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HPIN CONTROL

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Condenser hot vapor bypass control

What is the worst mistake? It is the one that is repeated in practically every refinery, and yet, we haven't managed to learn from it. I have chosen to discuss the very simple distillation column pressure control by partial flooding of the condenser. This method is used often when the column overhead vapor is totally condensed into the accumulator.

As illustrated in Fig. 1, a valve is placed on the condenser outlet to create a flow restriction and build up liquid level inside the condenser. As level rises, condensing area shrinks and then the column pressure starts trending up. And vice versa, upon draining the condenser, condensing area increases and pressure starts trending down. This control method must allow some hot vapor to bypass the condenser to control accumulator pressure. Hot vapor coming into the accumulator condenses on the subcooled liquid surface, and hence, the hot vapor flow is always unidirectional. Accumulator pressure should be set somewhat lower than column pressure to permit proper operation of the condenser outlet valve.

This system in Fig. 1 works well and is easy to tune. Accumulator pressure is tuned fairly tight, whereas the column pressure is tuned slowly, much like a level controller. That makes sense because in response to a change in outlet valve position, uncondensed vapor keeps accumulating and the pressure acts like a pure integrator. While these two control loops interact, they interact in such a way as to help each other. When column pressure goes up the accumulator pressure controller would shut the bypass and the column pressure controller would open the condenser outlet, and both these actions go in the same direction of reducing the column pressure.

In the "enhanced" system in Fig. 2, the accumulator pressure controller is replaced by a pressure difference controller. It is a minor DCS change with a very good intention. In the configuration of Fig. 1, when the column pressure is to be changed the operator must change the setpoints of both controllers. While these columns operate day in and day out at constant pressure, there may be some seasonal changes, and the configuration in Fig. 2 might save the operator one minute or so upon changing column operating pressure. In any case, this is a tiny DCS change, so why not do it?

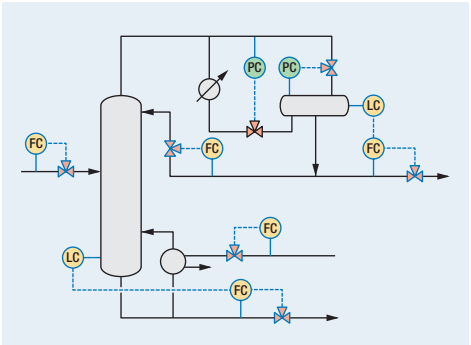

FIG. 1 Condenser hot vapor bypass control.

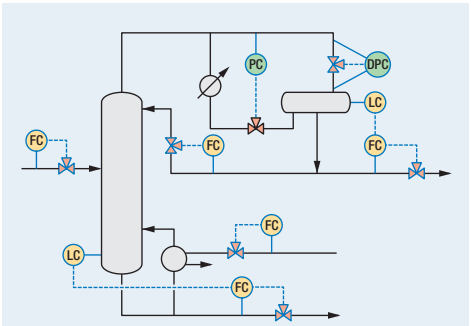

FIG. 2 "Improved" hot vapor bypass control.

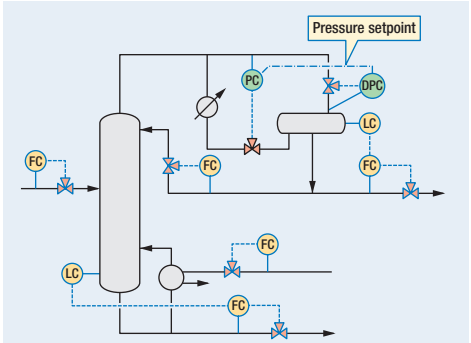

FIG. 3 Another tiny change of DCS structure will now restore the favorable dynamics of Fig. 2 while maintaining the intended convenience of Fig. 1.

Because this tiny DCS modification creates a not-so-tiny change of loop interaction pattern. In the previous configuration, upon an increase of column pressure the bypass valve closes, but with this new Fig. 2 configuration, when column pressure goes up, the bypass valve would open. That is, as the column pressure controller is trying to drain the condenser, the bypass control acts to increase accumulator pressure, preventing condenser drainage. That interaction makes the control loops next to impossible to tune. I must have seen at least 100 Fig. 2 configurations and none of them worked. Invariably the hot vapor bypass was operating manually, and the good intention of avoiding the nuisance of changing two setpoints instead of one has caused a much bigger nuisance of having to change the hot vapor bypass position manually, and experiencing frequent pressure disturbances.

Fig. 3 offers a way to "have your cake and eat it too." Use pressure difference for controlling the hot vapor bypass, but instead of the actual column pressure, use the column pressure setpoint. Another tiny change of DCS structure will now restore the favorable dynamics of Fig. 1 while maintaining the intended convenience of Fig. 2. Do please try that and see the magic of an impossible-to-tune loop becoming a cinch. **HP**

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