Constraint Control

A simple technology for substantial savings

Achieving cost savings of several 10,000 €, possibly even 100,000 € per year - and this every year - seems at first glance rather wishful thinking than reality. And yet, it is indeed feasible.

One of the techniques that can deliver this is called „constraint control". Another one, also rarely known and used, is model-free optimization (discussed on the following page) .

Both technologies share some common features:

- First off, both can indeed deliver substantial credits with minimal effort.
- Both are much simpler than often perceived.
- Both can be used directly in the DCS.

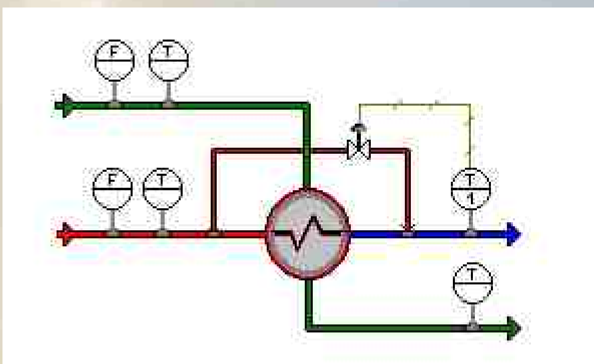
The task of a constraint control scheme is to push a target variable as far as possible in the desired direction. With other words: The target variable shall reach ist - depending on the objective - maximum or minimum value without violating any other limitations.

A widely found example is the cooling of a product stream in a heat exchanger, e.g. with cooling water. The run-down temperature of the product must be controlled and on top the product flow rate shall be maximised. Yet two constraints must be observed: The exit temperature of the cooling water must not exceed a certain value and the valve in the bypass shall not close more than a certain percentage.

The control scheme will increase the product flow until one of the constraints is reached, for example the cooling water exit temperature.

Upon any change in the conditions, e.g. the CW inlet temperature (day-night or summer-winter-effect) the scheme corrects the product flow immediately, much faster than any operator can react. Thus, overall a higher throughput can be achieved.

In the case shown in TOPAS (see diagram below) the product flow rate can be increased by ~3 m3/h. The resulting credits depend on the product, its value etc., yet is always a multiple of the application development cost.



Pressure minimization of distillation columns to reduce the energy consumption is another widely found application. Therefore many data exist showing respectable results: On average savings of 3 - 5% are reported. This translates to annual savings of ~800 € per ton product, at e.g. 50 t/h no less than 40,000 €/a - every year - achieved with an effort of 2 to 3 days!

The main advantage of this technology is that under varying conditions the maximum use of the equipment and the resources is always ensured.

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Model-Free Optimization

A simple technology for substantial savings

Model-free optimization is another elegant technology that allows to realize cost savings of several 10,000 €, sometimes even 100,000 € per year with only a few days of effort.

It has some commonalities with the constraint control technology:

- First off, both can indeed deliver substantial credits with minimal effort.
- Both are much simpler than often perceived.
- Both can be used directly in the DCS.

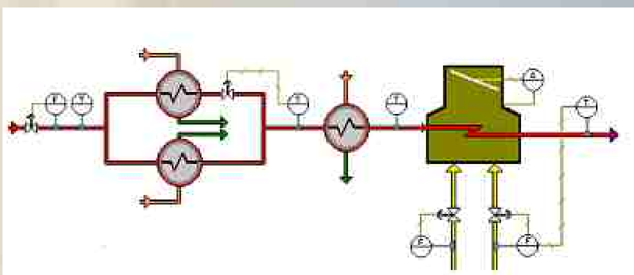
Model-free optimization determines the best operating point empirically by means of a special algorithm.

A widespread example is the preheating of a product with two (or more) heat exchanger in parallel that supply waste heat. The final product temperature control is done with a furnace.

The question here: How is the best load distribution, i.e. the best distribution of the product stream over the parallel exchangers? "Best" means here, the distribution for which the maximum heat-up of the product and consequently the lowest fuel consumption in the furnace is achieved.

