Applications and Benefits of Advanced Process Control in M&M

Background

A technology has no value unless it can drive profits for the Mining and Metals operation. Process control can play a dominant role in driving the company bottom line. Every time an operator makes a set point change, it can affect the plant profitability. Today, determining whether the Operator decisions are good or bad has become increasingly complex due to many conflicting factors involved. Not only must traditional Operator objectives be met such as maximizing production and/or product quality, but now new factors have been introduced to the modern-day Operator. For instance, decisions around control set point changes now take into consideration minimizing energy consumption, minimizing water consumption, minimizing environmental impact and others. And all the while, attempting to maximize the plant profitability. One solution is to use advanced process control (APC). Modern-day APC solutions no longer makes this an insurmountable task for Mining and Metals operations to use.

What is Advanced Process Control

Advanced Process Control is a general term used to describe process control software that simultaneously controls multiple setpoints of a process. As shown in Figure 1, an APC is a supervisory control system that sits on top of the existing controls.

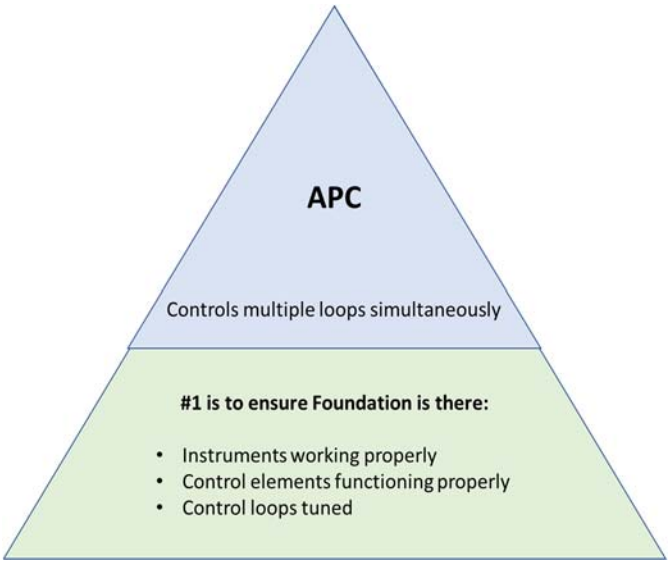

Figure 1 *Foundation of APC is good plant control*

For an APC to work properly, firstly all the existing instrumentation, control elements and the control loops need to function correctly – i.e.; "the Foundation" needs to be in place. APC's sit on top of this Foundation, reading process variables, and then simultaneously writing to multiple controller set points, with the software safely making optimum decisions based on pre-established operating constraints.

The software technology has progressed to the point where APC's commonly use an optimizing engine to maximize profits for a broad range of given operating variables and constraints. Early APC adopters were found in the Oil and Gas industry during the 1960's where significant bottom-line profitability was experienced and documented.

The technology has increasingly become more "mainstream" not only because of the recognized and fully-established benefits, but because costs have decreased due to improved control system OPC connectivity, lower software licensing costs and easier "off-the-shelf" implementations.

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There are four types of process variables used in an APC:

- Controlled (CV) – where the -process output is to be maintained at a specific setpoint
- Constraint (AV) – the process output which must be maintained within a specific range (takes precedence over target)
- Manipulated (MV) – which is the process input that is adjusted to maintain a controlled variable at setpoint or a constraint variable within limits
- Disturbance (DV) – the process input which may affect both controlled and constraint variables (feedforward)

The math behind what an APC uses can vary widely. APC is the "umbrella" term that encompasses a number of techniques, including:

- MPC or Model Predictive Control (the most commonly used technique)
- neural networks
- expert / rule based systems
- fuzzy logic systems
- genetic algorithms
- non-linear / multivariable control
- optimal / robust control

The choice of the math model (or combination thereof) would depend on the process itself. Other model choice considerations would be the ease of installation and the long-term maintenance requirements of the application. For a company with multiple sites and various process control systems (PCS), having a common APC platform helps with support, training, people movement, strategy sharing, and sustainability in general. There should also be within the organization an "owner" of the APC installation who ensures Operator usage of the APC is more than 80% utilization. Typically, it would be the plant process engineer or metallurgist. The ISA competency model for ownership of the APC is a good guideline to follow. For security reasons, PCS access is usually limited to process control staff and the third-party APC solution provider.

