Dairy Technology Award
Molkereitechnik-Preis

ProLeiT: Autotuning for PID controllers

Honoured with the Dairy Technology Award 2012

Author: Roland Riedl, Sales Manager Dairy Industry, ProLeiT AG, Einsteinstr. 8, 91074 Herzogenaurach, Germany, phone: +49 9132 7770, email: roland.riedl@proleit.com; proleit.com

PID controllers have always been a key component of process engineering plants. However, practical experience has shown that even very experienced engineers set the control parameters intuitively rather than conceptually in accordance with the actual conditions. This often results in the parameters of the controlled systems not corresponding to the technical requirements. On the other hand, sensors and actuators are placed at easy-to-access positions which do not comply with the installation guidelines.

These errors become apparent during commissioning and are subsequently a real problem. However, incorrectly set controllers are accepted as long as the results remain within a specified tolerance range. Oscillations in the system are tolerated or not brought to the attention of process managers. But the control system finds it a struggle coping with the next new product. This is the point where the services of a project engineer are required.

ProLeiT AG has identified this key problem and developed an innovative solution to overcome it: the autotuning function for PID controllers, honoured with the Dairy Technology Award 2012.

This new self-optimising function for PID controllers complements tried and tested software controllers as an integral part of the process control system Plant iT. In the future, ProLeiT customers will profit from the new autotuning function as follows:

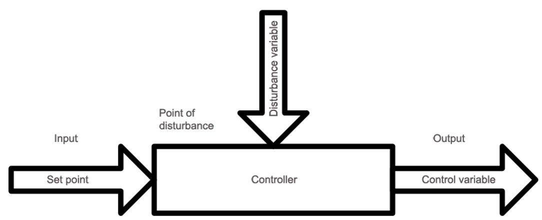

Figure 1: Controlled system

- 100% practice-based orientation with the allowance for deviations to standard control models
- Smooth transition from the control process to self-optimising mode (Autotuning)
- Automatic detection of interference caused by disturbance variables, e. g. further controlled systems and their consideration

Short overview of control theory

General control function

The aim of technical controls is the enhancement of the temporal behaviour of physical variables. The controller is considered part of a technical system which should be influenced. The input variable of the controller is the set point, the variable to be controlled is the control variable. Faults occur at points of disturbance, thus influencing the control variable (see figure 1). The control variable (e. g. temperature, pressure or flow rate) is recorded at the output and compared to the input by taking the difference between the two. The reference variable (target value) is specified externally. The control variable must comply with the specification of the set point. The difference between the set point and the control variable is called the control difference. The controller plays a key role in suppressing the influence of disturbance variables on the reference variable.

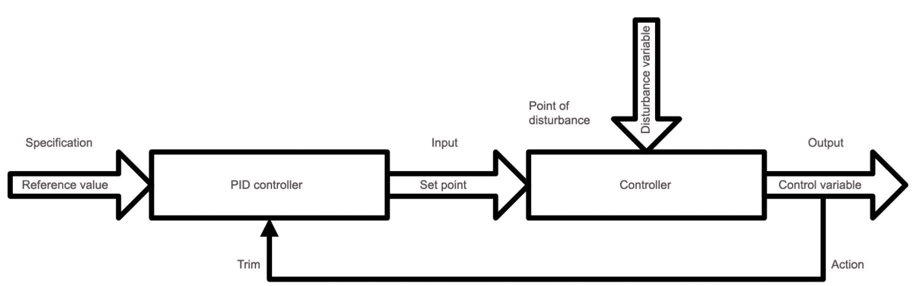

Figure 2: Controlled loop

Reference valued control loop

The control difference is the reference value of the PID controller. The PID controller specifies the set point at the output which influences the input of the controller (see figure 2). All unchangeable components of the control system specified by the design and plant concept must be added to the controller. The control-technical analyses then refer to the properties of controllers which can be selected or set (structure and parameters) and must be determined during control synthesis.

Once the controller structure has been set, the controller parameters must be determined. There are a number of ways of doing this:

- The parameters for controller optimisation are determined from the step response of the controlled system
- The gain factor (Kr) is increased in a stable controlled system until the system reaches its stability limit. The parameters are subsequently derived from it
- Creation of a model of the controlled system and determination of the control parameters via methods with numerical optimisation.

Autotuning – self-optimising control loop

Autotuning represents an option for automating processes in order to set controller parameters. Autotuning means:

1) automatic acceptance of the response step
2) identification of parameters from the controlled system and
3) calculation of the parameters of a PI or PID controller to ensure it can respond optimally to reference variable changes and faults.

A vital effect of autotuning is the quality assurance provided through the used auditable software, i.e. reduction of product loss. Further effects are the reduction of effort, and therefore costs, during the commissioning phase when changing parameters, e.g. other temperatures, pressures or flow rates.

