



Oil, Gas and Petrochemical

Advanced Process Control

The proven way to process optimization

Advanced Process Control

A complete suite of process optimization products

ABB, as the world leading supplier in automation systems, offers a complete suite of solutions aimed at the optimization of industrial processes.

With numerous installations in the oil and gas, pulp and paper, and power generation industries, APC has a proven success rate in squeezing more production at lower cost from complex and demanding processes.

Process control from the global market leader

For more than 30 years ABB's application engineers have faced and tamed every possible control problem in just about every conceivable process control application. Over the decades we have provided thousands of advanced process control and optimization solutions, many of which are based on our powerful Advanced Process Control (APC) suite of control and optimization products.

ABB brings a wealth of expertise and customer commitment to every control project. We have the world's largest installed base of process automation systems, and we are consistently ranked the world leader in distributed control systems, both for the DCS market as a whole and in industry verticals like oil, gas, refining, petrochemical and chemical, pulp and paper, and minerals.

To protect our customers' investments in this installed base, ABB invests more than \$1 billion a year in R&D, much of which is channeled into process automation, control and optimization.

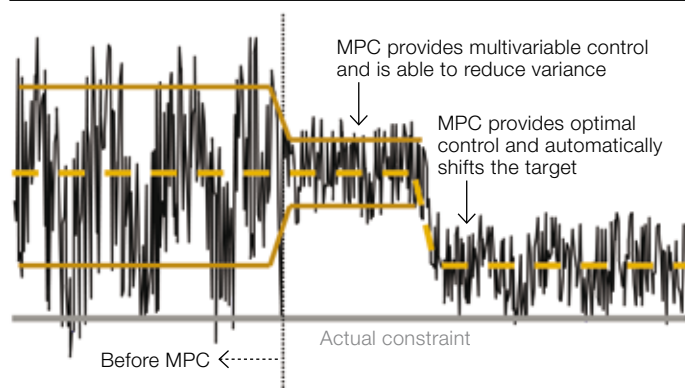
A world-class suite of products

ABB's Advanced Process Control (APC) is a set of world-class control and optimization products, which are fully integrated into a uniquely powerful suite that meets the requirements of every process application, from a small-scale single-unit plant to a large-scale multi-unit facility.

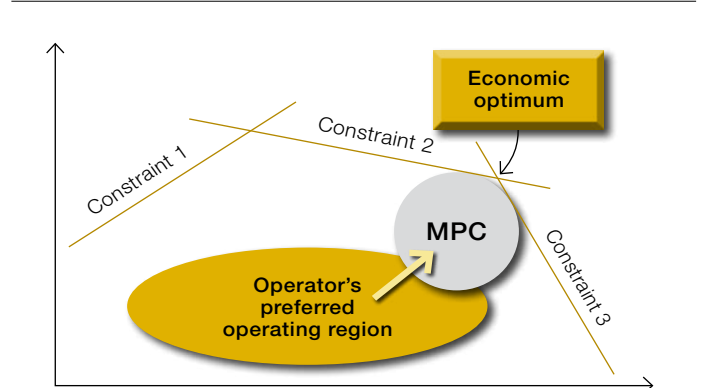
The APC suite delivers the most effective and advanced solutions for any process task or problem. It has a proven track record in achieving major and measurable improvements in plant and business performance:

- Increased throughput
- Minimal quality giveaway
- Increased profitability
- Enforcement of safety and environmental operating constraints
- Reduced energy consumption
- Improved efficiency
- More stable operation

How model predictive control (MPC) improves performance



APC drives the process to the economic optimum point



Single-source integrated solutions

ABB has the capability to provide complete integrated solutions comprising APC, distributed control system, safety systems and turnkey analytical solutions. Each system is designed to interface with the others in a common user environment that provides a single accurate source of system information and a single window into the plant's process automation systems.

ABB APC products offer multitasking, multi-language support, graphical operator interfaces, flexible connectivity, fast installation, and easy diagnostics and programming. The APC suite is based on a set of common components, which give the products a uniform look and feel and provide a familiar interface for engineers and operators.