How and Where APC is Used in Control Systems

APC's connect to existing control systems, typically at an ISA-95 standard Layer 2 or 3 of a control system architecture. An OPC server is typically used by the APC to ensure trouble-free reading of Layer 0 instruments and writing to Layer 0 control elements, being controlled through the Layer 1 controllers. The best APC software is compatible with any control system in use at the M&M facility. Best practice is to locate the APC application on a server within the secure control network and follows good standards for process network security per the ISA-99 standard:

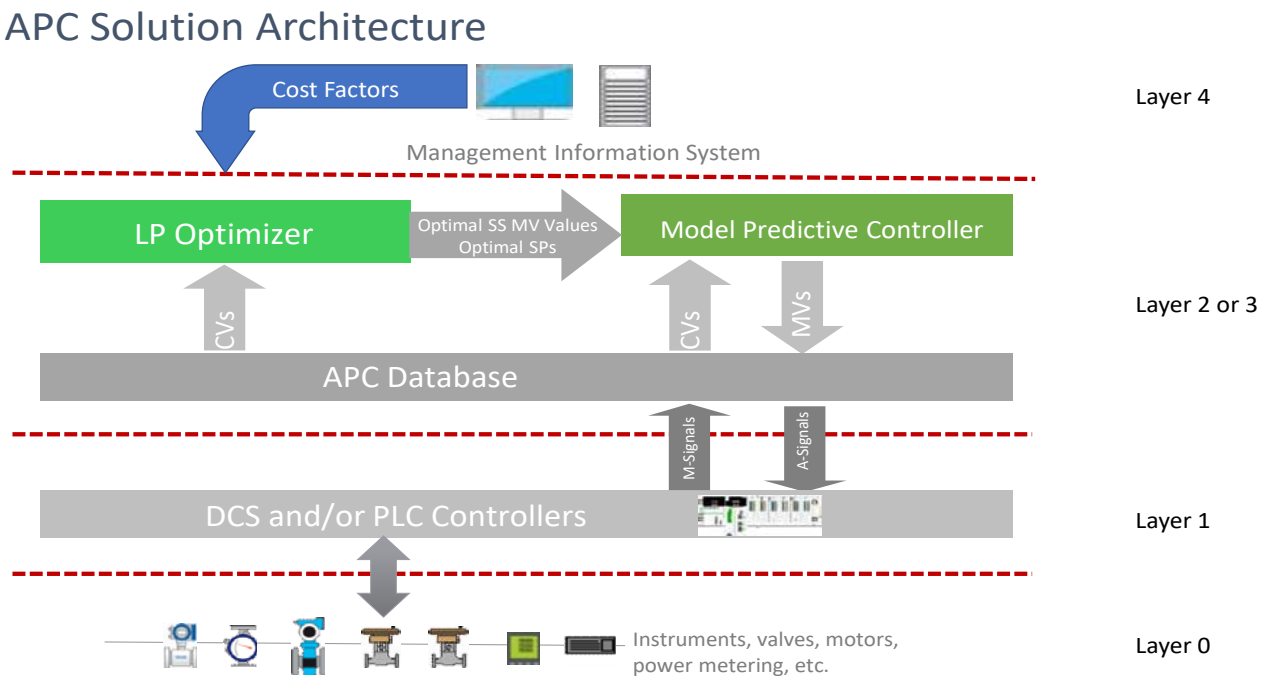


Figure 2 Installation of APC follows good security practice like ISA-99

Security considerations are important because the APC plays a direct role in the control system function. Any APC-related activity such as optimization, often use connectivity with the business network. This requires a secure connection to the "outside" world. It would also include monitoring APC performance and connectivity, reporting APC usage KPI's, accessing system diagnostics, and remote access for support by specialists.

