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Controlling the mundane naphtha stabilizer, Part 1

Consider the distillation column in Fig. 1. It is called a “stabilizer” and removes LPG from naphtha. Every refinery has at least three of them, and often five or more, one each in every crude unit, reformer, FCC, hydrocracker, coker, isomerization and possibly other units. Being simple in structure, and with a well-defined objective, you would think controlling a stabilizer is a cinch. Why then do we encounter so many of them being run with the main DCS controllers in manual?

The name stabilizer reflects a historical task of removing enough LPG to reduce the naphtha Reid vapor pressure (Rvp), permitting its storage in floating-roof tanks. Economics have changed, however, and the objective is to remove essentially all LPG from the naphtha, subject to a constraint on LPG purity of about 1% C₅ contamination. The reasons why operating targets have changed vary from unit to unit, and usually have to do with Rvp and alkylation economics. In FCC gas plants, it is of value to remove butane from naphtha because olefinic FCC butane is one of the alkylation ingredients. In saturated gas plants, we try to maximize isobutane recovery because it is the other alkylation ingredient. That calls for removing all butane and processing it in a deisobutanizer tower. Furthermore, stabilized virgin naphtha is split into light and heavy naphtha, and light naphtha is processed in an isomerization unit. LPG is problematic in the isomerization unit and should be removed from the feed. Even where these considerations do not apply, Rvp specifications have tightened, and gasoline blending is easier when the components have low Rvp.

In short, a more appropriate name for the column of Fig. 1 would be “debutanizer,” but that is in theory. Most debutanizers I have looked at leave about 2% butane in naphtha and their top C₅ contamination is less than 0.2%, i.e., we still operate them as stabilizers, losing money by not recovering all of the butane. How much money? Take typical numbers, 2% LPG in naphtha and 200 m³/Hr of naphtha (that’s the approximate naphtha production of a 150,000 bpd crude unit), and a cost penalty for leaving LPG in naphtha of \$50/m³. If those numbers are realistic for your refinery then the penalty for leaving LPG in naphtha adds up to \$1,600,000 annually.

Debutanizer control. How is a debutanizer to be controlled to maximize LPG removal from naphtha? Fig. 1 suggests a rectifying section tray temperature controller several trays from the top manipulating reflux, while the reboiler heat duty is set manually by the operator. The alternative to this structure is actually more common: a stripping section tray temperature controller manipulating the reboiler. Which temperature controller is better—a rectifying tray or stripping tray temperature controller?

The stripping section tray temperature can be viewed as an approximate inference of C₄ in naphtha. If the naphtha cutpoint, column pressure and reflux ratio are approximately constant, the stripping tray temperature defines naphtha C₄ content on that

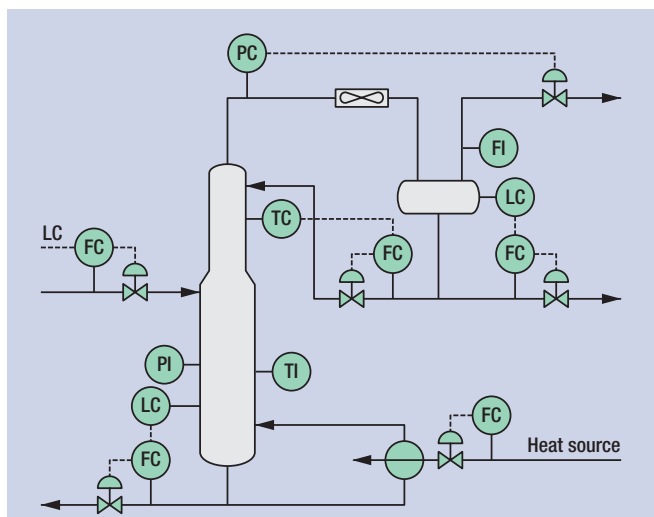


FIG. 1 Control configuration for a stabilizer used to remove LPG from naphtha.

tray. Thus, stripping tray temperature control is very appropriate if the operational objective is to leave 2% C₄ in naphtha. The tray would contain approximately 20% C₄, and at constant operating conditions the ratio between tray composition and bottom composition does not vary very much. But if the objective is to minimize C₄ in naphtha, and we could expect values of 0.2% C₄ in the debutanizer bottom, then the stripping tray temperature loses its ability to infer bottom C₄. Instead of bottom C₄, it starts inferring the quantity of C₅ in naphtha—perhaps of interest to process engineers but of no relevance to the control objective.

Suppose we have a stripping section tray temperature controller and a rectifying section temperature indicator, should we restructure the DCS control as Fig. 1 suggests? The main problem with rectifying section tray temperature control is that it does not provide a very precise inference of C₅ in LPG. The debutanizer feed typically comes from an overhead condenser on an upstream fractionator, where the LPG composition and C₂ content vary with weather and the number of fans being turned on the upstream air-cooled condenser, i.e., the correct rectifying tray temperature controller setpoint is not constant. **HP**

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