemented in a supervisory architecture similar to that depicted in Fig. 1. In this environment, the APC applications are executed in a separate computer, interfaced by some means to a DCS that performs the basic control functions and field I/O. The supervisory system usually has its own user interface, DCS drivers, database, scheduler and tag synchronization issues. Usually, at least some level of custom programming is required in the DCS to provide the operator on/off functions, fail/safe logic and watchdog timer functions.

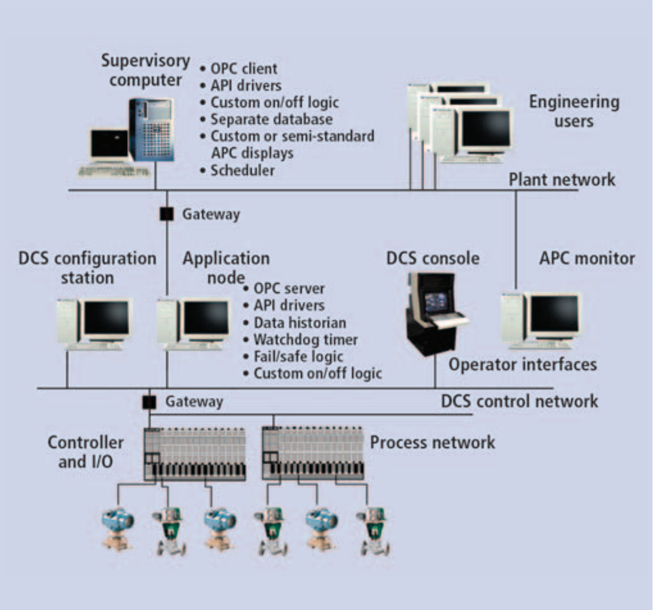

FIG. 1 Traditional advanced process control is usually implemented in a supervisory architecture.

Step-testing the process often requires 24-hr engineering coverage for days or weeks at a time. Furthermore, APC applications historically required very experienced consultants with specialized skills to implement and maintain. As a result, only the largest processes with the biggest potential benefits could afford to implement these technologies.

Unfortunately, a significant proportion of APC applications implemented over the years have been turned off within a few years after commissioning. A number of reasons for this problem are:

- *Regulatory control problems*—The basic regulatory loops must work well before an APC application has any chance of success. Malfunctioning valves, poor tuning and controllers in manual can cause APC performance to deteriorate.
- *Process changes*—Any change to the process that affects the controller design or significantly changes the dynamics or gain of the process models will require additional work to update the APC applications.

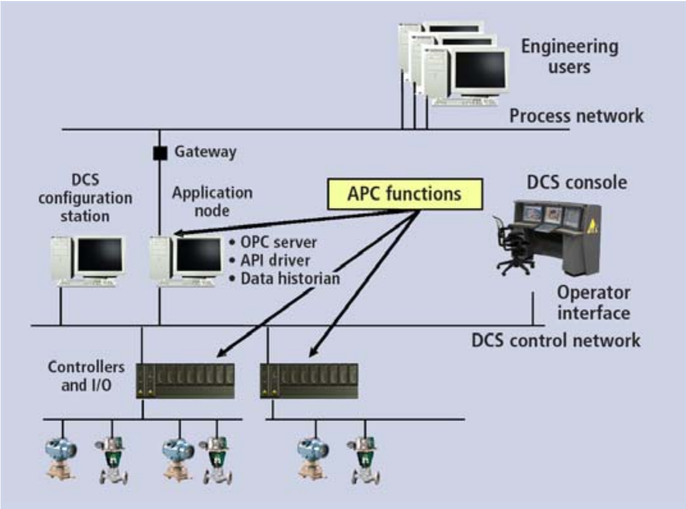

FIG. 2 In an embedded advanced process control architecture, functions can be distributed and executed on multiple controllers or application stations running on the native control system bus.

• *New constraints or limits*—Process or equipment limits that were not considered in the original control design must be incorporated into the APC strategy.

• *Different control objectives*—Sometimes the process operating objectives change from the original design due to changes in economics, feeds, constraints or operating conditions.

• *Controller requires restepping process*—Any time process dynamics change significantly, the process needs to be restepped and the models refit to reduce model errors. This can be an expensive, time-consuming process.