Benefits of APC in your Mining and Metals (M&M) projects

For the Mining and Metals industry, APC's have been successfully implemented with documented benefits of guaranteed production improvement. Depending on the project size and complexity, installed costs of APC projects range between $200k – $500k with returns on investment of 1 year or less. In the M&M industry these kinds of ROI's exist for applications such as:

- SAG and ball mill grinding
- Washing and finishing circuits
- Flotation circuits
- Roasters and other pyrometallurgical processes
- High-Pressure leach and other hydrometallurgical processes
- Cement processing and lime kilns

Typical APC projects can take between 6 – 10 months to complete and commission. APC and optimization can improve operating profit margins in 4 ways:

i. Higher production rates with documented improvements typically from 3% to 5% – by pushing against constraints.

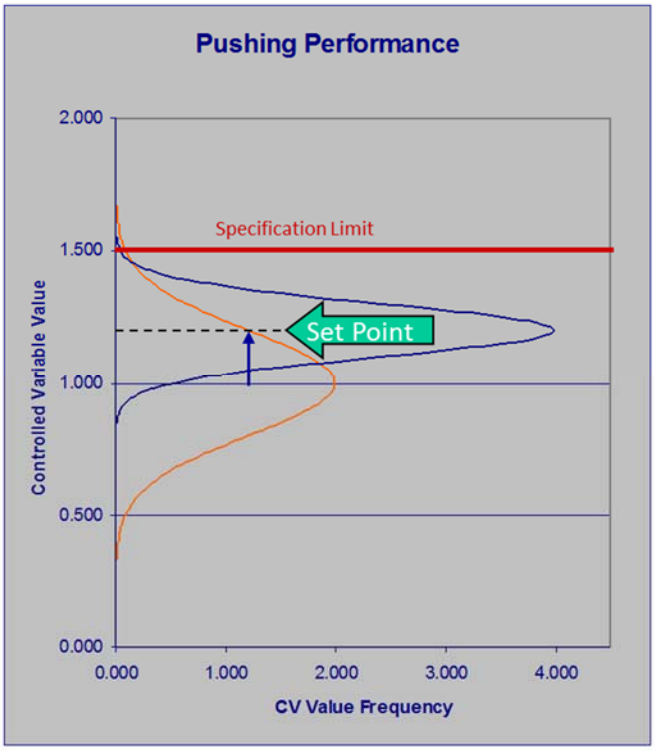
ii. Lower raw material, energy usage per unit of product and emissions with documented improvements typically from 3% to 5% – by pushing against constraints.

iii. Lower product losses & rework – by reducing quality variability with documented improvements typically from 10% to 20%.

iv. Improved maintenance costs such as reduced refractory consumption with documented improvements typically from 10% to 20%.

Approach in Justifying APC

Justifying an APC is done by establishing process variability of key process variables (CV's) for the manipulated variables MV's. And then an estimate is made on the reduction in key CV variability – it's typically a reduction in one-half to one standard deviation. Establishment of DV's or feedforward variables and AV's or process constraints, will determine the limits on what would be the potential change in the new setpoint.



Justification is developed by predicting the potential process variability reduction and then the corresponding potential change in setpoint based on the Specification Limit constraint. This is nicely shown in Figure 3:

- Random influences create a normal CV variation.
- Advanced control can reduce the standard deviation of a performance variable typically by up to a half.
- Then, moving the set point an amount equal to the reduction in initial standard deviation or to the constraint limit, it will yield economic benefits with no degradation of product quality.
- Based on a newly-established set-point, an economic justification can be made to project expected benefits.

