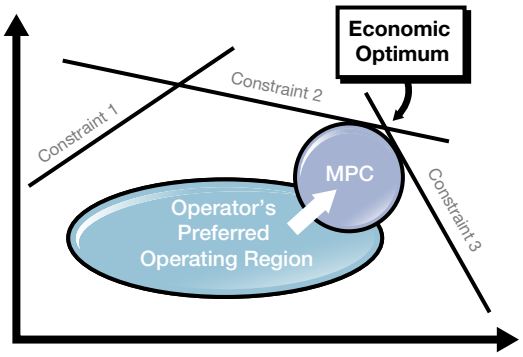
OptimizeIT Predict & Control (P&C)

Tight quality control is essential in today's increasingly competitive marketplace. This is no longer limited to the refining, petrochemical and polymer processing industries, where traditionally a high priority is placed on economic performance and reproducible quality, but now more industries are recognizing the necessity to operate close to constraint limits to maximize plant profitability.

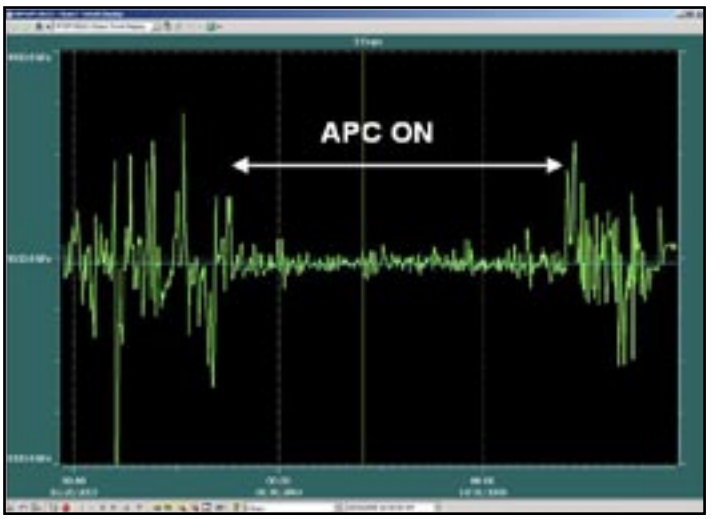


Operations are complicated even when dealing with consistent feeds and product requirements, but many processes do not operate with consistent feedstock. Here, the challenge after a feed change is to re-establish production of high-quality products and to do it in the shortest possible time. Similar considerations apply in other sectors – blending, polymer processing and the pulp and paper industry – where product slates are changed in response to market demand.

The first step to maximize control system performance is to optimally tune the basic PID controllers. While a pre-requisite, this step is seldom enough to keep the pace of competition. PIDs, being Single Input - Single Output controllers, cannot take into account the existing interactions among the different feedback loops. Moreover they cannot take into account process constraints and economic targets. As a consequence process operators are forced to keep the operating point at a "safe distance" from the process constraints eventually resulting in quality give-away, energy waste and reduced production.

MPC Technology

Model Predictive Control (MPC) is a widely used industrial technique for advanced multivariable control. For processes featuring strong interaction among different units, MPC offers substantial performance improvements compared with traditional single-input single-output control strategies. Additionally a main feature of MPC controllers is the ability to handle constraints, for both manipulated inputs and process variables.



MPC controllers reduce the variance of process variables which allows the plant to operate closer to the economical optimum.

This result is obtained through the use of models that allow the controller to plan its moves taking into account their effects on the specific process dynamics. The future process behavior is predicted and compared to process operating objectives and constraints within an optimization engine that computes appropriate future control actions.

IndustrialIT enabled

Predict & Control Technology

Optimize IT Predict & Control is much more than the latest version of another model predictive control (MPC) algorithm. It's based on new 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.

$$x(k+1) = \mathbf{A}x(k) + \mathbf{B}_u u(k) + B_d d(k) + w(k)$$

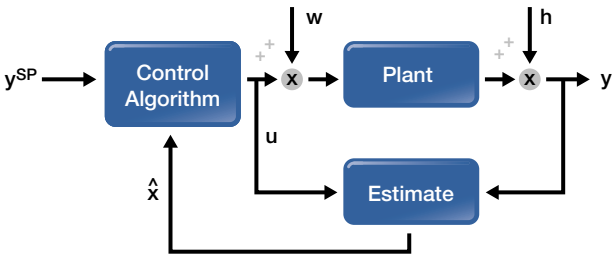
$$y(k) = \mathbf{C}x(k) + v(k)$$

ABB's approach is made possible through a new model identification algorithm that identifies accurate state space models from plant test data. The state space model predicts the effect of disturbances with far better accuracy than current technology. And better predictions imply better control.

Optimize IT Predict & Control merges a solid control algorithm with vastly superior modeling technology to deliver superior performance.

Maximum Use of the Available Information

The state space model approach permits Optimize IT Predict & Control to use a Kalman filter for state estimation as part of the feedback control algorithm. The Kalman filter makes the best estimate of process input and process output disturbances.

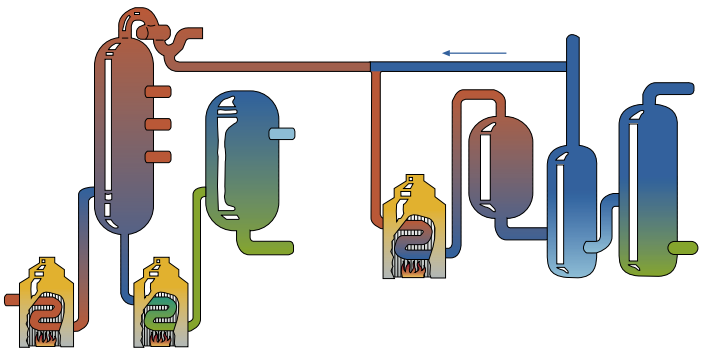


Where a SISO step response model merely allows estimates of static biases to the process variables, the MIMO state space model allows estimates of the total dynamic effect of process input disturbances.