ABB's advanced solutions encompass the following products:

- Predict & Control - multivariable model predictive control
- Inferential Modeling Platform - combines neural networks, statistical regressions, statistical process control (SPC) and multivariate SPC (MvSPC)
- APC Performance Manager - allows seamless continuous optimization by tracing APC performance and presenting further possibilities for improvements

Connectivity through OPC standards enables each product to operate and communicate with any ABB or third-party distributed control system.

Stepwise optimization and continuous collaboration

Process optimization is a long-term undertaking based on a relationship of collaboration between the customer and ABB. If the customer has a process problem or simply wishes to enhance the performance of a specific part of the process, ABB has the technology and the engineering skills to fix it. Once that has been achieved, we – with the help of your process engineers – usually find that there are possibilities to further optimize process behavior.

For instance, we might start by assessing the performance of your DCS PID controllers, monitoring how they perform and determining where there is room for improvement. Next we might use our Inferential Modeling Platform to continuously measure online what the laboratory takes several hours to measure. Then, we might assess the performance of each item of process-critical equipment and use Predict & Control to push each unit to its performance limit and squeeze the maximum revenues out of your capital investment.

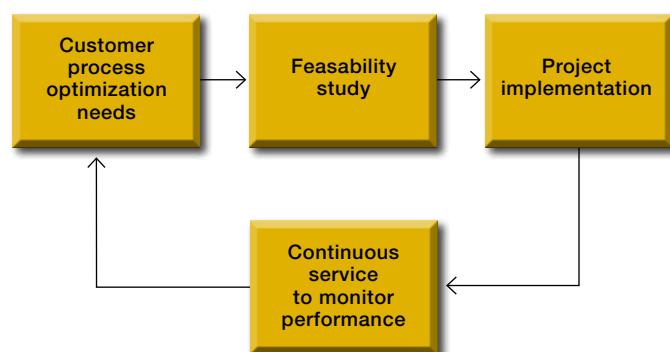
Optimization is a stepwise process that is built on collaboration between your process engineers and the ABB team, and the deployment of ABB's APC software. Step by step, ABB will help raise the performance of your plant process.

Our services embrace the following:

- Site surveys and analysis of existing facilities
- Master plans and ROI estimate
- Base control fine tuning
- Operator and engineer training
- Engineering, installation and commissioning
- Post-commissioning services and application maintenance based on tools that measure APC performance and suggest continuous improvements



Optimization collaboration cycle



Predict & Control

State-of-the-art multivariate model-predictive process control

Predict & Control provides multivariable model-predictive control to ensure that process performance remains optimal and repeatable in all operating conditions and across all product changes.

It uses state-of-the-art state space modeling to reduce process variations, increase throughput and reduce production costs by operating safely at the closest possible process constraint limits. P&C has an unrivaled success rate in improving productivity in a wide variety of industrial processes.

Much more than an MPC algorithm

Predict & Control is much more than the latest version of a model predictive control (MPC) algorithm. It is based on new cutting-edge ABB technology that replaces the typical MPC collection of single-input/single-output (SISO) step response models with a true multiple-input/multiple-output (MIMO) state space model.

Traditional MPC uses finite impulse response models, which have a limited capability to correctly describe fast and slow dynamics simultaneously. ABB's approach utilizes state space models to accurately account for complex process dynamics with a reduced number of parameters. Additionally, this technology makes it possible to implement explicit state estimation by using the Kalman filter to achieve early and accurate disturbance detection and therefore improved rejection. This gives the engineers the freedom to add extra measurements that provide supplemental information about the internal state of the process. Better process state estimation means better control and superior plant performance.

