KERIOSENE FLASH-POINT CONTROL

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Editorial

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Kerosene flash-point control

On crude fractionators economics often calls for maximizing kerosene and minimizing naphtha production, and such maximization is as effective as our ability to infer and control kerosene flashpoint, deceptively simple and practically quite difficult.

And what's the meaning of "flash-point"? Heat kerosene and its vapor pressure would increase. At a certain temperature kerosene vapor pressure would reach about 0.02 atmospheres and if that kerosene evaporates in a tank in the presence of air then the concentration of 2% kerosene and 98% air forms an explosive mixture. The temperature, above which kerosene vapor can explode, is called flash-point. Obviously flash-point is an important jet-fuel specification, and even if not sold as jet-fuel but just stored in a tank we need to control the kerosene flashpoint to be safely above actual tank temperature.

Typically side drawn from fractionators as shown in figure 1, kerosene is in equilibrium with naphtha vapor passing through the draw tray. Dissolved naphtha lowers the kerosene flash-point and must be stripped it out, usually by steam stripping in a kerosene side stripper. Given about 10% naphtha in kerosene drawn, to remove the naphtha effectively about 30% of the draw must be evaporated by the steam and returned to the fractionator. Stripping severity has a nonlinear effect; depending on stripper efficiency, going from no stripping to 7Lb steam / BBL kerosene could improve the flash-point by about 30 ºF, then increasing evaporation further to 14 Lb/BBL could gain another 10 ºF, but any further increase would gain only marginally.

What if at a stripping steam ratio of 14 Lb/BBL the flash-point is still below target? That could happen if the naphtha cut is too ambitious, and need to increase that cutpoint to further improve the flashpoint. Cutting kerosene deeper also improves flashpoint, thought that is limited by other jet fuel specifications, notably freeze point.

What's a good way to infer kerosene flashpoint? The following steps have worked for me

1. Estimate the kerosene initial boiling point assuming a perfect cut between kerosene and naphtha.
2. Reduce the estimated boiling point to reflect incomplete stripping. This penalty is a nonlinear function of stripping steam ratio
3. Use Antoine pressure – temperature relation, convert the atmospheric boiling point to a pressure of 0.02 atmospheres. IE, the point at which there is 2% vapor naturally occurring over kerosene
4. Fit that low pressure boiling point against lab flashpoint results, using a bias and possibly a gain multiplier

Figure 2 illustrates how well such an inference can work. The figure is a two months trend of inference model versus lab test without any biasing of the model. Considering the lab flash test repeatability of +- 2 ºF, the fit of this model is quite good.

Once a reliable inferential model has been established the control problem can be considered. Of the two handles which affect kerosene flashpoint, one is the naphtha cutpoint (or column top temperature), well behaved and nearly linear in response, and the second one is stripping steam, nonlinear and difficult. Our standard multi-variable controllers are not very good at handling nonlinear responses. My preference for dealing with the nonlinearity problem is to configure the top temperature as the main manipulated variable for kerosene flashpoint control. Steam ratio can be used as an auxiliary handle, set up as a DCS steam ratio controller with minimum and maximum limits of 5 and 14 Lb/BBL. Changes to the steam ratio policy would be executed slowly. When economics call for kerosene maximization the stripping steam would be maximized to 14 Lb/BBL, and otherwise it would be minimized to 5 Lb/BBL. The mid range of stripping steam is to be avoided.

Figure 1. A typical kerosene draw arrangement

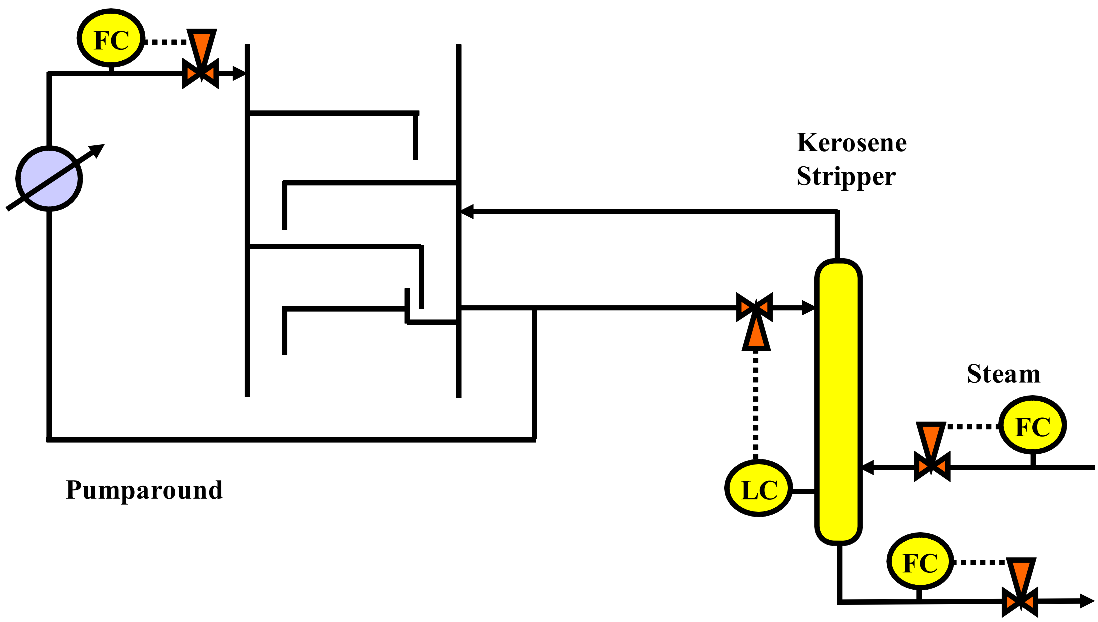

Figure 2. Kerosene flashpoint inference trend