

Why don't we properly train control engineers?

While there are managers in the process industry that see training control engineers as a “no-brainer,” these are very much in the minority. They may send staff on courses covering configuration of the distributed control system (DCS) and implementation of multivariable predictive control (MPC), but some managers seem to miss the point that engineers also need to develop expertise in *basic* control techniques. It appears to be a case of not knowing what they don't know—i.e., there is a lack of appreciation of what a fully trained engineer can achieve. Without an injection of expertise, so-called “experienced” staff lack the knowledge to pass on to new recruits.

Of the engineering disciplines relevant to the process industry, process control is probably the least well-taught at universities. Often handled by lecturers with backgrounds having little to do with chemical engineering, the courses are laden with complex mathematical techniques that have little relevance to the industry. While all graduates need additional training to advance their careers, this is particularly true for those destined to work in the field of process control.

Process control engineers have an immediate impact on the process. Today's systems permit the engineer to move from idea to commissioning with little involvement of other staff. Most other engineers develop recommendations that are reviewed with others, move on to designs that are also reviewed, and work with others during commissioning. Control engineers are more akin to process operators in the way they work. Operators are well-trained, so why aren't control engineers?

Questions to consider. The following 10 questions are designed to expose common gaps in a reader's knowledge. If you are a control engineer, be honest in answering them:

1. Have all of the controllers been configured with the best choice of a proportional/integral/derivative (PID) algorithm? For example, am I aware that most systems support the option to have proportional action based on the process variable (PV), rather than on error? Do I believe that this algorithm is inferior because it gives a slow response to setpoint (SP) changes, or do I know that, for many controllers, applying this option with the correct choice of tuning can reduce, by a factor of three, the time that it takes the process to recover from a disturbance? (See FIG. 1.)

2. Am I using trial-and-error as the main tuning method? Am I aware that this increases, by a factor of around 50, the time taken to properly tune a controller? Do I know that, because of the time required, the controller is unlikely to ever be properly tuned? Am I aware that there are over 200 tuning methods published for PID control, and that most—if not all—of them

have some major deficiency? Does my chosen method properly compromise between a fast return to SP and the movement of the manipulated variable (MV)? (See FIG. 2.) Is this method designed to be used with the chosen version of the PID algorithm?

3. Do I know that applying derivative action can greatly improve controller performance if the process deadtime is large compared to the lagtime? (See FIG. 3.) Am I reluctant to use it because it makes tuning more complicated? Do I abandon its use if the measurement is noisy, or do I know how to solve this problem? Do I know how to resolve the spiking problem that derivative action causes with regard to discontinuous signals?

4. Is maximum use made of the surge capacity in the plant? (See FIG. 4.) Are vessel levels maintained close to SP, or are they allowed to approach alarm limits to minimize downstream flow disturbances? Are level gauges ranged to maximize vessel working volume? Do I know that nonlinear algorithms such as “error squared” and “gap control” can be used to more fully exploit surge capacity?

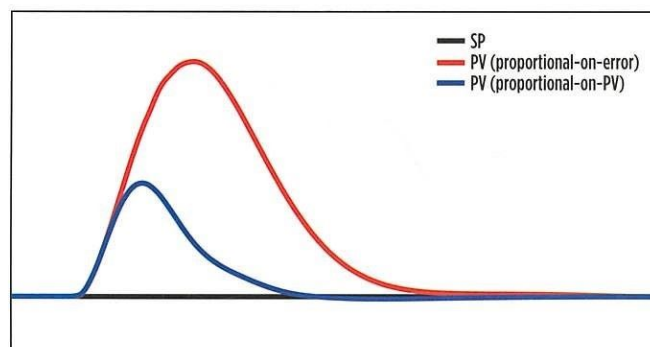


FIG. 1. Response to a load change.

