Originally appeared in HYDROCARBON PROCESSING® April 2010, pg 13. Posted with permission.

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Distillation column dual-temperature control—Part 2

Part 1 of this editorial[1] has considered a distillation dual temperature control structure and concluded that such strategy is problematic and not likely to work. If you accept that dual-temperature control is not the ideal basic structure—how then should we configure DCS for distillation? In my experience, either with heat balance or mass balance, only one of the tray temperature controllers can work. Many considerations affect the selection of rectifying versus stripping tray, and it goes without saying that this temperature controller must ultimately affect the yield and, hence, it isn't desirable to choose a stripping tray temperature for a mass-balance control structure.

Say we have selected the stripping tray temperature on a heat-balanced column, and that is a simplified inference of bottom purity. What should we do to control top purity? The simplest way is to set the reflux-to-feed ratio to a reasonable value. I prefer reflux-to-feed ratio over reflux-to-product because the latter introduces a mass-balance component into a heat-balance structure. I.e., the ratio to product flow makes reflux proportional to the drum level controller output.

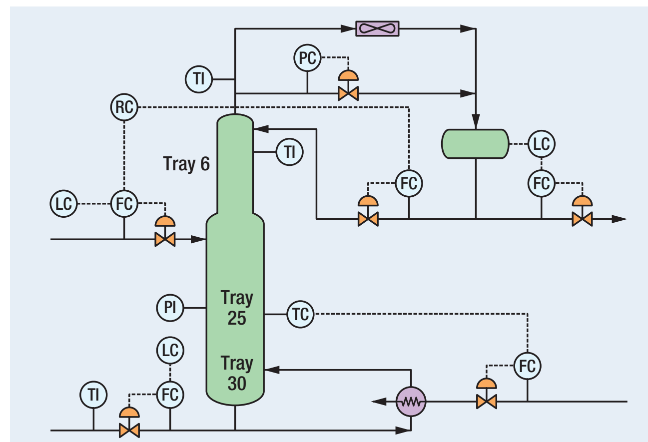

FIG. 1 Single-temperature control on a heat-balance control structure.

ARC vs. MPC. That gives us the basic DCS structure of Fig. 1, and now we can discuss APC, and whether MPC or ARC is to be employed for dual composition control. It is rather rare in refining to find both top and bottom analyzers on a single column. Not counting main fractionators, I would say that fewer than 10% of refinery distillation columns have two analyzers. If we consider only reliable analyzers then the number goes down below 5%. APC has to rely on inferential models, and that is not bad because inferential models do not have the dead-time of analyzers, and inferential models, if done right, have fewer reliability problems than analyzers. If you are lucky enough to have a reliable analyzer as well as an inference model, the ideal structure is to connect the inference as the primary controller, while setting up a slow inferential bias to reduce the difference between the inference and analyzer.

And what if two inference models are available, can we attempt control of both top and bottom composition? Being in the inferential modeling business, I often come up with both top and bottom models that rely on rectifying and stripping tray temperatures. Connecting both models in closed loop is just as problematic as dual-temperature control. My approach for avoiding interaction between the two loops is to use one of the models for manipulating yield, for example connecting it to the reboiler steam. The other, say top model, I would rework as a function of bottom purity and internal reflux, and use that model for setting reflux ratio. Now we have an APC design that overcomes the top/bottom interactions, and would work either in MPC or ARC format. The temperature based inference controller—ARC or APC type—would act quickly on the reboiler, directly or via a tray temperature controller, making the top purer and bottom more contaminated (or vise versa) by changing the yield. The internal reflux based inference controller would act slowly on the reflux, an action which makes both products purer (or more contaminated).

Lastly, where do I stand in this argument about whether ARC works better or worse than MPC? In the '70s, MPCs were not available and we implemented all APC using ARC plus custom logic. When implemented by a competent engineer they worked well. By and large we continued this way into the '80s. MPCs were already there but the early versions were no better than ARC.

I have continued to be involved with ARC through inferential modeling. I often supply models in open loop. Then once the inference works there's a push to close the loop, and the cheapest way to do that is ARC. I have thus implemented ARC applications with fairly high complexity in crude units, alkylation units, FCCs and a host of smaller distillation columns. My judgment is that under multiple constraints MPCs work somewhat better, but the most important factor is the engineer. The difference between a competent implementation versus a mediocre one is much greater than the difference between MPC and ARC. A second important consideration is availability of local skill to perform MPC or ARC maintenance work. **HP**

LITERATURE CITED

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The author is a principal consultant in advanced process control and online optimization with Petrocontrol. He specializes in the use of first-principles models for inferential process control and has developed a number of distillation and reactor models. Dr. Friedman's experience spans over 30 years in the hydrocarbon industry, working with Exxon Research and Engineering, KBC Advanced Technology and since 1992 with Petrocontrol. He holds a BS degree from the Israel Institute of Technology (Technion) and a PhD degree from Purdue University.