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What is APC 2.0?

Large-matrix model-based multivariable control (call it MPC or APC 1.0) has been the dominant advanced process control technology in industries such as oil refining, chemicals and petrochemicals, for going on three decades.

The virtues and successes of MPC aside, it has also earned a reputation as an ownership challenge in many areas, including cost, maintenance, support and performance. While MPC may always be the preferred solution in select applications, many end-users have long been moving away from MPC as an everyday tool, even if the technology to backfill that gap (call it APC 2.0) has yet to fully emerge.

Experience makes it increasingly clear that industry needs a multivariable control tool that is much more *agile* – more operation-friendly in every respect – to enable renewed progress in advanced process automation. Thirty years of the APC 1.0 paradigm have left many people thinking that large-matrix, model-based, multivariable control and optimization, must all go together – that you can't have one part without all the others. But experience now shows that alternative solutions are actually quite possible and even readily available within existing modern control system capabilities.

Going forward, how will the emerging APC 2.0 paradigm differ in key respects from APC 1.0?

- APC 2.0 will feature a matrix, but not necessarily models
- Focus will shift to control-layer automation and business-layer optimization
- *Operational* performance will become the new norm (after fully 75 years of Zeigler-Nichols!)

Behold the Matrix!

Probably the most important and enduring contribution of the model-based era to process automation will prove to be the matrix (not models). The matrix has emerged as the natural way to define the essential aspects of the multivariable nature of almost any process. It captures the available handles, important constraints, useful interactions, and optimization potentials, in a useful intuitive format. It serves as a guide to operation and as a specification for automation. The matrix puts all members of the operating team – control engineers, process engineers, and operations personnel – onto the same page, to align their efforts for more effective operation. Industry owes a large debt of gratitude to APC 1.0 for bringing the concept of the matrix to the forefront of process operation and automation technology.

Models, meanwhile, have proven to be unreliable and as much a vulnerability as a strength. Building an APC solution based on model-based control theory, experience has shown, front-loads the solution with many ownership challenges. It remains to be shown – 30 years on – whether that burden is sustainable or ultimately outweighs the benefits of using models in the first place. Fortunately, experience and emerging technology also suggest that models may actually be dispensable to the job of performant closed-loop control.

- Figure 1: The matrix and its fundamental elements (located at end of document)

Automation rules! (at the control-layer)

In most industrial process operation, the optimization solution (i.e. the target operating point), just like the matrix (i.e. the operating window), is well-known *a priori* by the operating team. Process engineers are likely to make process economics, constraint limits and key process interactions, the first things they learn about new processes; and operators are unlikely to move up to the console or supervision without learning these aspects of operation. This knowledge is *common knowledge* among the operating team, so that building an optimizer into the APC solution to come up with it on a real-time basis is largely superfluous. It adds substantially to APC complexity and ownership burdens, without adding commensurate new value.

A better paradigm is to let optimization results flow down from the business layer to the control layer, whether via the computer system or the chain of command (these are both common today in any case). The business layer has a vastly more global optimization horizon – much more complete information – and results do not normally change in real-time. The essential role of APC is to honor these optimization results in the live process environment, where the related process values (not optimization results themselves) are subject to change in real-time. This optimization paradigm is more streamlined, eliminates the redundancy and enables each layer to focus on its essential role.

- Figure 2: The APC 2.0 optimization pyramid (located at end of document)

Operational control performance

Virtually every aspect of modern process control technology is rooted in the concept of models. But it turns out that control performance is one area where industry does not want a model-based solution. Industry wants *operational* performance. This has been another long slow lesson of APC 1.0 – and of single-loop PID control for even longer!

Operational performance, in a nutshell, means having preset process "speed limits"; approaching targets and constraints in a steady first-order manner; avoiding overshoot and oscillation; and taking extra precautions where appropriate to preserve and assure process stability at all times. This is quite a different statement – and in sum directly conflicts – with traditional error-minimization control performance criteria, which is based on process models.

Experience has shown that operators are perfectly willing to sacrifice automatic control – place loops in manual and circumvent (degrade or switch off) APCs – whenever operational performance is not forthcoming. To achieve greater success, APC 2.0 – both single-loop and multivariable – must come to grips with *operational* process control performance criteria.

Figure 3: Error-minimization vs. operational control performance (located at end of document)

Agility is the word

All this suggests a more *agile* APC 2.0 solution and paradigm. This means costs that fall within normal operating budgets; schedules that fall within modern manufacturing precepts – days or weeks, not months or years; support requirements that fall within the purview of on-site control engineers; performance that meets with operations' expectations and approval; and technology that falls within existing control system capabilities (think function blocks). To the extent this paradigm has yet to fully emerge, industry would do well to make this its target paradigm.

	CONSTRAINTS	51AI110	51AI115	51AI116	51AI125	51PC105	51PDI104
HANDLES		NAP90	KERO90	KEROFLSH	DSL90	PRESSURE	TOP DP
51TC102	FEED HEATER					+1	
51FC103	BOTTOM STEAM					+1	
51FC128	PUMP-AROUND					-1	-1 OPT
51TC106	TOP TEMP	+1 OPT	+1	+1	+1		
51FC112	KERO DRAW		+1 OPT		+1		
51FC122	DIESEL DRAW				+1 OPT		
51HC128A	PA BYPASS					+1	+1

Figure 1: A sample matrix for a crude oil distillation column. The concept of the matrix may prove to be the most enduring aspect of the model-based era (not models). Its principle elements include control handles, constraints, interactions, and optimization objectives.

Slide 1

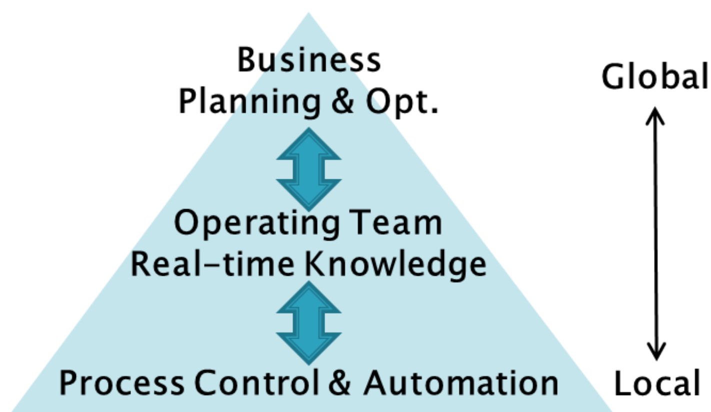

Figure 2: The APC 2.0 paradigm avails itself of business-domain planning and optimization, which eliminates redundancy and empowers each layer to focus on its core area of expertise and responsibility.

Slide 2

Figure 3: The analogy of a passenger plane changing altitude illustrates why 'operational performance' criteria are more appropriate for industrial process operation than traditional model-based error-minimization.

Slide 3