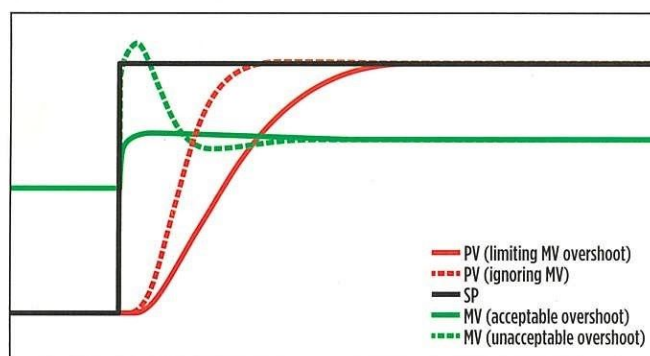


FIG. 2. Taking account of MV overshoot.

5. Are filters being used mainly to reduce the visual impact of noise on trended variables? Filters can significantly reduce the controllability of the process and may not be necessary in all cases. Do I know that I should instead check what impact the noise has on the final control element (usually a control valve)? Do I know of other readily available filtering techniques that cause less distortion to the base signal? Am I aware of the importance of eliminating noise at the source, particularly with level measurements, and how this can be achieved?

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6. Am I aware of other algorithms that can outperform even an optimally tuned PID algorithm? Do I know that these can be easily implemented in most DCSs?

7. Do I know that most MPC packages provide *bias* rather than *ratio* feedforward? In many cases, performance can be substantially improved by implementing ratio feedforward at the DCS level. Do I know how to properly tune the dynamic compensation in such controllers? Do I know of the benefit that ratio feedforward gives in automatically maintaining optimum PID tuning in all of the unit's controllers as the feed rate is changed?

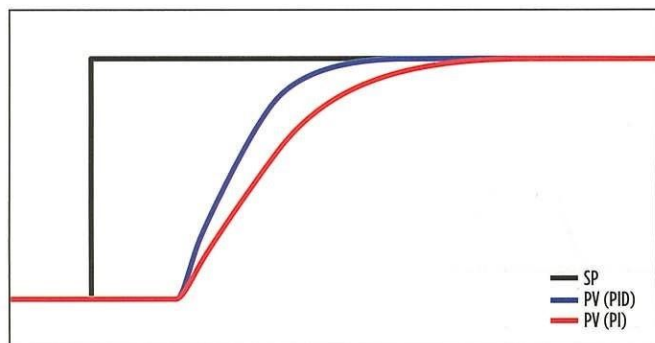


FIG. 3. Use of derivative action.

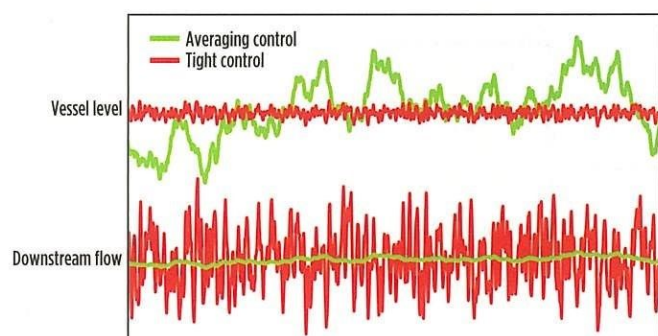


FIG. 4. Use of surge capacity.

8. Do I apply density compensation to fuel gas flow controllers to display flowrates in standard volumetric units (e.g., Nm³/hr or standard cubic feet per minute)? Do I know that this worsens the disturbance caused by changes in gas heating value?

9. Are my inferential property calculations automatically updated using laboratory data? Am I aware that, in most cases, this can cause the inferential to become *less* accurate?

10. Have I been persuaded to locate my compressor controls in specialist hardware rather than in the DCS? Do I know that, if I apply the correct tuning method, this may not be necessary?

How did you do in the test? If it has exposed even one area where your knowledge is incomplete, then chances are that there is an opportunity to improve process performance that will capture benefits far exceeding the cost of effective training.

Training costs. What does it cost to train a control engineer, and what are the economic benefits? In addition to the time spent on learning how to configure the DCS and how to apply the chosen MPC, a control engineer will need around three weeks of further training. This training should cover basic control techniques, "conventional" advanced control, process-specific techniques, inferentials, etc. Such courses can cost \$1,000 per day. Factoring in travel and living expenses, the total price of training could be \$20,000. A manager might view this as costly, but it is insignificant compared to the benefits to be achieved through additional training.