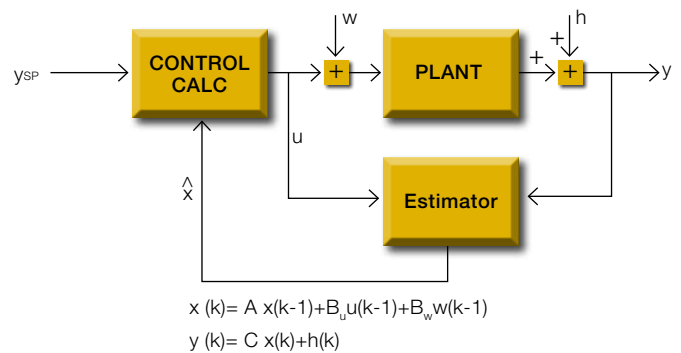
Maximum flexibility at all times

ABB's control algorithm is designed to provide maximum flexibility for users to define and achieve the plant's process goals and control objectives. It combines multi-objective optimization with prioritized control targets and time-domain tuning parameters. Multiple levels of constraints are difficult to tune without a multi-objective, sequential optimization algorithm like P&C's. Where competitors' controllers use a gain scheduling approach to handle non-linearity, P&C allows the scheduling of full models and tuning parameters to handle non-linear dynamic processes. This approach utilizes the simplicity and robustness of linear models to improve the performance of model predictive control.

Offline and online capabilities

Predict & Control is a native Windows client-server package comprising an offline engineering toolkit and online applications. The offline engineering tool is designed for application configuration, data pre-processing, model building, controller tuning, offline simulation and analysis. The online package comprises P&C Built-in Client Operator Interface, and P&C Engine – the computational core of Predict and Control. P&C Online connects to any underlying base-automation control system by means of a standard OPC interface.

The Kalman filter also gives the possibility to account for unmeasured entry process disturbance



P&C features

- State space modeling
- Kalman filter with explicit state estimation
- Process input and output disturbance estimates
- Uses auxiliary process variables as early warning of disturbance occurrence
- Quadratic and linear objectives
- True prioritized constraints
- User-defined trajectories for setpoints, feed-forwards and constraints
- Native representation of integral models (like level) makes it easy to control levels
- Online update of models and tuning parameters based on process conditions
- Powerful model identification methods

Inferential Modeling Platform Creates non-linear inferential models from process data

Inferential Modeling Platform (IMP) is a software package designed to allow a straightforward and efficient distillation of process data into valuable real-insight production information.

It includes all the data processing and modeling technologies necessary to create non-linear inferential models from process data. These powerful functionalities are integrated in such a way to unleash all of their potential while hiding the unnecessary mathematical details. They include neural networks and genetic networks, statistical process control and multivariate statistical process control.

IMP is a native Windows client-server software package for the offline development (IMP Model Builder) and online deployment (IMP Online) of inferential models.

IMP Model Builder

The IMP approach to inferential calculation is to provide a platform for process engineers in which all the functionalities are readily available, easy to use and arranged for the best possible workflow. These built-in functionalities include:

- Data import from different sources
- Data handling (data set merging and splitting, data editing, calculated tags, etc)
- Data analysis (statistical analysis, principle component analysis, etc)
- Automatic outlier removal
- Multi-chart (2D and 3D) visualization facility

Pre-processed data can then be used to build either empirical models or a baseline for statistical control purposes.

IMP Online

Once a model has been built and validated, it can be used online with IMP Online to deliver timely and accurate predictions. Additionally, it can be used offline for what-if analysis and sensitivity studies by means of the Model Explorer utility. Real-time estimation is performed by direct connection to the plant DCS or PLC through OPC, using IMP's built-in OPC Client. Automatic recalibration of inferential models through use of laboratory data is available by means of built-in bias handling functions.

APC Performance Manager

APC applications deliver large benefits immediately after commissioning, but they may suffer performance degradation over time. The reduction in performance has more to do with changes in the plant that occur over time than with the technology itself (for instance, modifications in instrumentation, equipment fouling, changes in load level/type, and so on). In other cases, performance reduction may occur due to incorrect operator use of the APC system, such as conflicting objectives or limits that are too tight. In most cases, top performance can be retained with small tuning or model changes and with periodic operator training. APC Performance Manager continuously monitors the performances of your APC applications and identifies areas where improvement would be beneficial.

