WHITE PAPER

Achieving Operational Excellence in the Chemicals Industry Using APC

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Introduction

Most chemical operators would agree that operational excellence is one of the major pillars in achieving and maintaining a strong market position. One of the keys to achieving operational excellence is through a well-planned Advanced Process Control (APC) implementation program. APC applications have been proven to improve variable margins by leveraging existing capacities, reducing energy costs, maximizing production and reducing variations in product qualities.

The goal of APC implementation in the chemicals industry is simple: to maximize margins while meeting customer expectations. This paper explains how to achieve that goal using APC applications in the chemical industry.

How APC Delivers Benefits

Advanced Process Control has been around since the early to mid-80s and initially was mainly implemented in refineries and petrochemical sites. APC is a process control and optimization technology that takes into account the multivariable interactive nature of process units to reduce variability and drive the process to an optimum on a minute-by-minute basis. This is done by manipulating variables such as feed flow, temperature settings, pressure settings, and reflux flows, which are normally changed by operators who run the unit.

Process units without APC typically have higher variability in process parameters. As a result, there is variability in energy usage, production yields, product specifications and production rates resulting in lost profits. Variability in process can also result in issues that are not as easily translated into lost profits, but are important to safe and reliable operations of the process unit. For example, variability in reactor temperatures and furnace tube skin temperatures affect catalyst life and tube life respectively. Below is a summary of how APC delivers benefits.

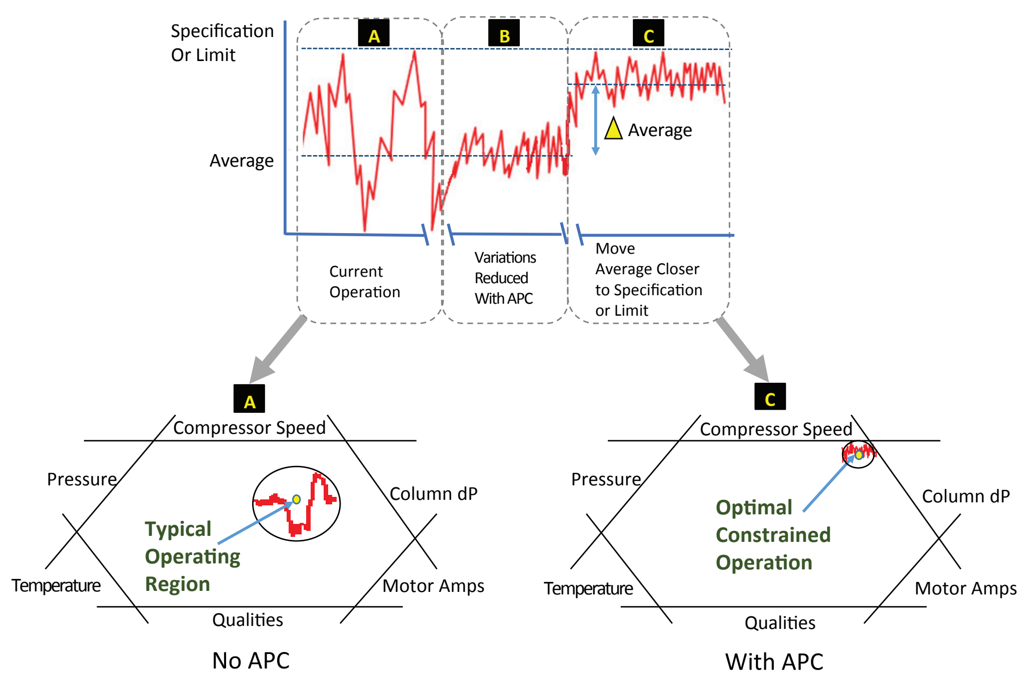

Figure 1: How APC delivers benefits

Because of the multivariable nature of process interactions and variability that is inherent in process units, operations cannot fully optimize the process manually, as this will result in key variables moving out of the desired range of operation from time to time. To be on the conservative side, operations are forced to move the process out of optimum and into a more comfortable operating range (represented by "A" in Figure 1). However, this often results in higher costs and/or lower production rates. There is more energy usage, lower yields and lower feed rates compared to operating with APC.

For decades APC has proven to reduce the variability in the process (represented by "B" in Figure 1) by actively controlling key process parameters on a minute-by-minute basis. The controlled variables are stabilized and the standard deviation is reduced. Once the key variables are stabilized the optimizing nature of APC is used to move the process to a more optimal point (represented by "C" in Figure 1). This results in consistently operating the unit close to the maximum possible profit day in and day out, safely and reliably.

