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Are there any good APC training programs out there?

I have written several articles and editorials warning about the failure rate of advanced process control (APC) applications. See for example my January 2006 editorial,[1] which also references related literature. One of the reasons for these failures is the chronic shortage of quality APC engineers. APC has always been bottlenecked by availability of experts, but when "streamlining" (a euphemism for the industry-wide massive layoffs of the 1990s) came in vogue, this problem was exacerbated, since many APC experts retired or changed direction. Those experts left in the field are so busy and heavily traveled that their burnout rate is high. Thus, it is time industry trains a new generation of APC experts. My feeling is that, two decades ago, there were about 500 experts worldwide. Presently, this number stands at about 200.

How do we train APC experts? We cannot! One has to begin by training APC engineers, and then creating a favorable environment for them to stay in the career long enough to become experts. And how does one cultivate APC engineers? A good way to begin thinking about it is by listing the job requirements:

1. First, APC engineers should have very good process engineering skills. Ideally, the starting point of an APC engineer is someone with several years' experience as a process engineer. That is a problem in itself because companies no longer provide the level of training for process engineers that they used to give in the pre-streamlining days.

2. Be very familiar with the units on which they implement or maintain APC: understand unit chemistry, constraints, dynamic behavior, effect of different feedstocks, fouling or other gradual changes, catalyst changes, seasonal operational changes, etc. The object of APC is to nudge the unit toward real constraints, and APC engineers must discriminate between myths versus real equipment limits.

3. Know the upstream and downstream units, i.e., influence of upstream operations on the feed properties and influence of the unit under APC control on downstream units. Unit constraints are often dictated by upstream or downstream considerations.

4. Be aware of the economics, not only of the unit in question but also the entire plant—upstream, downstream and sideways of the unit.

5. Be proficient at performing degrees of freedom analyses to avoid infeasible control strategies.

6. Be acquainted with inferential modeling techniques, specify the measurements that affect product qualities as input to the inferential models, and, ideally, be able to develop first-principles or semiscientific models. Inferential models estimate product qualities and other unmeasured constraints. When the unit is butting up and down against constraints, we must be sure that product qualities are met.

7. We now come to control engineering dynamic skills: comprehend the tuning requirements of different DCS loops, from fast flow controllers to intermediates, to intentionally slow level controllers. Recognize the dynamic interactions between loops, the process reasons for these interactions and possible tuning or decoupling solutions.

8. Be familiar with control theory and especially with predictive techniques. After all, multivariable predictive controllers (MVPCs) are based on multivariable Smith predictors.

9. Understand the commercial MVPC controller structure: a dynamic controller working to keep the unit in a feasible region, plus an optimizer to push the unit against constraints, typically to a vortex on the constrained space.

10. Recognize the multitude of MVPC tuning coefficients and how to use them to improve control performance.

Well, who are you kidding? Could any individual combine the knowledge of process engineering, planning, scheduling, control engineering and, on top of that, have modeling ability and familiarity with the complex MVPC software? Yes, all of the above and then some! APC engineers should be passionate and assertive, because pushing the unit against real constraints is a tough battle against operational myths and a prevalent desire to operate the same way as yesterday and not rock the boat. Those battles are stressful, and the APC engineer risks a loss of credibility on making mistakes.

Furthermore, there are no textbooks. APC engineers must be self-sufficient. Of course, you do not create such an expert overnight. Since the lead time is long, right now is not too early for the industry to develop APC training programs. Newly trained APC engineers would still have a chance to rub shoulders with, and be nurtured by, the few experts still active in the field. In 10 years or so, we would hope to have the next generation of APC experts.

Does the APC expert need to be more of an expert than other hydrocarbon industry professionals? In some respects, yes. APC makes moves on a unit, maximizing yield of some products subject to constraints. Those constraints are often not in the unit of interest but often in downstream units or even in product blending, or they may be in the unit, but without being measured—for example, catalyst deterioration rate. Constraints, including unmeasured ones, have an economic function that goes up gradually as we nudge the unit toward the constraints, and they are penalized heavily as we exceed the constraint.

When APC operates correctly, it takes the planned production and improves on it. Thus, the APC engineer must understand the workings of the whole plant just like schedulers and planners. APC can improve on an already optimized plan because the so-called optimized plan was created for a then-future situation with assumed constraints. Here, in the present, APC measures the actual situation and constraints. If it has the right wisdom built into the application, it can improve the schedule, making money in the process. But use of the wrong logic would be equally counterproductive.

When you leave the bird's-eye view of the complex and go into a specific unit, APC manipulates DCS controllers to achieve an economic outcome: throughput, yields, safety, run length and product qualities. The relationships between DCS controllers and plant economics are neither simple nor linear. Process engineers work hard to figure out these relationships, and yet they usually think only in steady-state terms. The APC engineer must consider these same functions, in about the same level of detail, not only at steady state but also and foremost as a dynamic relationship. In APC, we perform step tests on the unit to obtain a dynamic model, which give us clues as to the behavior of the unit. But these techniques provide only simplified linear information, whereas much additional knowledge outside of the step test model should reside in the APC engineer's head. Step tests, by the way, are difficult, and their identified dynamic models are apt to be wrong. It is worth its weight in gold when an APC engineer looks at the dynamic models with critical eyes, judging which models are OK, and which tests are to be repeated.

That is not the end of the argument about needed APC expertise. APC works minute by minute. On that time scale, there are no lab measurements to help judge the situation. The schedulers and planners also do not have the luxury of lab feedback, and indeed their plans are conservative. If we hope to improve them by the added precision of APC, then the APC engineer should know something about inferential modeling. I am a proponent of first-principles models over regression models, but, even if the engineer resorts to regression because he or she has no access to first-principles models, the engineer should be able to select the best set of inputs to an inferential model, and sometimes make a judgment that there are no sufficient measurements to facilitate the desired inference.

I am very convinced that the dwindling supply of APC experts calls for an emergency effort to create advanced APC training programs, but thus far, to my knowledge, not much has been done. Does anyone offer a good APC training course? APC vendors typically offer product training programs, addressing items 9 and 10 of the requirements: MVPC structure, controller setup and tuning considerations. Such training is useful for the job but does not inspire the individual to become an expert. I also know of several consultants who offer dynamic courses covering items 7 and 8. Items 1 through 6 are, to the best of my knowledge, not widely covered.

I would welcome comments from vendors offering APC courses and ask them to elaborate on which of the 10 requirements they cover. Please avoid infomercials and just state clearly what the course is about. Comments from operating companies whose courses are not open to the public are also welcome. Should there be a reasonable response, I would inform the readership of what's available in another editorial. I would also include then a series of unit-specific courses that I have developed to address the problem of insufficient process engineering experience among APC engineers. **HP**

LITERATURE CITED

[1] Friedman, Y. Z., "Has the APC industry completely collapsed?" *Hydrocarbon Processing,* January 2006.

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