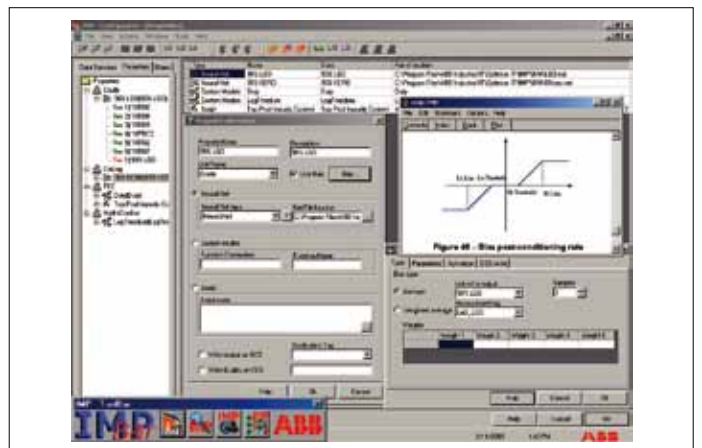
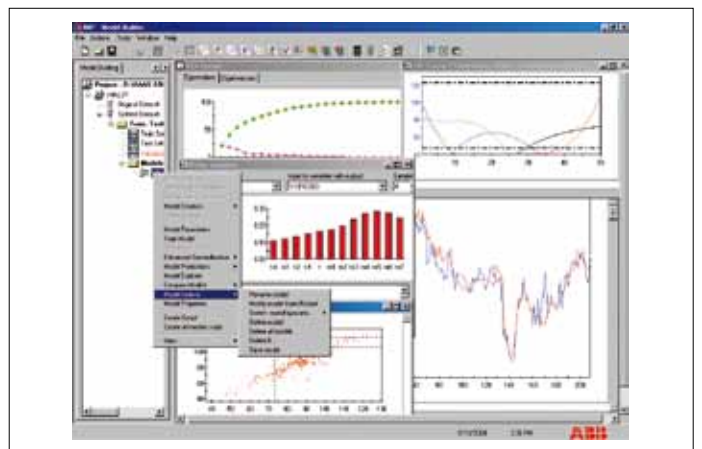


ABB APC achievements in process control

ABB's Advanced Process Control is a well-established technology used in all petrochemical processes. Refinery, ethylene, gasification and gas treatment, and LNG for gas liquefaction all gain large benefits from APC. Typically, the return on investment with APC is less than six months.

Due to the increasing cost of energy and new challenges in operational efficiency, APC is becoming increasingly important for all process industries - pulp and paper, minerals and energy production facilities in particular.

Refinery application: Delayed coking

The main economic targets of the unit are related to the capability of keeping the most valuable outputs (heavy gasoline and light gas oil) as close as possible to pre-defined quality targets. Prior to the installation of APC, these qualities were measured only once a day in the plant laboratory, which meant that the control goals had to be turned empirically into maintaining reference tray temperatures.

The APC inferential model estimates the values of the product qualities, whose accuracy is increased by correcting the neural net predictions with a bias factor, calculated on the basis of the discrepancy between inferred and lab-measured values. The MPC controller, in turn, manages the loop setpoints that control feeding flow rate, distillate extraction flow rate and pumparound flow rate, in order to control temperature and to apply the constraints imposed by the operating limits of the unit.