Identifying APC Opportunities and Benefits

The first step of implementing an APC program is to understand what process units or part of the units are good candidates for APC. To be able to quantify benefits and improvement opportunity, it is necessary to first understand the economics of the unit and the production process. It is also necessary to consider the unit by itself or in many cases its role within the bigger production value chain.

If organizations have business or process KPIs, they can serve as a good starting point for analyzing the APC opportunities. There are many different ways potential APC benefits can be calculated. Below are some specific examples that can be used to quantify the benefits associated with an APC project.

1. Production Increase

Typically, APC projects have proven to increase capacity by 3-5%. By reducing the variability in the process and operating closer to limits (represented by "C" in Figure 1), APC debottlenecks the process or part of the process, allowing for higher production rates. An understanding of how the intermediate products affect downstream units, and why is required. Are these determined by market conditions or by process conditions? If the unit is constrained by process conditions, what would it mean to the overall value chain to debottleneck the constrained unit? Identify which units in the value chain are the bottleneck and how an increased throughput in the range of 2-3% would benefit the company.

2. Energy Savings

Energy savings from APC implementation have been reported to be in the range of 3-15% depending on the process and current operations.

Let's consider a simple distillation column. Assume that the overhead top distillate quality average is 99.8% and the specification is 99.2%. Because of the variability in the process, operators keep a higher purity than minimum to remain within specification and operate in the "comfort zone". This could be done by refluxing more than required, resulting in more energy usage in the reboiler section of the column. The amount of steam saved on reducing the giveaway and operating closer to the specification of 99.2% can be calculated.

Most of the time, utilities management, especially steam, is a complex control issue which spans across the site and at times also affects the electric grid. APC applications can be designed to manage utility systems effectively by matching steam production to the site's demand. Benefits come from reducing pressure let-downs and reducing or eliminating vented steam on site. Many companies report a 60-90% reduction in vented steam using APC.

After the steam header pressures are stabilized, APC can also be used to optimize energy production. For example, boiler loads, gas turbines or other sources of energy can be adjusted to maximize the efficiency of the overall system while ensuring stable header pressures, day in and day out.

3. Quality Improvements

It's important to reduce variability in the final product quality. Some products, for example certain types of polymers and specialty chemicals, sell their product at a value which is dependent on the quality variability of the batch produced. Many companies report a reduction in standard deviation of product qualities of up to 50%. If the production quality standard deviation was reduced by 30-50%, how much of a price increase could that product command?

4. Yield Improvements

Many companies report a yield improvement of 1-2% through APC deployments. This is typically achieved by optimizing the reactor part of the process and/or the separation portion. In almost all cases, the reaction is highly exothermic or endothermic, meaning good reactor temperature control is key. Additionally, good control and optimization of the ratio of feed components to catalyst is also very beneficial. Well-controlled reactors typically see an increased yield of 0.5% per pass at the same throughput rates, while maintaining safe operating temperatures. In some cases, it has been proven that a well-controlled polymer reactor online time is increased by up to 5% before a shutdown is required to clean out the reactor, resulting in improved yields and throughput.

For the non-reaction part of the process, such as distillation columns, maintaining the specifications on the final product can increase the yield of the desired product by increasing impurities up to the contracted specifications. Higher amounts of lower value products (impurities) in the final product are sold as higher value product, while maintaining the specifications and customer expectations.

5. Optimizing the Polymer Production Wheel

In polymer production, the production wheel is usually not optimized to market needs, as difficult transitions may be rejected by operations. Without APC, grade transitions take longer and result in low value products produced during these transitions. It's common to see a 20-50% reduction in grade transition time. Through APC, it is possible to "bust the production wheel" and produce grades when they are in demand, while minimizing the time when the low-value transition products are produced. Companies using APC in conjunction with supply chain software can exploit the new capabilities to further optimize the production wheel.