The state space model also permits the engineer to specify the model structure and to define "extra" or auxiliary process variables that are used to further improve disturbance estimates. A key temperature, for example, can provide advance warning of disturbances to a critical composition. Optimize IT Predict & Control advantages come from a better, more complete use of the available information.

Complete Flexibility

ABB's control algorithm is designed to help your plant reach its operating objectives by providing the user with an easy way to directly specify goals. Predict & Control provides multi-objective optimization with prioritized control objectives and time-domain tuning parameters. Multiple levels of constraints are difficult to tune without a multi-objective, sequential optimization algorithm. When extra degrees of freedom exist in the process, the controller can drive the plant to operator-entered manipulated variable



(MV) targets through a quadratic objective function or to an economic optimum using linear cost coefficients for controlled variables (CVs) and MVs.

Improve transition

The controller can be configured to use trajectories for setpoint, feedforward and constraint variables. If the desired behavior for a setpoint is a ramp, the controller uses a ramp in the control algorithm objective function. Other controllers try to fool the control algorithm by changing setpoint a little at each execution. These controllers operate with insufficient information to control tightly to the ramp.

Feedforward variables can be scheduled with an input trajectory. This is especially useful for cyclic operations such as regeneration of absorbers, back-washing filters or for any other discrete operations with defined start and stop times. Feedforward and setpoint trajectories can work together to execute product grade changes or production rate ramping. Constraints also use trajectories, but this is to ensure smooth, steady, robust behavior while enforcing the process limits.

Where competitor controllers use a Gain Scheduling approach to handle non-linearities, P&C allows the scheduling of full-models and tuning parameters to handle non-linear dynamic processes. This approach combines the simplicity and robustness of linear models to improve the performance of MPC.

P&C Software

Optimize IT Predict & Control is a native Windows, client-server package and it consists of offline tools to screen and process data, dynamic model identification procedures and controller tuning analysis. The on-line portion of the package consists of a control server that executes the applications configured with the offline tools. An operator interface is provided through a client application.

P&C *Engineering Tool* (Offline)

The Engineering Tool is the off-line environment designed for application configuration, data pre-processing, model building, controller tuning, off-line simulation and analysis.

The *configuration function* is used to create and modify the structure of the multivariable controller: which signals should be used as manipulated variables, process (controlled) variables and feed-forward variables. Properties associated with these signals are also defined using the configuration tool.

P&C embeds am effective, yet easy-to-use *data-processing* utility which allows to properly import, trend and filter process data collected through the exclusive *Optimize IT Data Manager* package. User have an amazing number of functionalities at their fingertips, including: automatic outlier identification & removal, removal of means and trends, signals filtering (transformation & linearization), possibility to add calculated variables, data merging and resampling.

The *modeling function* is used for building models of the process from data. There are modeling tools for process identification and for merging of models obtained from different process identifications. The tool also contains elaborate analysis functions to assist the user. The main part of the modeling tools is the parametric identification tool that is used for building state-space models from data sequences. The two step state-of-the art algorithm for parametric identification combines the ease of use with the ability to use data sequences from both open and closed loop identification experiments.

The *tuning function* is used to define the tuning parameters for the controller, e.g. scaling weights on control errors and moves, constraint priorities, and observer design parameters. The tool also contains elaborate analysis functions to assist the user.

P&C Online

The online package include three different components: *Online Controller Manager*, *Operator Interface* and *Engine*.

P&C *Operator Interface* (OI) allows the users to have full insight into and control of P&C through a number of displays, which support complete monitoring of the process and MPC behavior. Operators can set the on-line controller parameters such as Setpoints, optimization targets and constraint, limits.

P&C *Online Controller Manager* is designed to provide centralized, supervisory management of multiple, underlying MPC controllers. It allows to startup/shutdown and activate/inactivate controllers and to load/switch multiple controller definitions. Additional task automation is possible by means of customized scripts (e.g. during process startup).

P&C *Engine* is the computational core of P&C. At each cycle time it reads actual process variable values, executes the control algorithm to identify the optimal sequence of moves able to drive the process toward its optimum, and then implements the first set of these moves.

P&C *Online* connects to any underlying base-automation control system by means of a standard OPC interface. This allows the controller to write important information back to the DCS for a single-window operator interface.

Features

- State space model
- Kalman Filter state estimation
- Process input and output disturbance estimation
- Use auxiliary PVs to improve disturbance estimates
- Quadratic and linear objectives
- True prioritized constraints
- User defined trajectories for: Setpoints, Feedforwards, constraints
- Time-based tuning parameters
- On-line update of models and tuning parameters based on process conditions (not just gain scheduling)
- Operator/Engineer Interface Client
- Fully integrated engineering tool suite
- Powerful Model Identification methods with disturbance suppression
- Offline controller design analysis tools
- Integrated testing simulator

Advantages

State space models represent process behavior more realistically:

- Estimation and representation of disturbances are improved with Kalman Filter
- Models are more accurate, with better estimation of gains during model building
- True representation of integrating variables, such as level, provide greatly improved control performance

Controller algorithm allows maximum flexibility to define and achieve control objectives:

- Prioritized specification of constraints and optimization objectives more closely matches operating objectives
- Time-based tuning is more intuitive for the user
- Use of multiple models and tuning parameters together with Setpoint and FF trajectories allows for better performance and faster transitions

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