On-board experience included

Optimum tuning and operation of PID controllers requires trained experts – are there alternatives?

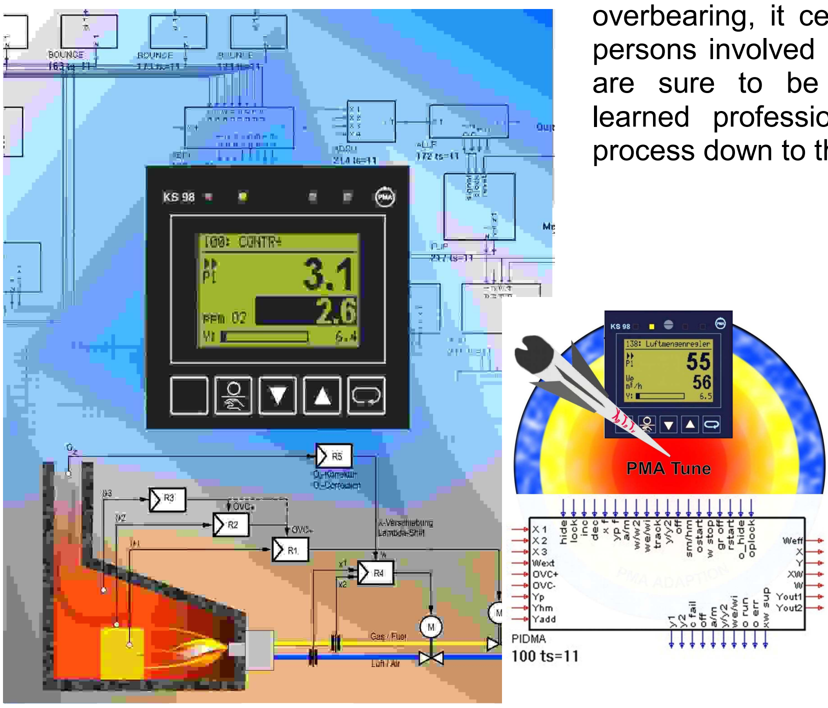
Klaus Vogelei

First published in MSR MAGAZIN, Germany, 6-2005

In Germany alone, some 300.000 control loops are installed or renewed every year. Hereby, the main problem involves finding the correct settings for three essential control parameters, i.e. proportional band, integral action time (reset), and derivative action time (rate) – frequently under considerable time pressure. Backed by investigations of actually achieved control performance, quality managers assume that with over half of all processes, control is poor rather than good – but what remedial action can be taken?

Author: *Klaus Vogelei is Product Manager at PMA Prozess- und Maschinen-Automation GmbH in Kassel, Germany*

This article will show that the self-tuning and optimizing functions supplied with modern PID controllers are not only indispensable, but also leave much room for improvement. Frequently, the basic know-how required for perfect adaptation of a control loop to the process is no longer available on site. Meanwhile, due to the lack of experienced in-house personnel, plants are commissioned by available employees. In many companies, control engineers with many years of experience have become hard to find. Consequently, experts are hired temporarily when the need arises. If the commissioning date has already been fixed, the hired engineer has good reason to ask himself whether he feels able and confident to get the job done within the assigned time – and with the expected quality, of course. The result will be either success or despair. Although this might sound somewhat overbearing, it certainly does not mean that the persons involved are insufficiently qualified. They are sure to be experienced experts in their learned profession, and are familiar with the process down to the smallest details.



New and changing demands

However, the necessary “feeling” for dynamic procedures encountered in control technology is often lacking, and when it comes to tuning a control loop, it's possible for them to discover that they are hopelessly out of depth. After all, the three buttons for the control parameters Xp (Kp), Tn (Ti), and Tv (Td) can be turned in either direction, and depending on the loop's behaviour, waiting for a “good or bad” change in the process might take hours. Without a certain amount of intuition coupled with corresponding experience, there's absolutely no chance of success. But what exactly is experience in this respect? Modern developments also change the dynamic behaviour of machines, equipment, and processes. Throughputs of energy, mass, or products are pushed to the upper limits, processes become more compact with less mass, and they respond faster. They are better insulated, and their behaviour approaches that of processes without self-regulation – as found with level control vessels, for instance. Once energy has been introduced into a furnace, it will only pass slowly to the ambient air as waste heat. For example, a modern 60 t/h steam boiler obviously responds quite differently than its outdated predecessor. Which means that previous experience can only be applied to modern installations to a limited extent. So, instead of risking trouble with a trial-and-error approach in practice, it is far easier to rely on the automatic tuning aids, which practically all well-known manufacturers of PID controllers include in their products.

The result will be either success or despair

Can the all-clear be given?

