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Temperature points on main fractionators

Main fractionators are distillation columns that handle wide boiling curve feeds, cutting it into several products. Almost every major refinery unit has such a column, all with similar design features, though some are easier to operate than others, and "easier to operate" translates to more optimal operation and fewer incidents. From my advanced process control (APC) and inferential control perspectives, units that are easier to operate naturally lend themselves to better inferential modeling and better APC. This editorial attempts to highlight the differences, and it concludes that a small investment in instrumentation can substantially improve main fractionator performance.

To fit the space we cover only one typical style of main fractionator design (Fig. 1). Hot partially vaporized feed enters the flash zone. The vapor portion includes all distillate products plus some additional evaporated material called overflash. Below the flash zone is a steam stripping section for stripping absorbed distillates off the bottom residue product. Above the flash zone, vapor is condensed in stages by cooling circuits called pumparounds, and side streams are proportionally drawn, stripped in side strippers and become middle distillate products. In the style of Fig. 1 the draws are partial draws, meaning—excess internal reflux not drawn out flows down the column. For simplicity, Fig. 1 does not show stripping steam, but it shows all other control handles: top temperature controller, side product flow controllers and pumparound flows.

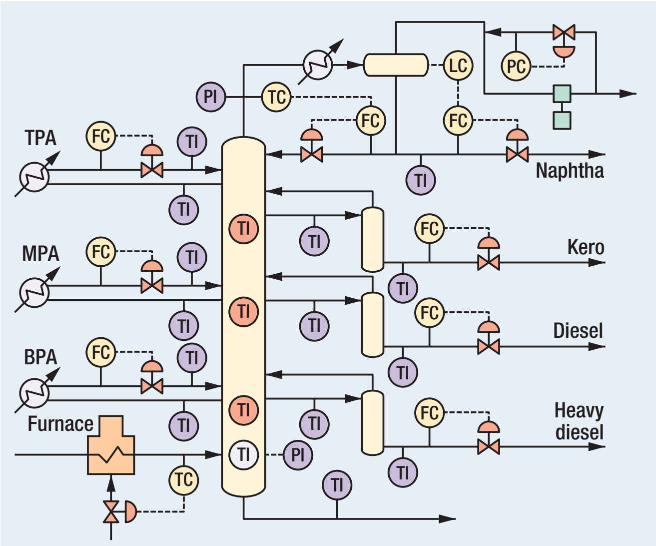

FIG. 1 Wide-cut fractionator structure.

What's missing? What this control structure misses is the fact that the operator does not know the content of middle distillates in the feed. If too much side products are taken, they would go off specification. Worse yet, the section of column immediately above the flash zone can run dry, resulting in contamination of heavy diesel by entrainment. On the other hand, if side draws do not take all of the middle distillate material available there are economic penalties. At steady state operation that is merely an inconvenience, forcing the operator to rely heavily on lab tests, but upon disturbances, such as crude switches, coke drum switches, operational mode changes, etc., the operator is in the dark. Danger of contaminating the lowest side draw makes overflash perhaps the single most important control variable, only that most important variable is unmeasured. Of the attempts to measure overflash by orifice meters the rate of success stands at about 10%.

Temperature indicators typically available on main fractionators are shown in Fig. 1 in purple: cooling circuits, draws and flash zone. But draw temperatures are bubble points, not so much related to the product 90% point, but rather to the initial boiling point. Farther, draws are saturated with light materials, which skew the interpretation of temperature readings. Pumparound heat duty calculations might be useful for engineers but they do not provide inference of product qualities. To use these available indicators in a productive way one needs to employ an inference package connecting all of this information together and digesting it into product quality inferences. That implies implementing APC, and even then, model repeatability improves if it does not have to rely on draw temperatures.

Best temperature points. Temperature points that could help the operator handle fractionator disturbances should be located in the vapor space of trays immediately below the draws, and are shown in Fig. 1 in orange. These are dew point indicators with much cleaner interpretation. Dew points are rough inferences of the 90% points we are trying to control, and as opposed to bubble points are less influenced by light material flowing across the tray. Especially the one temperature point below heavy diesel is of much value. In addition to this temperature being a rudimentary inference of heavy diesel 90% point, the temperature difference between the flash zone and vapor below heavy diesel is rough inference of overflash, and being able to control overflash is mandatory for good operation during disturbance. I hope equipment designers read this and take notice. **HP**

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.