The APC analysis confirmed the project expectations from both qualitative and quantitative perspectives, showing a

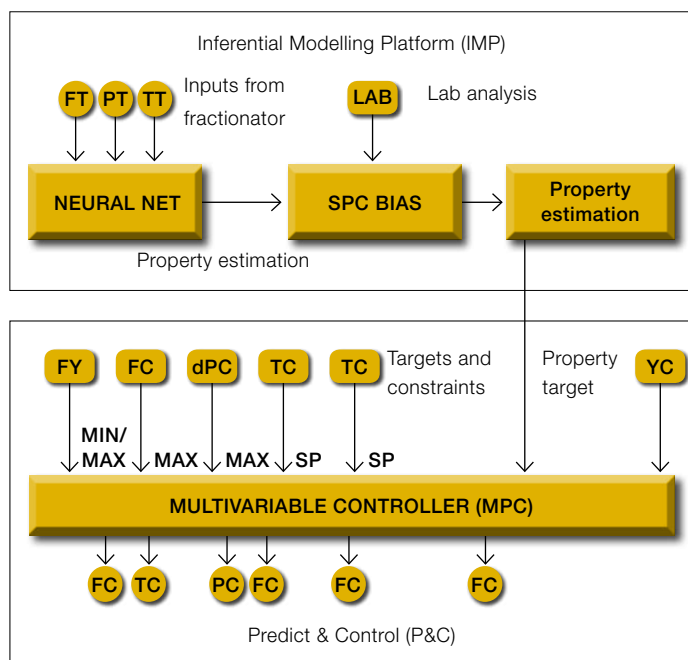
number of cost-saving effects on plant operation:

- The fractionator showed greater stability, due to a dramatic reduction in magnitude and time extension of the disturbance coming from drum switching and related procedures
- Clear variance reduction in APC ON (around 75% for heavy gasoline and 60% for light gasoil), enabling higher product quality closer to the best market specifications
- Increase in the yield of more valuable light distillate: 36% reduction in the amount of light gas oil lost in heavier streams

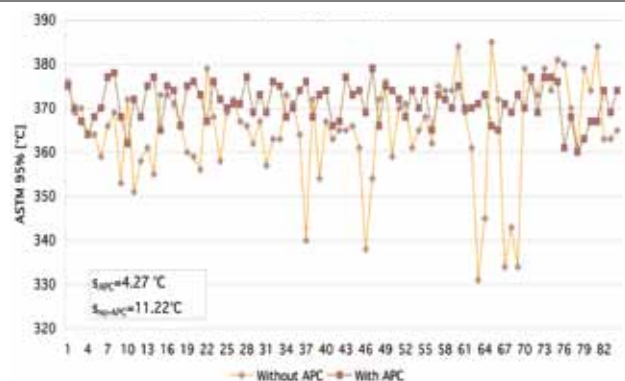
IGCC and gas treatment

IGCC (integrated gasification and combined cycle) plants are among the most advanced and effective processes for power generation using bottom of the barrel refinery residuals. IGCC plants present a significant challenge: the combination of complex reactions, highly integrated design, and variable feed composition requires coordinated control to simultaneously satisfy production, controllability, operability and environmental objectives.

ABB APC software for refinery



Light gas oil quality improvement with APC



Implementation of ABB multivariable process control systems successfully helps in tackling these challenges.

- Gasification unit - the APC system maintains the CH₄ content stable even in the event of large feed density changes. Another benefit is the improvement in the five scrubbers' interacting level control, which is not related to any economic target but greatly reduces the operators' workload and therefore enhances safety
- Acid gas removal and gas treatment area – the APC objective is to minimize energy consumption while maintaining residual H₂S in syngas within the specifications: steam consumption is reduced by about 20%
- Master control for overall plant coordination - this is a complex task due to the different dynamics between slow syngas production in the gasifier and fast consumption in combined cycle. On top of this, multiple additional constraints (such as post-firing max temp, post-firing pressure, feed pump amperes, etc) have to be met. APC keeps pressure stable at the gasifier exit even during a fast load transition, and enables more power to be produced (>1%) in the combined cycle