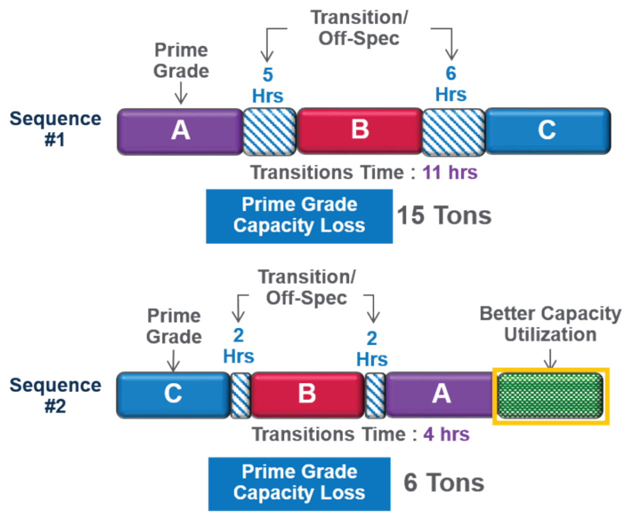

Figure 2: Optimizing the production wheel

6. Recycle Ratios

Units that have recycles are good qualifiers for APC. The addition of the fresh feed components depends on the quality of recycle. Without APC, a fixed ratio of fresh feed to recycle is maintained. This does not consider the product quality or downstream equipment operation or the unit constraints. The multivariable nature of APC allows for optimizing the fresh feed to recycle ratio, to maximize throughput and/or maintain quality at specifications.

7. Emissions Control

APC implementation can also help control environmental constraints. By using APC to model and actively control the furnaces and boilers on a steam utility plant through APC, it is possible to operate closer to the emissions limits without violating them. It also helps decrease energy usage and minimize costs to meet NOx and SOx emissions constraints.

8. Exploiting Ambient Temperature Effects

APC has proven to exploit the benefits associated with ambient conditions. Ambient temperature has an effect on compressor performance, condensation capacity, gas turbine operation, cooling water temperature, refrigeration capability, gas volumes and many more process related conditions. Diurnal effects, humidity or even cloud cover have an effect on cooling water temperature, which can result in changes in compressor throughput limits. Operators cannot be expected to exploit the benefits associated with ambient temperature changes. This would mean anticipating the ambient temperature effects on the process and adjusting the process parameters only to reverse all changes as the sun rises in the morning.

Units that are affected by ambient conditions can benefit from APC applications as they can anticipate these changes and adjust process parameters accordingly on a minute-by-minute basis.

9. Dynamic Opportunities

Without APC, disturbances arising from upstream or downstream will effect process units and reduce margins. For example, in temporary situations where feed quality is decreasing by 1-5%, operators will react to keep the product on spec, but most likely not in an optimal way. When things are more stable the unit may not be optimized as the situation is temporary. This at best means producing on-spec product but at a very large giveaway. At worst it would mean decreasing feed to cope with the situation. Units that have APC will react to the disturbance in the most optimal way on a minute-by-minute basis.

Consider another example where 2% more feed is available temporarily. Increasing feed to the unit could disturb the unit for eight hours (high-purity columns have long settling times). In this situation the operations best practice is to not introduce this feed, which results in a missed opportunity. With APC, operators can exploit this situation due to the multivariable nature by controlling the unit and actively maintaining all constraints.

10. Site-wide Optimization Opportunities

Operating units with APC presents a larger scope of optimization opportunity for the site. Optimizing a part of the process as a standalone would mean lost opportunity compared to optimizing multi-units together. For example, pushing a reactor to maximum throughput might not make sense if the bottleneck of the unit is the off-gas stripper. If this happens, light materials that should be removed are pushed into either flare or off-gas where they are lost. At some point this may mean reduced margins. These interactions and constraints are considered in the design of APC systems and can lead to significant benefits for the overall site.

APC Deployment and Project Lifecycle

After identifying the business case for an APC project, the next step is to start building and implementing the APC controller. Traditionally, APC projects have been long and expensive with many defined steps needed for a successful APC commissioning. This results in lost margins during the lengthy deployment phase and disruptions to the process for gathering data to build APC models. Traditional APC technology also needs highly experienced users to build and sustain controllers.

Since the release of Aspen DMC3™ APC software, Aspen Technology has significantly changed the way APC applications are designed, deployed and sustained on sites. Aspen DMC3 features Adaptive Process Control (patent pending) technology that enables faster deployments and sustained benefits through continuous model updates in the background with no disruptions to the process. In one example, a complete cold end of an ethylene unit was completed from start to finish in less than three weeks using Aspen DMC3. With traditional APC technology, these projects take months to commission and generate benefits. Aspen DMC3 also features technologies that enable more and less experienced users to deploy and sustain APC controllers.

Project Lifecycle Using Traditional APC Technology:

1. Pre-Step Testing

This is the preparatory and exploratory phase, where the base control layer (DCS) structure is reviewed, basic control loops are tuned, and some preliminary step tests are made to the process in order to understand plant economics, current operations and dynamics.