Only if the control parameters have been adapted perfectly to the control loop's dynamic behaviour with its characteristic values for dead time Tu and recovery time Tg (or maximum rate of change Vmax), will the PID controller be able to respond optimally and adequately to disturbances and setpoint changes, in order to ensure that the controlled variable is kept stable at the setpoint without oscillations. Apparently, this no longer seems to be a problem, considering that practically all of today's PID controllers come with self-tuning functions, which can be started easily without the need for detailed knowledge, and are intended to provide good results automatically. Does this mean that the oracular assessment made above no longer applies? Was the judgement too pessimistic? The answer is partially yes and partially no. Naturally, good to satisfactory results are obtained in many cases – mainly in those target applications for which the self-tuning procedures have been developed. It must be remembered, however, that regardless of the controller manufacturer involved, all the usual methods are based on the findings of Ziegler & Nichols. They either use the step response approach with dead timer and recovery time, or the oscillation test with critical loop gain and duty cycles at the limits of stability, in order to determine the optimum parameters for their primary application areas. Moreover, before the tuning attempt is started, all automatic procedures expect a constant and stable process condition. Unfortunately, this is frequently not attainable, simply because the loop's inertia prevents gradually drifting process values from coming to rest within a short time – in spite of manual operation. Impatience or time pressure can then lead to the self-tuning attempt being started too soon, which in turn leads to poor results or even a premature stop of the attempt. As is generally known, PID controllers provide excellent control performance for processes with a ratio of recovery time to dead time (Tg/Tu) above 10. With Tg/Tu > 3 things start to get difficult, and with Tg/Tu < 3 practically all methods fail to determine satisfactory control parameters. Evil tongues even claim that PID controllers are entirely unsuitable in the latter case. It is also well known that these difficult processes are encountered increasingly often. The reasons for this are found mainly in the modernization of plants mentioned above, but also in the non-observance of control technology aspects already during the design stage. Sensors are installed in sub-optimal locations, or valves and pipes are dimensioned too small or too large. Similarly, the inflow and outflow pipe runs for flow measurements can be too short. Consequently, problems involving control technology are no longer the exception.

I "Creeping" transition
II Empirical attempt
III Critical settings
IV Robust settings with PIDMA self-tuning
V Tuning with PMA's standard method

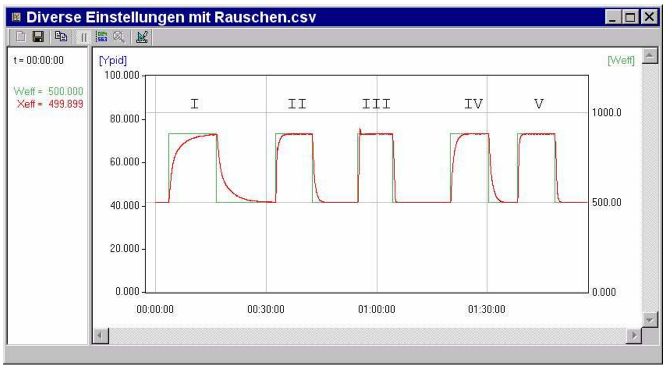


Fig. 1: Comparison of process value/setpoint curves for various PID settings

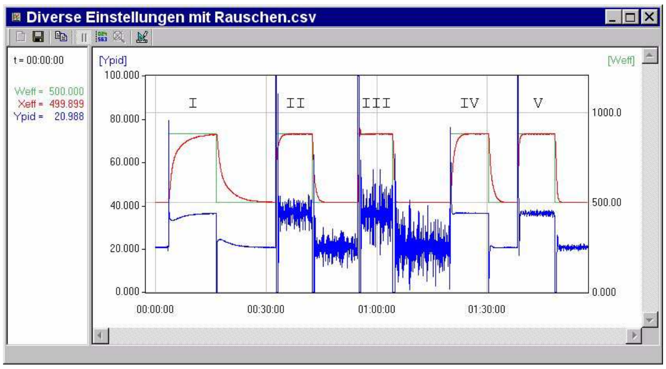


Fig. 2: The actuator's operating frequency is decisive for its service life

Are solutions in sight?

With its PC-based self-tuning tool «PMATune», PMA intends to prove that claims regarding the application limits for PID controllers are not justified. With just a single tuning attempt, the tool determines optimum control parameters for setpoint control and disturbance lineout for all processes with Tg/Tu = 0, i.e. under extremely difficult conditions. Hereby the settings enable a predicted control performance to be achieved reliably – regardless of whether the attempt is made during start-up or at the setpoint, with continuous, two-point or three-point stepping controllers, or in loops with or without self-regulation. The only exceptions are loops that are subject to self-oscillation, and loops with a pronounced non-minimal phase. Amplitude and direction of the output step change, as well as the amount of process value change are determined in advance by the user.

The practice-proven tool not only saves time, but also saves the nerves of everyone involved

After one year of tough field trials, it is safe to say that PMATune is a tool that not only saves time and money during commissioning, but also the nerves of everyone involved. This has been made possible by a complex and mathematically precise procedure, whose only common link with Ziegler & Nichols is the test set-up.

Practical assistance

Undisputedly, PC-based tuning tools can be a great assistance. However, life would be a lot easier, if one could do completely without them. This has now been made possible with PMA's multi-function unit KS 98. The on-board function library has been extended with the controller block PIDMA, which contains the described features of PMATune. Self-tuning is started and monitored in the accustomed simple manner during operation, and delivers robust settings for the PID parameters. The remaining time for the tuning attempt is estimated and displayed. Determined parameters are activated automatically. With PIDMA, every controller comes with its own integral self-tuning function – as it cannot be forgotten, there is no need to purchase it subsequently under possible time pressure. Commissioning almost becomes a routine matter, and there is no need to worry about good control performance. In short, it's an extremely valuable and practical tool for every control engineer and technician, whether he is experienced or not.