Figure 3 Setpoint can be changed after process variability is decreased

Economic justification is calculated by computing the expected change in 3 basic components for the operation unit run time (RT):

Change in Production Rate (PR) and Product Value (PV)

$$(PR_{new} \times RT_{new} \times PV_{new}) - (PR_{old} \times RT_{old} \times PV_{old})$$

Improvement in Energy Efficiency (EE) and Energy Cost (EC)

$$(PR_{old} \times EE_{old} \times RT_{old} \times EC_{old}) - (PR_{new} \times EE_{new} \times RT_{new} \times EC_{new})$$

Improvement in production Feed Rate (FR) and Product Yield (PY)

$$(FR_{old} \times RT_{old} \times PY_{old}) - (FR_{new} \times RT_{new} \times PY_{new})$$

APC's are a great opportunity for the M&M Industry

In summary, APC's are becoming increasingly common-place with the Mining and Metals industry. This is due to decrease in project capital cost, relatively fast commissioning times of less than two months (and without plant interruption), along with recognized and proven increase to plant profitability. Most the major automation companies have proven APC solutions and most are built on similar technology platforms. APC applications are no longer development projects and now can be characterized as using well-established control engineering methodology.

APC software has become increasingly easy to use and with many modern-day features. Best in class developments in APC software now include

- Modern and intuitive User Interfaces, tag-building, data management and easy-to-use historian
- Secure and integrated OPC connection tools into the control network
- Capability to interface with other business systems for optimization and "big data" integration
- Auto-model build capability
- Customizable models to support unique process behavior
- Integration with first principles dynamic models
- Improved performance monitoring

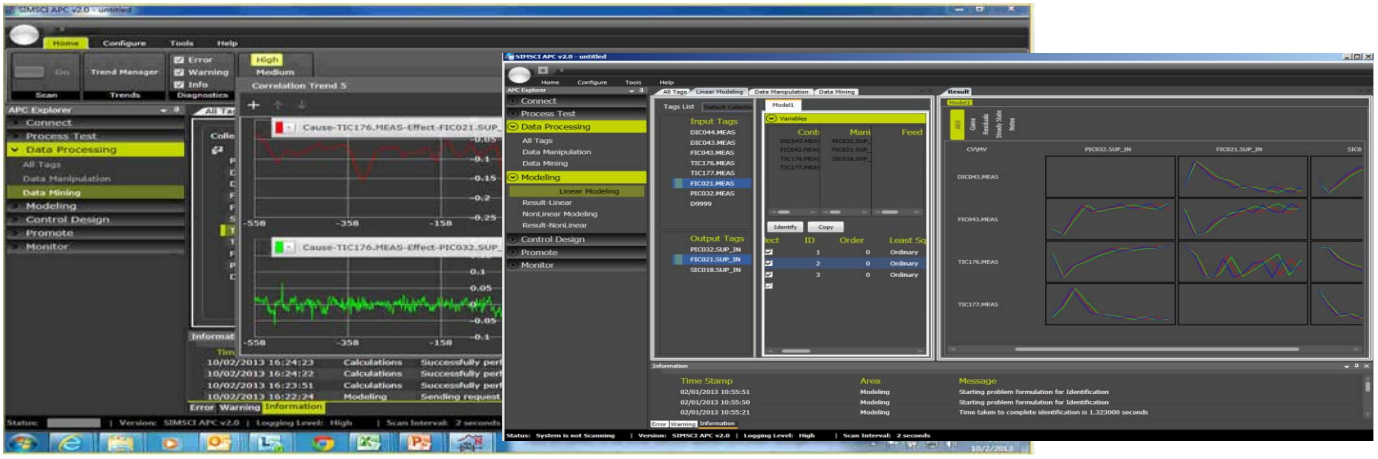


Figure 4 Modern-day APC software now have an excellent User Interface following ISA 101 standard
Photo with permission from Schneider Electric SimSci APC

A well-run APC project always starts with a well-defined scope and an up-front establishment of project deliverables. In some cases, those deliverables can even be guaranteed by the vendor. A key factor for success with any APC project installation is good support by automation company, along with their experience in the APC end-use application. APC applications truly are a technology of value and can drive profits for the Mining and Metals operation!

Further references

1. ISA-95, Enterprise-Control System Integration. https://www.isa.org/isa95/
2. ISA-99, Industrial Automation and Control Systems Security. https://www.isa.org/isa99/
3. ISA-101, Human-Machine Interfaces. https://www.isa.org/isa101/