2. Step Test

In this phase, the variables that will be manipulated by APC (flows, pressure set-points, etc.) are moved in a step fashion to generate data that will be used to build a model used by the APC controller. Traditional step testing, either through manual or automated testers, is an expensive exercise as parameters are moved further away from limits in order to gather appropriate data to model the process.

- Manual step testing is a much longer process, which takes about two to four weeks for a typical unit, and causes significant disruptions to the process. It also needs constant attention by both engineers and operators alike to keep variables within safe limits. Often 24x7 engineering coverage is needed to perform manual tests.

- Automatic step testing is an improvement above manual testing, however the production process is still disrupted and not at or near the optimum. The variables are free to move in pre-determined high-to-low limits in order to achieve a good step test and dynamic response of the process. If initial seed APC models are accurate enough it typically does not need 24x7 engineering coverage.

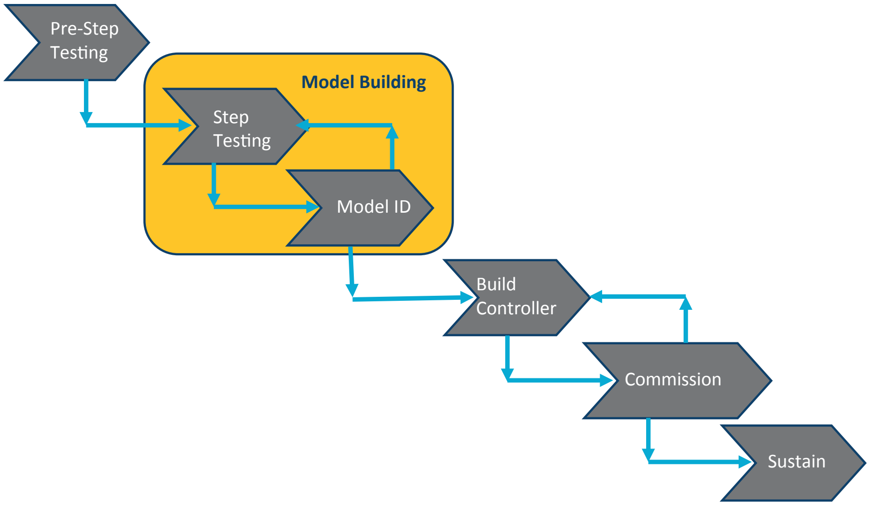

Figure 3: Tradional APC project lifecycle

3. Model Identification

Through the data available from ongoing step testing, APC models are identified to ensure good results are obtained. Final model identification is done when step testing has concluded.

4. Building the Controller

In this phase the controller is built and pulled together with the model. Initial tuning parameters are identified and economic targets are set. Tuning the controller using traditional technologies requires significant experience and careful consideration. The APC controller may also be connected to the DCS so that it is ready for commissioning.

5. Commissioning

The APC controller is commissioned online. This is the first time the APC controller is controlling the unit and starts delivering benefits. Operators are also trained on the use of APC technology.

6. Sustaining Benefits

As soon as the final commissioning has been concluded, the maintenance phase starts. It is well known that poorly maintained controllers will quickly lose the initial benefits. Significant changes in the process or economic conditions require changes in the APC controllers so that the benefits are sustained. A new operating regime usually means that the plant behavior may change. This requires additional data through re-step testing of the unit at the new operating point.

A complete ethylene cold end APC project was completed in three weeks using Aspen DMC3"

- Large international energy and chemicals company

Project Lifecycle Using Aspen DMC3 APC Software

Aspen DMC3 is the most advanced APC software currently available in the market. It addresses most if not all the issues encountered by using traditional APC technologies. Aspen DMC3 features Adaptive Process Control (patent pending) technology which enables background step testing, while optimizing the unit at the same time. This enables much faster and cheaper new APC deployments and a continuous improvement methodology for sustaining APC applications. Aspen DMC3 delivers the highest value and the lowest total cost of ownership compared to any APC technology.

