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APC designs for minimum maintenance—Part 1

I, and others, have written much about the difficulties of maintaining advanced process control (APC) applications.[1–5] It is a problem to be tackled on many levels. There are issues of manning, training and organizing that we APC engineers have only a limited influence on. On the other hand there are other areas that we do indeed influence, and this editorial addresses one of those: Design of the APC application in a way that would make it easily maintainable. What is more important for the APC—to recover 100% of potential benefits or to recover 70% of potential benefits and be easy to comprehend and maintain? Considering the history of APC maintenance the latter is better by far.

I would like to offer several rules for making APC more robust and durable, to the point that applications can survive in an environment of poor maintenance, but lack of space permits only one rule, leaving the others to be addressed by following editorials. The rule is generic and should apply to any APC configuration, though the simple distillation column of Fig. 1 will serve to illustrate the points.

Design rule 1. Do not clutter the control matrix. Associate each control variable (*CV*) preferably with one, hopefully no more than two, manipulated variables (*MVs*).

But aren't we dealing with a multivariable predictive control (MVPC) tool? Can't we move many *MVs* to bring a *CV* to its desired target? Yes, the *CV* of interest could have a model against many *MVs*, but the easy-to-maintain (and to implement) application would move only one or two handles per *CV*. If those two *MVs* are off then the associated *CV* should be shed. In our distillation example, *CV1* is a top product purity inference and *MV1*, the associated manipulated variable, is tray six temperature. Are there other *MVs* that could affect the top product purity? Yes, of course, increasing reboiler steam, *MV2*, would increase fractionation and affect the top purity. Increasing column pressure, *MV3*, would change the equilibrium on tray six and affect top product purity as well.

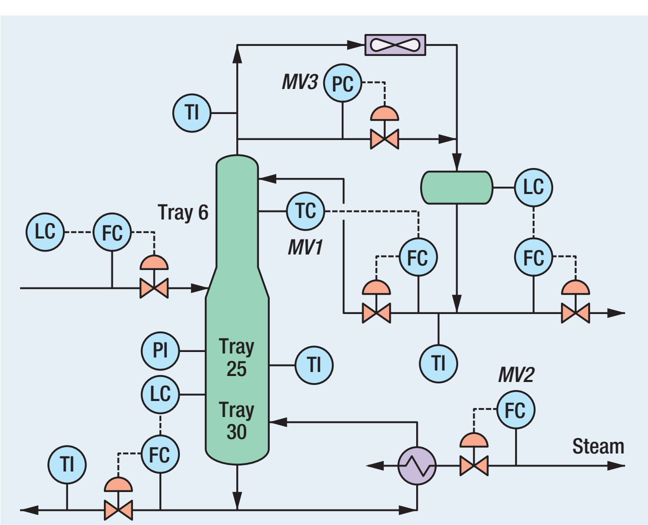

FIG. 1 A distillation column candidate for APC.

How then would the MVPC know that pressure and steam are not to be used to control top purity? How would the top purity be controlled when tray six TC is against a max limit?

Answer. Associate the column pressure, *MV3*, also with the top quality. Now there are two handles for control of top quality. Set one of these to a lower priority: Pressure changes are to take place only when the tray temperature controller is against a limit. In a well-operated application the tray temperature setpoint would not be superficially bound, but in a poor maintenance environment, if the operator makes a mistake of setting a temperature limit quality, control would still work.

And how should we use reboiler steam, *MV2*? The column of our example has a DCS tray temperature controller manipulating reflux. Increasing reboiler steam heats up the column, and the tray temperature controller would close the heat balance by increasing the reflux. This MV has only a limited influence on the top product quality, and I would be inclined to use it solely to control reboil ratio, *CV3*. A reasonable reboil ratio would ensure that if top purity specification is met then bottom purity is also under control.

To complete this design we ought to consider abnormal constraints, such as a hydraulic reflux valve limit, *CV2*, or a flooding limit, *CV4*. Should the demand for reboil ratio conflict with reflux valve position or flooding constraint that renders the control problem infeasible, dictating that the reboil ratio target, *CV3*, must be abandoned.

Thus, we have come up with the simplest possible design, and if the top product inferential model is reliable, such a design is likely to survive in a lack of maintenance environment. **HP**

LITERATURE CITED

1 Friedman, Y. Z., "Avoid advanced control project mistakes," *Hydrocarbon Processing*, October 1992.
2 Latour, P. R., "Does the HPI do its CIM business right?," guest editorial, *Hydrocarbon Processing*, July 1997.
3 Friedman, Y. Z., "Advanced process control,it takes effort to make it work," HPIn Control, *Hydrocarbon Processing*, February 1997.
4 Kane L. A., "Controversy in Control," editorial, *In Control*, March/April 1998.
5 Friedman, Y. Z., "Audit your APC applications," *Hydrocarbon Processing*, December 2006.
6 Friedman, Y. Z., "Choosing inferential modeling tools," *Hydrocarbon Processing*, January 2006.

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