The control scheme changes the load distribution in regular time intervals until the maximum temperature before the furnace is reached. And it keeps on testing further on a regular basis and immediately adjusts the distribution if e.g. the temperature or the quantity of the heating medium or the heat transfer of one exchanger changes.

Such a control scheme will detect shifts in the optimum operating point much faster than an operator and thus ensures that the furnace is always running at the minimal possible firing rate.



In the case shown in TOPAS (see diagram) the temperature can be increased by almost 3 degrees. At the current prices for energy (crude oil 80 US$/bbl) savings of 500 € per year, m^3/h product flow and degree C temperature increase can be realized.

In our case with 50 m^3/h throughput savings of more than 70,000 Euro per year can be achieved with an effort of just 2 to 3 days!

As a consequence, two advantages are realized at the same time: Each ton of fuel that is saved reduces the burden on your plant's budget and also the burden on the environ-ment.

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AMC

Model Based Predictive Control the easy way!

The Motiviation for Model Based Control

Model Based Control (MBC) is **the** technology of choice where the PID cannot deliver the needed performance. Key selection factors are:

- Difficult process dynamics: Long deadtime (Controllability Ratio CR > 2), inverse response, irregular signal updating, strong interactions between variables, etc.
- High control performance: The process must be kept very close to targets or constraints, no overshoot or 'double kick' is allowed (esp. for cascades, feedforward)
- Careful, smooth control action: Important for heat integration, sensitive equipment, minimum use of resources
- Inherent prediction and improved process monitoring capabilities (detection of slow effects)
- Reduced effort for tuning - depending on the approach used.

Some of the key applications of MBC include:

- Analyzer feedback control (long deadtime, irregular measurement updating)
- Distillation tower product yield & quality control
- Furnace, continuous reactor, FCC control, product blending
- Batch reactor temperature control, etc.

➔ Despite its power, MBC is still not fully utilized as it is still considered by many as complex, difficult to apply and to tune and usable only on extra computing platforms.

The Advantages of AMC

The actual benefits of AMC prove all these assumptions wrong:

- Extremely simple: Short development and maintenance time, immediate operator acceptance. Our record: A reactor feedback + feedforward scheme in just 10 hours from the first plant test to the first run
- Usable in every DCS
- High performance and outstanding robustness against modeling errors (important for non-linear processes)
- Separate tuning for load upsets and setpoint changes in an unparalleled easy, simple way
- Easy addition of feedforwards, use of limits (absolute or “speed limits”)
- Use of 'real' physical process parameters - easy to understand, to maintain, to update
- Extremely easy extention for adaptive control

➔ NET RESULT: Substantial operation improvements with optimum benefit-to-cost ratio.