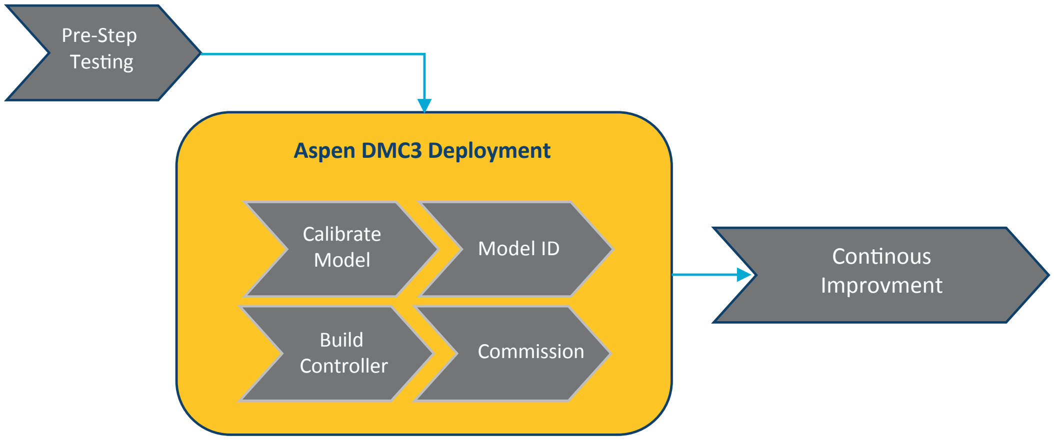

Figure 4: Aspen DMC3 project lifecycle

1. Pre-step Testing

The pre-step testing phase is common, as it's necessary to understand, study and review the base control system layer, as well as the unit performance. It also serves as an initial data gathering step for building a seed (skeleton) APC model that is used for the next step.

2. Aspen DMC3 Deployment

With Adaptive Process Control technology in Aspen DMC3, the step testing, model building, controller development and commissioning phase are all combined in one step.

Aspen DMC3 features Adaptive Process Control (patent pending) technology that enables faster deployments and sustained benefits.

Model Calibration

The seed model obtained from pre-test is utilized online in Aspen DMC3 to calibrate the model during the deployment phase. Calibrate mode in Aspen DMC3 allows the controller to run in a closed loop while optimizing the unit. Although the controller is in closed loop, the patented technology generates data that is very rich for modeling. Another benefit of using calibrate mode is that it allows for background testing with very few disruptions to the process. This has excellent buy-in from the operators and does not require 24x7 engineering supervision.

Many companies report that the best practice is to continuously update the models and tune the controller simultaneously during commissioning. This significantly shortens the time to benefits accrual. Existing models are progressively getting better every day and the controllers are constantly pushing the unit closer to optimum during commissioning.

3. Sustaining Aspen DMC3 Controllers Through Continuous Improvement

As mentioned before, with traditional technology, changes to the process or equipment requires re-identifying the model. This often involves costly step testing and is handled as a project. With Adaptive Process Control technology in Aspen DMC3, sustaining controllers is no longer handled as a project but rather as a continuous process.

Sustainability tools in Aspen DMC3 include automatic bad-model identification. These models can be calibrated online, in a closed loop with no disruptions to the process. This makes sustaining benefits both easier and cheaper. Maintaining Aspen DMC3 controllers requires fewer resources, and as a result controllers maintain peak performance. This also enables companies to deploy and sustain more controllers leading to a best-in-class APC program.

Summary of Aspen DMC3 Benefits

1. Enables a best-in-class APC program: Deploy and sustain more APC controllers with ease.
2. Delivers faster time-to-benefits resulting in a much higher return on investment.
3. Non-disruptive testing leads to less giveaway, higher margins, higher operator acceptance and low engineering coverage.
4. Controllers maintain peak performance even with fewer resources.

APC is Key to Achieving Operational Excellence

The chemicals market is very competitive, volatile and fast paced. To maintain a strong market position, companies need to look harder and deeper into their equipment, production and operations to ensure the production chain is optimized. At leading chemical companies, Advanced Process Control (APC) is being used as a key strategic tool to exceed operational excellence goals.

Leading chemical companies use Adaptive Process Control as a key strategic tool to achieve operational excellence.

Consider partnering with Aspen Technology, a leader in APC technology and innovations for 35 years. The majority of the largest and most profitable companies are using the software from AspenTech to ensure profitability and process optimization. With breakthroughs such as Adaptive Process Control, Aspen DMC3 APC software is a step change from traditional technology that will help your organization achieve operational excellence.

Contact Us

For information on partnering with Aspen Technology, please contact **APC3@aspentech.com.**

AspenTech is a leading supplier of software that optimizes process manufacturing — for energy, chemicals, engineering and construction, and other industries that manufacture and produce products from a chemical process. With integrated aspenONE® solutions, process manufacturers can implement best practices for optimizing their engineering, manufacturing, and supply chain operations. As a result, AspenTech customers are better able to increase capacity, improve margins, reduce costs, and become more energy efficient. To see how the world's leading process manufacturers rely on AspenTech to achieve their operational excellence goals, visit **www.aspentech.com**.

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