Originally appeared in HYDROCARBON PROCESSING® September 2008, pg 178. Posted with permission.

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Alkylation product separation control

People do not speak much about advanced process control (APC) of alkylation product separation. Why? Precise product separation is crucial to alkylation unit economics. Alky reactor effluent is separated in a column called an "isostripper" (Fig. 1). Alkylate is the reactor product to be separated as the isostripper bottom product. IC_4 is one of the two main alkylation ingredients, supplied to the reactor in great excess and must be evaporated into the isostripper accumulator to be recycled to the reactor. (The other ingredients react fully and do not appear in the effluent). Parafinic C_3, NC_4 and C_5 that come in with the ingredient are inerts and must be removed. Ideally, C_5 is removed at the bottom with alkylate. NC_4 is a vapor side draw, whereas C_3 is removed in a downstream depropanizer, not shown in Fig. 1.

Isostripper operation is difficult. The temperature profile, except the temperature profile to be kept, is determined by the unknown reactor effluent composition. That leads to frequent mistakes:

- Build-up of NC_4 that penalizes octane, yield and energy efficiency
- Loss of IC_4, a valuable reaction component
- Bottom section flooding due to accumulation of C_5.

With such large and obvious APC benefits, why the silence about alkylation unit APC?

It is because reasonable inferential models would be central to any alky APC, whereas the industry generally lacks the ability to come up with quality isostripper inferences. The common industry approach involves regression of column temperatures against product compositions. I would qualify regression as a "better-than-nothing" method, which might produce low-fidelity inferences in some instances, but at this level of complexity where the purity models are interdependent it is completely hopeless.

Fig. 2 is a trend of inference against lab values and it indicates what can be accomplished by the way of first-principles modeling. To illustrate the point in a one-page editorial, we discuss only one of the important isostripper variables: IC_4 in the NC_4 purge sidestream. The first few weeks of this trend show not only that a correlation exists, but also how bad the operation was, losing occasionally up to 50% IC_4 with the NC_4 purge. At that point the plant engineer made the inference available to operators and asked them to try controlling the isostripper better. The following few weeks of the trend show dramatic process improvements, where simple manual control drove the IC_4 loss from erratic operation at an average of 10% IC_4 in the side draw to about 2%.

Considering the substantial incentive to to improve the operation, the plant engineer had decided to apply standard DCS controllers to control:

- IC_4 in the side draw, manipulating the draw
- Alkylate Rvp, C_5 and C_4 content, manipulating the reboiler
- Depropanizer C_3 removal, manipulating the depropanizer reboiler
- IC_4 inventory, manipulating IC_4 addition to the reactor.

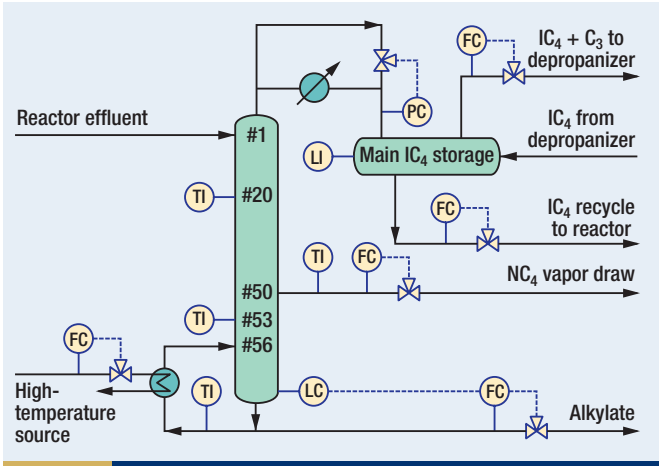

FIG. 1 Alky isostripper configuration.

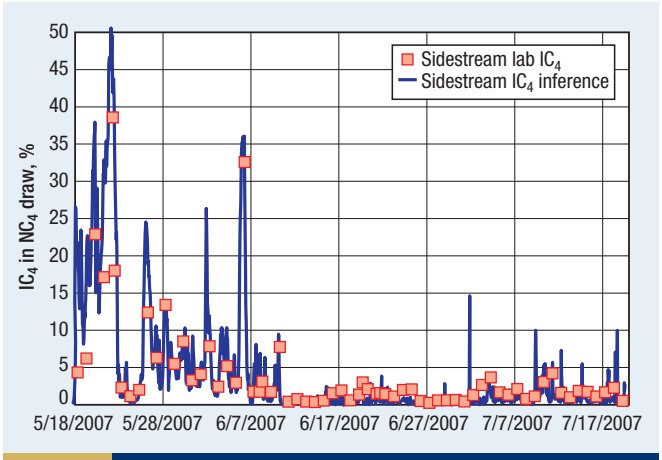

FIG. 2 Alky isostripper side draw IC_4 trend.

Not APC by definition—the purist would say, where is your multivariable controller? Correct, but do you care. The point I am trying to make is—APC is as good as the inference models it relies on. If you manage to develop good inferences, then alkylation APC is lucrative. **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.