For example, a control engineer typically will be responsible for control applications that are capable of capturing in excess of \$500,000 per year. Commissioning a project of this value just two weeks sooner would be enough to justify the training. If maintaining existing applications (for example, over a two-year period), then a 2% increase in their utilization would generate the same savings. Also, if the company relies on external specialists during implementation, then reducing the involvement of a top-grade consultant by two weeks would yield similar savings.

While such benefits apply to operating companies, similar benefits can be achieved by those companies offering advanced process control (APC) implementation and process engineering services. With only minor differences between competing technologies, the main criterion in selecting an APC implementation company is the expertise of the engineers it offers. Winning even one more contract by demonstrating a higher level of expertise more than justifies the cost of developing that expertise.

Similarly, plant owners are increasingly expecting engineering contractors to be more aware of the importance of good basic control design. Too many processes with inherent control problems exist, along with missed opportunities that could have been avoided at negligible cost, if considered at the process design phase.

Which course should an engineer choose? More than any other engineering subject, process control training requires practical, "hands-on" exercises. Most engineering disciplines work with steady state. It is relatively easy to demonstrate steady-state behavior in a computer slide presentation. However, it is not so easy to show parameters changing over time.

Student-friendly, dynamic simulations take far more time to build; it can take 50 hours or more to develop the material covered in one hour on the course. The ratio for the preparation of more conventional teaching material is likely less than 10:1. More effective courses are necessarily more costly. This is particularly true if they are presented by the more experienced—and, therefore, usually more highly paid—engineer. The value of a course should be assessed on what impact the participant can have on process profitability upon returning to work. He or she should return with several ideas that can be put into practice immediately.

Presenting the course on a manufacturing site provides the opportunity for practical exercises to be carried out on real controllers. The resulting improvements have a noticeable impact on process performance, and they greatly increase the confidence of the engineer to implement other ideas.

Who should present the course? It might be easier to answer this question by identifying potentially poor choices. The DCS vendor is best placed to instruct staff in the use of the system. However, vendors are generally more effective at explaining the “how” than the “why.” For example, they can describe the multiple versions of the PID algorithm available in their systems, but they are generally less adept at explaining when each algorithm should be used.

Similarly, the MPC suppliers will be able to describe how to effectively design, implement and monitor their technology, but they will not go into detail about the basic controls that should be in place before step-testing is undertaken. While MPC suppliers are concerned that such controllers operate well, they generally place less demanding criteria on their performance.

With a few notable exceptions, most academic institutions treat process control as a highly theoretical subject. Their courses tend to be cheaper because the tutor’s time and the facilities have already been paid for; however, their usefulness is often questionable.

Should the course be held in-company? There is the temptation, particularly if only one or two engineers need training, to send them on an open-access course. It costs the supplier more to run these types of courses than it does to run in-company courses since open-access courses must be marketed to a wide client base, there is a greater administrative load, and the course facilities must be rented.

For the customer, an open-access course may be the less costly option, even with the inclusion of travel and living expenses. Also, engineers may have the opportunity to develop valuable contacts in other organizations. However, the following points should be considered:

- An in-company course opens up the opportunity for others to attend; the most successful APC projects are those in which the entire staff is involved.
- Plant supervisors, process engineers and production planners normally do not attend open-access process control courses; however, they will usually sit in on at least part of an in-company course. An in-company course provides a valuable opportunity for these personnel to develop an awareness of technology and the role they can play in its successful implementation.

- An in-company course can be customized to closely match the company’s needs.
- Some material included in an open-access course may not be relevant; it may assume less previous knowledge, and its timing may be inconvenient.

When should training take place? Training budgets, like many expenses that are perceived as optional, are often the first to be cut when the economic climate is poor. However, this is precisely the time when control engineering expertise should be developed. The likelihood is that no major APC projects will be approved, and so releasing engineers for training does not disrupt their schedules.

Furthermore, engineers will have time to identify and exploit the many zero-cost improvements revealed by the training. Also, when major investments are again considered, the basic process control layer will already be ready to receive APC—therefore, substantially shortening its commissioning. **HP**



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