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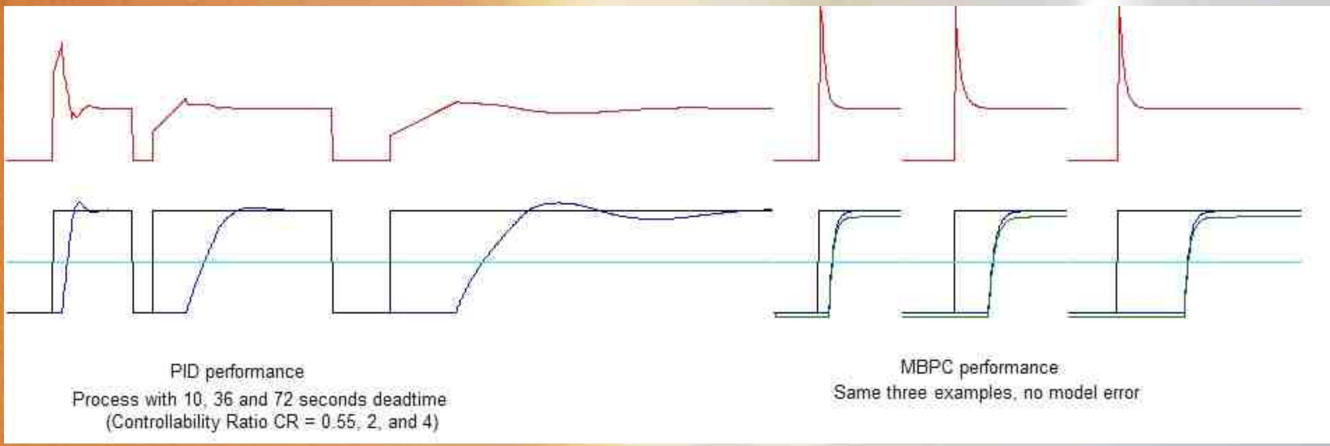
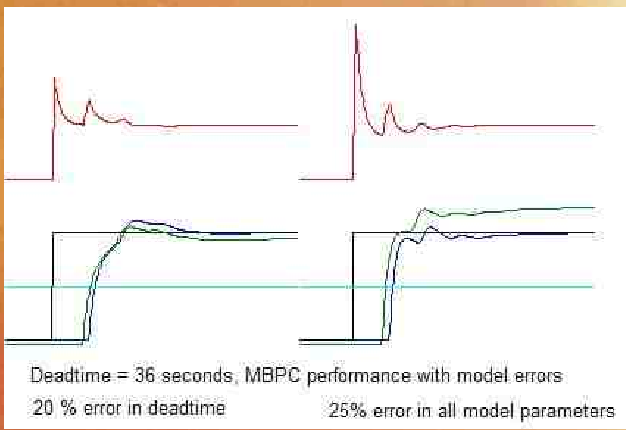
AMC

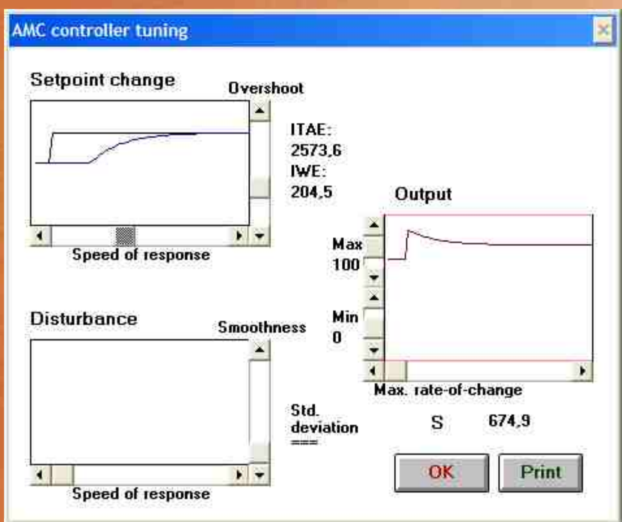
Below, a TOPAS screenshot shows a comparison between a well tuned PID and a (perfectly modeled) AMC controller for cases with different deadtime: Although the PID delivers similar performance in the presence of short deadtime (CR = 0.55), it loses in all other cases by a wide margin.





In the tests on the left, the AMC controller uses an imperfect model, first with an error in the deadtime and then with 25% error in all process parameters. It cannot work so smoothly any more but is far from poor performance or even instability.

A very special feature of AMC is that it is also extremely easy to tune. Just by moving the scroll bars, the controller can be tuned separately for setpoint changes and disturbances. This resolves the well known dilemma with the PID: The controller has to cope with two different scenarios - yet with just one set of tuning constants.



Users can specify the desired performance: Faster or slower, without or with some overshoot and also constraints on the manipulated variable. The so achieved performance is shown on the screen and the results can be tested with the integrated simulation environment in TOPAS.

MBC is the technology of choice for cases where the PID cannot deliver the required performance. AMC handles this in a easy to use way and runs right in the DCS.

Furthermore, AMC costs just a fraction of competing approaches. Thus AMC allows to exploit many operation improvement opportunities for which the 'big' approaches are just too expensive and complex.

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