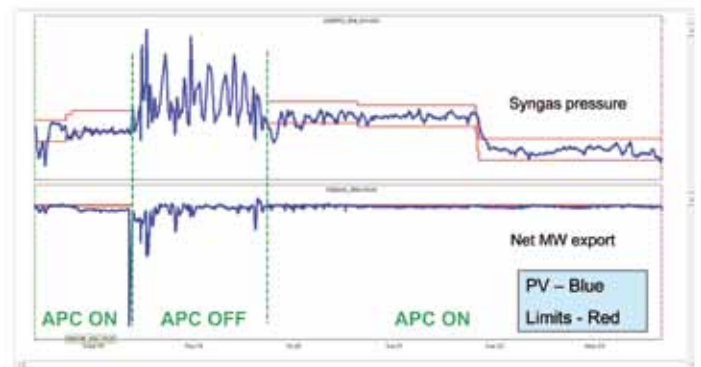
Process cogeneration optimization

All process facilities require energy in the form of electricity and steam, which can account for as much as 20% of overall production costs. This makes the site power plant an important element in the economic performance of the facility.

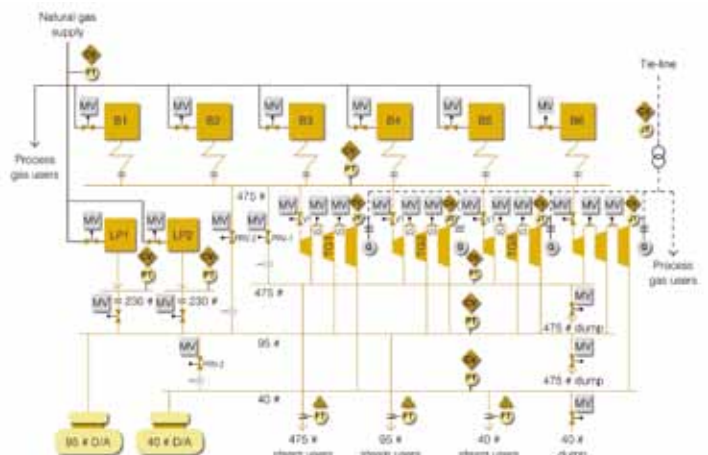
The site powerhouse is often a large plant with multiple boilers, turbines and steam headers. Economical operation of the plant can be a major challenge, due to fluctuating energy prices, the complexity of the plant, and the high reliability requirements for steam and power supply. To improve operational stability and flexibility and reduce energy costs, ABB Predict & Control can be used to coordinate control and optimization.

The most immediate benefit with APC is a huge improvement in process stability. The figure on the right shows the reduced variability (80% reduction) in pressure header with APC. Improved pressure control is important, since optimization requires the powerhouse equipment to make more frequent transitions between maximum power generation and minimum fuel operating modes. Better control of the steam headers completely eliminates situations in which a single boiler trip causes other equipment to trip, thereby reducing plant outages and production losses. Verified savings of 2% in powerhouse energy costs have been achieved, equating to a payback time of less than six months. Savings come from the maximization of backpressure power by utilizing the most efficient boilers and from the automatic efficient purchase of primary energy such as gas or external power supply.

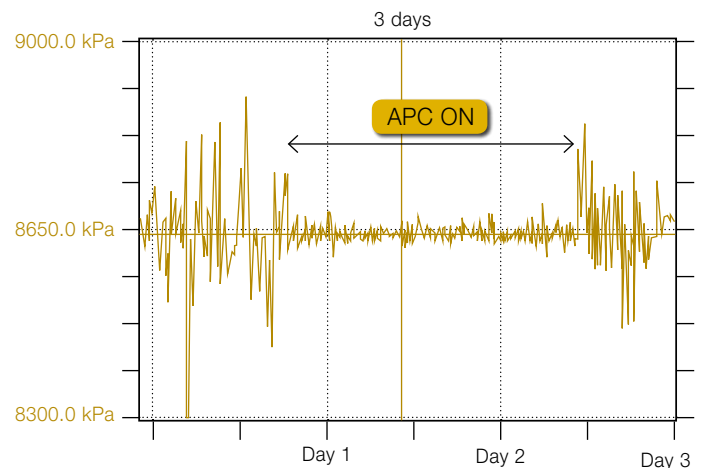
Pressure stabilization and power maximization with APC master controller



APC design for the powerhouse



Pressure stabilization with APC



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