• *Applications not maintained*—Applications need to be continually revised to stay up with the latest operating systems and software versions. Once the applications get too far out of date, it becomes prohibitive to upgrade them without significant investment.

• *Maintenance not budgeted*—Just like a pump or compressor, software applications need resources assigned and funding to maintain them and make sure they are used.

• *Lack of operator training*—If the operators do not understand what the controller is doing, it will get turned off. It is important that operators are properly trained on APC technology and advanced control strategies to ensure uptime is maintained.

• *Too expensive to bring in APC consultants*—The cost to hire APC experts to redesign, reconfigure, step-test, model, update documentation and recommission an existing APC application can be almost as much as the original engineering services. These expenditures often need to be planned and budgeted from tight operating and maintenance funds.

With the advent of new embedded APC tools, many of these problems go away. In more recent experience with APC projects, companies are seeing nearly 100% uptime for the applications years after their original implementation, without the need for bringing in outside consultants.[4,5]

What's new about these tools? Embedded APC functions eliminate need for a separate supervisory system and all the extra databases and programming that go along with it. The new tools are just part of the automation architecture—like a PID block—completely removing a whole layer of complexity in systems, software, databases and interfaces.

Under the new architecture, APC functions can be distributed and executed on multiple controllers or application stations running on the native control system bus (Fig. 2). As a result, the effort to implement and maintain these applications is dramatically reduced. With these new systems, there are:

• No extra databases to maintain on the supervisory system

• No database synchronization issues as points are added, changed or recalibrated

• No watchdog timers required to confirm that the APC application is still working

• No controller fail/shed logic design to automatically handle failure of an APC application

• No custom DCS programming required for on/off logic or shed

• No interface configuration or programming to communicate between the DCS and the supervisory computer

• No separate operator interface monitors or custom graphics for the APC functions.

A few vendors offer embedded APC tools that can run entirely in automation system controllers, in a high-speed, robust and redundant environment. This architecture opens the technology to a whole new class of control problems, including those with very high-speed dynamics or applications that need to output directly to a valve instead of a PID controller setpoint.

Vendors have been working hard to automate and simplify many of the tasks required to configure, test, develop models and commission APC functions. Automated step-testing tools are common for most of the major APC vendors. "Wizards" guide a novice user through the implementation process with minimal need for a deep understanding of the actual mathematics or technology. Newer systems use the familiar Microsoft Windows look-and-feel with standard features like right-click, drag-and-drop, and copy and paste. Modern APC applications are graphically configured with prebuilt function blocks and built-in tag browsers (Fig. 3).

The new systems automatically detect common design problems like colinearity and ill-conditioned matrices and warn the user when these conditions occur. Poor step tests and modeling results are similarly flagged and displayed to the user graphically with confidence limits and statistical indicators.[7]

Embedded tools have the advantage that data are collected, analyzed and used to generate APC applications entirely in the control system, so there is no need for external interfaces, historians or transferring files between systems. Also, most of the configuration, testing and modeling work is done onsite, eliminating the need for a staging system and a factory acceptance test in the APC vendor's office.

What does this mean for practitioners? The primary result of these enhancements is development of a class of APC tools that are easy to use, and designed for typical process control engineers with limited training and experience. Chris Kominar, the process control engineer at the Ergon West Virginia refinery in Newell, West Virginia, states, "We implemented our first APC applications on our crude and vacuum distillation columns in less than six months and reduced standard deviation of our critical product qualities by more than half for our most valuable products. This allowed planning to decrease the operating target range from 10 to 6 degrees."

Neil Stanton, the refinery manager at the site claims, "The cost for implementing and maintaining these applications has fallen by more than 25–50%, based on my past experience and impressions. We are very pleased with the results and have been able to maintain close to 100% uptime strictly with our own staff."

For those that invest in control system platforms with embedded APC tools, there is great potential to take advantage of APC technology at much lower cost. BP's BDO plant in Lima, Ohio, uses embedded MPC tools to solve unique control problems where regulatory controls have proven unsatisfactory.