As production processes are burdened with shrinking product batches, the various product parameters (e. g. viscosity) must be provided with the respective flexible control algorithms. An effect which should not be underestimated is the ease of work for maintenance engineers or responsible employees, who often lack detailed knowledge of control technology. Autotuning as an option for optimising and mastering technological processes can, however, not be seen

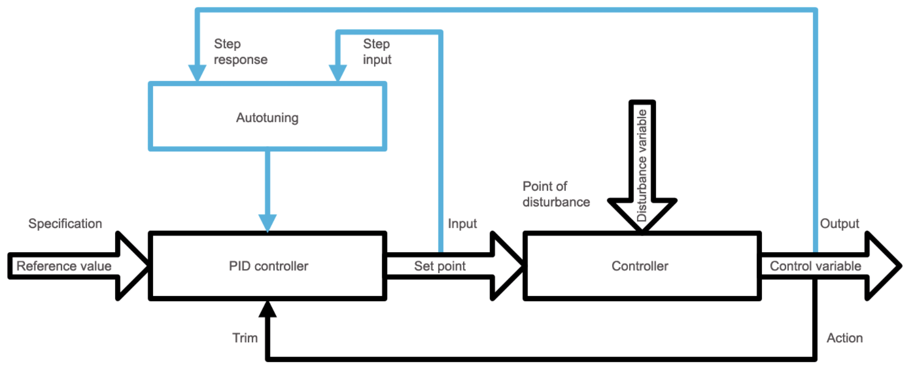

Figure 3: Self-optimising control loop

as a universal remedy for incorrectly planned plants. The application of the ProLeiT autotuning function is highly recommended for the food industry where technological processes are rather slow and extensive dead times are often experienced.

In contrast to common solutions, the ProLeiT autotuning function is also very impressive under the most difficult process conditions:

- A maximum practice-based approach due to the application of specifically developed algorithms of signal processing which guarantees a reliable detection of the process dynamics and correct identification of controlled system parameters;
- Detection and consideration of extensive dead times;
- Stable asymptomatic behaviour of the control loop is also achieved under intensive interference by changing system parameters in the individually controlled system as well as by further controlled systems;
- Smooth change-over from operating point to autotuning mode;
- Selection options for process dynamics (high dynamics with short response times or stable progress with small over-oscillation).

Integration into the process control system

Autotuning is a method for automatically calculating the PID parameters of a PID controller. The properties of the controlled system are determined and the parameters calculated. These calculated parameters can then be transferred to the PID controller.

The new autotuning function is available as an add-on for the current ProLeiT process control systems Plant iT and brewmaxx. To be precise, it is an extension of the automation classes for:

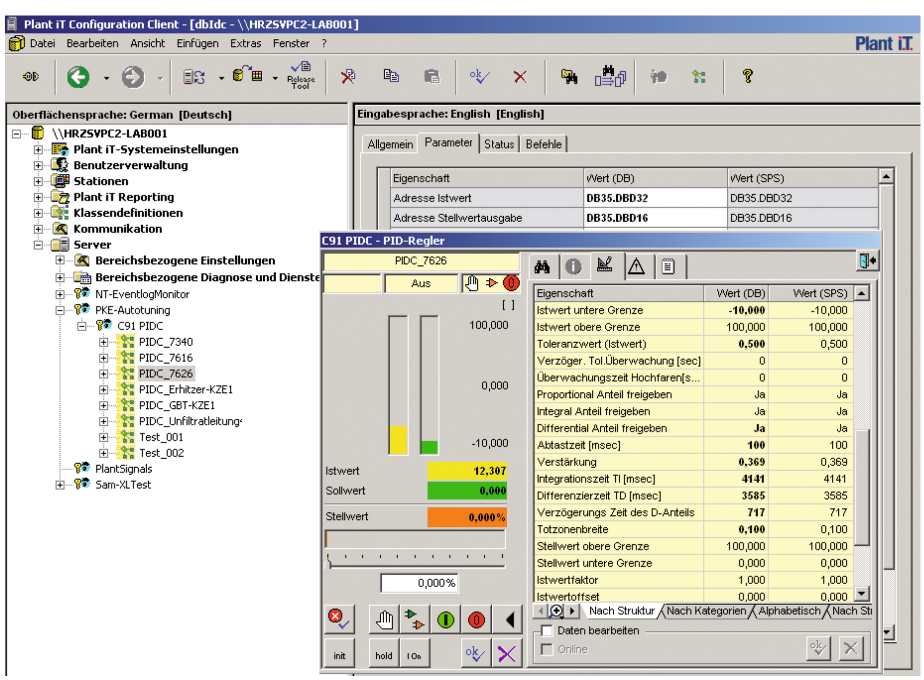

Figure 4: Integrated in the process control systems Plant iT/brewmaxx

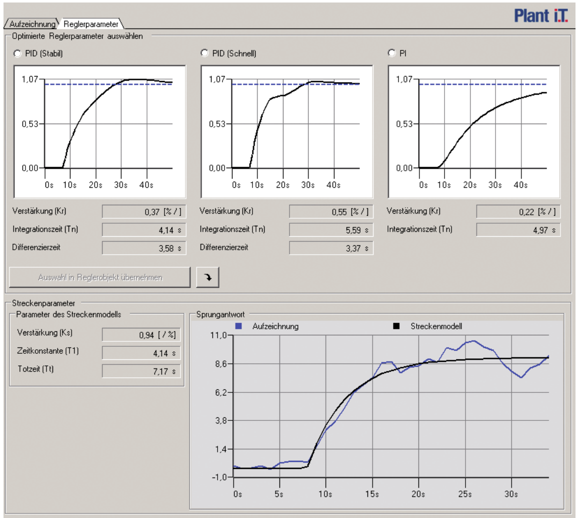

Figure 5: Comparative view of the controller parameters

- continuous P, I, PI, PD and PID controllers,
- cascade controllers,
- mixing controllers and
- ratio controllers.

Performance comparison with other systems

Autotuning tests were performed on various automation platforms for a ProLeiT customer.

Figure 6 shows the differences between a Simatic-based ProLeiT system (purple curve) and another control system (yellow curve) under identical conditions. Despite the considerably higher gain factor compared to the real curve of the yellow system, the ideal response of the ProLeiT system can also be clearly identified with extensive dead times.

The application of the autotuning function for the complex interacting PID controllers of an evaporator at BASF Personal Care and Nutrition GmbH in Illertissen, Germany, shows customers the added value. Nicolai Ziegler, the responsible maintenance engineer, explains: "Autotuning for software controllers from ProLeiT is amazing! Prior knowledge of controller parameterisation is simply not necessary. Parameters (Kr, Tn, Tv, etc.) do not have to be specified as the PID controller is optimised automatically. After autotuning, the controller is set perfectly; a task even very experienced measuring and control technicians cannot always fulfil."

Andreas Höpfl, the Head of Maintenance at BASF Personal Care and Nutrition GmbH, agrees with Nicolai: "The ProLeiT solution for autotuning the PID control loops achieves excellent results despite the extensive dead times of our technological processes."

Summary: The new autotuning function as an integral part of the current process control systems Plant iT and brewmaxx offers excellent results for controller parameterisation. Operation is easy and intuitive. Even inexperienced operators can achieve excellent results in a short period of time.

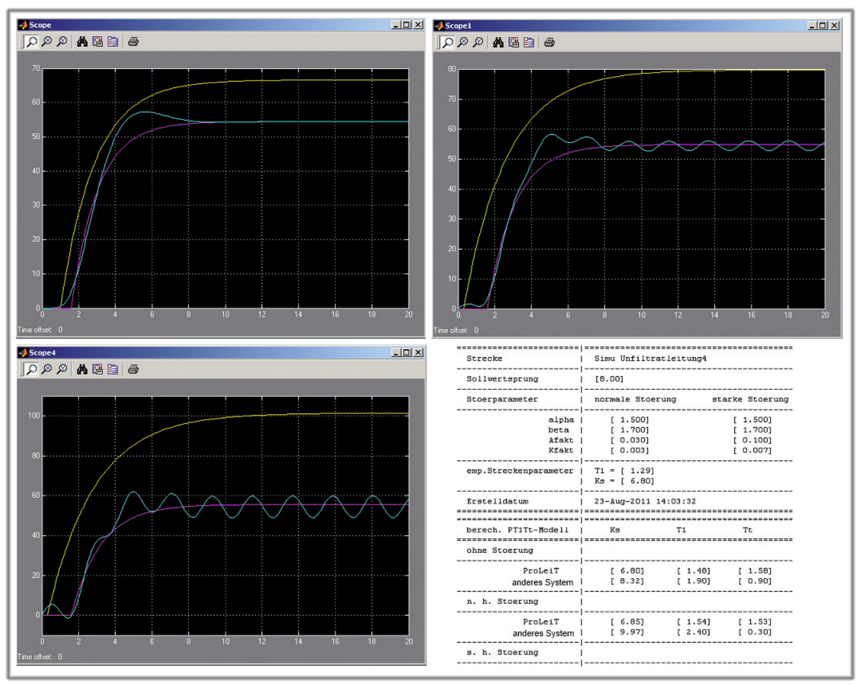

Figure 6: Comparative test – optimum controlled system with the new autotuning function from ProLeiT