One small application saved more than $300,000/year in natural gas savings alone. The plant uses small MPC applications on a few distillation columns and for controlling a hydrogen plant feed rate. By compensating for significant dead-time, and handling multiple constraints, the MPC controllers are able to stabilize operation across shifts and operate closer to minimum hydrogen requirements. These applications use predictive features to improve control of long dead-time processes with excellent results and huge paybacks, even for single input single output (SISO) problems.

While the new APC tools do not require that you know the math, and they warn you when anomalies are present, some experience with APC techniques is helpful. Knowledge of the process is critical. This implies process engineers will have a strong role in future APC implementation, while decreasing need for systems and software skills. A linear program (LP) configured in an MPC loop can automatically drive the unit to the right (or wrong) operating point, depending on the model gains and prices entered. Thus, participation with the plant's planners and schedulers is essential to ensure control strategies are designed and used properly to achieve desired operating objectives.

With systems, software and interfaces no longer an issue, the most difficult part of an APC implementation project is the functional design and step-testing. First, persuading the operating team to allow step-tests is sometimes a challenge, and the trust and patience of an operator is easily lost and difficult to win back. An experienced guide can help ensure that the needs of the modeling effort are met without making any operator's day longer or harder: Part of the "art" of APC is performing the tests in a way that is least disruptive to the running plant, while still getting meaningful data.

Good preparation can help ensure that good models are derived without need to restep the process, which further reduces stress on the organization. Prestep tests are still recommended to get a feel for the dynamics and understand relative gains for each manipulated variable. Automated step-testing tools help execute the tests without requiring 24-hr engineering coverage.

Problems with the regulatory control loops must always be resolved before attempting to add any APC blocks. This activity typically includes tuning PID loops, properly sizing valve trim, fixing valves that stick or exhibit excessive hysteresis, replacing faulty measurement devices and transmitters, and installing digital valve positioners. Modern automation systems have loop performance monitoring and asset optimization tools that flag instrumentation problems and provide infrastructure necessary to keep control loops performing optimally—thus keeping APC systems online longer.

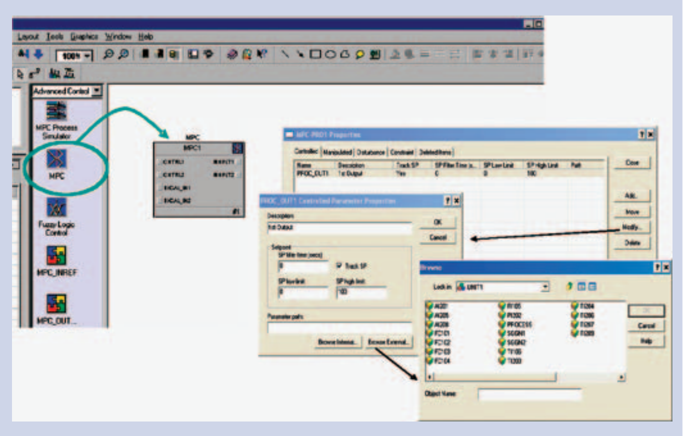

FIG. 3 Modern APC applications are graphically configured with prebuilt function blocks and built-in tag browsers.

Services still required. While the ease-of-use accommodated by new APC tools may tempt novices to "Do It Yourself," the services of an experienced APC specialist are still recommended for your first projects. APC tools still require some level of experience to appropriately design and use, although the skill level is now greatly reduced. Understanding the process and its interactions, combined with basic knowledge of APC tools and their application, are keys to identifying and designing APC functions that provide high returns.

The new tools do not remove the requirement for step-testing the process, although the engineering effort required for testing has decreased. Finally, the basic regulatory functions are still a critical element in overall success of the APC project and must be addressed first. But today's intelligent field devices and modern asset optimization systems are designed to help control engineers keep the automation systems humming and the APC applications online.

As a result, the new family of APC tools embedded in the automation architecture has dramatically lowered the cost, time and effort to implement and maintain these applications. Simple functions for solving loop interactions, multiple disturbance feed-forwards and constraint selectors can easily be implemented with a single MPC block. Implementing a neural net to predict unmeasured qualities takes only a few hours to set up, train and turn on.

These tools should become part of every process control engineer's "bag of tricks" to be applied where appropriate. The mysticism and apprehension associated with APC applications are decreasing. Management's impression that APC projects are expensive and require special funding and appropriations is becoming outdated. These are just tools of the trade. **HP**

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