7
Control of Sidestream Drawoff Columns

7.1 INTRODUCTION

to reduce investment and energy consumption, column designers sometimes tackle the separation of multicomponent mixtures with one sidestream drawoff column instead of using two or more conventional columns, each with two product drawoffs. The most extreme example of this philosophy is the crude column or crude still of oil refineries. These columns not only are very large in diameter, commonly 25–40 feet, but also have a large number of product drawoffs and auxiliary heat exchangers. For the chemical industry, it is more common to see columns with a single side draw. In this chapter we will concern ourselves with this type of column. Even the simplest side drawoff column is usually much more difficult to control than conventional two-product columns. Further, such columns generally have much less flexibility and less turndown capability.

Whether to take side draw as a vapor or as a liquid is usually decided as follows:

1. If side draw is taken below the feed tray, it is usually taken as a vapor. This is done for the purpose of minimizing high boilers in the sidestream.
2. If side draw is taken from a point above the feed tray, it is usually taken as a liquid. The objective here is to minimize low boilers in the sidestream.

7.2 SIDE-DRAW COLUMNS WITH LARGE SIDESTREAMS

Sidestream drawoff columns sometimes have the task of removing small amounts of both low boilers and high boilers from a large intermediate boiler. Solvent-recovery systems in plants manufacturing plastics or synthetic textile fibers often utilize such columns.
Figure 7.1 shows a typical control scheme for a column with a vapor side draw. Since the top and bottom products are small, base level is controlled by throttling side draw. When the side draw is a vapor, column base holdup should be generously sized. Changing the side draw changes vapor rate to the top of the column; this changes the rate of condensation, which finally changes reflux back down the column. The overhead level control loop that manipulates reflux flow is nested within the base level control loop. Top draw (distillate), bottom draw (bottom product), and steam flow are shown ratioed to feed. If this is not done, composition control will be poor, column capacity will be limited, and steam will be wasted.

A practical problem is that of maintaining adequate reflux down the column. As will be shown in Chapter 9, this requires overrides or limiters for the side draw; otherwise the base level controller on occasion may cause so much side draw to be taken that reflux temporarily will be inadequate.

An alternative arrangement is shown in Figure 7.2. Here the side draw is a liquid. The downcomer, instead of emptying into the tray below, empties into a small surge vessel. Base level is controlled via side draw while surge-tank level control sets reflux back down the column. This scheme has been used successfully on a nonequal molal overflow distillation. By measuring the reflux flow being returned from the surge tank, we can use an override on the side draw to ensure adequate reflux.

As an alternative one might control surge vessel level by side draw and base level by reflux from the surge vessel.

### 7.3 SIDE-DRAW COLUMNS WITH SMALL SIDESTREAMS

As mentioned in Section 1.9, a distillation column sometimes tends to collect intermediate boilers, compounds that are heavier than the light key but lighter than the heavy key. In this case a small sidestream is required. As shown in Figure 7.3, the column-control scheme is very similar to that of a conventional two-product column with the addition of sidestream controls. Ideally the side draw should be ratioed to the feed, but in practice, if it is very small, simple flow control is sometimes used.

### 7.4 COMPOSITION CONTROL OF SIDE-DRAW COLUMNS

As indicated in Chapter 1, exact composition control of product streams requires as many streams as components, and as many manipulated variables as components. Let us consider how to provide composition control of the system in Figure 7.1.

Here top- and bottom-product flows (or their ratios to feed) are available for composition control, but the side draw is needed for column material-balance control. For this column, however, composition of the sidestream is of primary importance. Let us assume that the feed consists of lumped low
FIGURE 7.1
Basic control scheme for column with sidestream drawoff
FIGURE 7.2
Controls for liquid sidestream drawoff column
FIGURE 7.3
Alternate control scheme for column with sidestream drawoff
boilers $A$, product $B$, and lumped high boilers $C$. The top-product stream will consist mostly of $A$, the bottom-product stream mostly of $C$, and the side product mostly of $B$ with some $A$ and $C$.

The following control strategy therefore is suggested:

1. If there is too much $A$ in the side product, increase the top-product/feed ratio. See Figure 7.4.
2. If there is too much $C$ in the side product, increase the bottom-product/feed ratio. See Figure 7.4.
3. If there is too much side product $B$ in either the top or bottom product streams, increase the steam/feed ratio. This increases the reflux ratio, thereby decreasing the concentration of intermediate boiling component $B$ at both ends of the column. See Figure 7.5.

Figure 7.5 illustrates a method of minimizing the concentration of $B$ in either the top product or bottom product. If the signal from either analyzer becomes too high, steam flow is increased. For pneumatics the two bias relays are each biased such that relay output is 9 psig when component $B$ reaches its maximum permissible concentration.

If turndown of more than 2:1 is anticipated, and if composition control is used, impulse feedforward compensation (see Chapter 12) for feed flow will do a better job than ratio controls.

It should be noted that many existing side-draw columns have neither composition controls nor ratio controls. In some cases the purge flows are so small that the loss of product in them is deemed negligible. In view of the rising cost of energy, however, many columns can make good use of steam/feed ratio controls.

### 7.5 AN IMPROVED APPROACH TO COMPOSITION CONTROL OF SIDE-DRAW COLUMNS

To gain one more degree of freedom for composition control, Doukas and Luyben came up with the idea of changing the location of the sidestream drawoff tray.

As shown in Figure 7.6A, there are four specifications for the three product streams (three components assumed), which are controlled as follows:

1. The concentration of the intermediate component in the top product (distillate) is controlled by manipulating the reflux ratio.
2. The concentration of the lightest component in the sidestream product is controlled by the location of the sidestream drawoff tray. As shown in Figure 7.6B, this easily can be implemented by conventional analog hardware. The fixed-gain relays are calibrated so that only two of the drawoff valves can be partially opened simultaneously. Thus as the signal from the XS1 composition controller increases, the valves for trays higher in the column open as valves for trays lower in the column close.
FIGURE 7.4
Scheme for control of sidestream composition
3. The concentration of the heaviest component in the sidestream product is controlled by the sidestream drawoff rate.
4. The concentration of the intermediate boiler in the bottom product is controlled by heat input to the reboiler.

### 7.6 PREFRACTIONATOR PLUS SIDESTREAM DRAWOFF COLUMN

Doukas studied two schemes involving a prefractionator as shown in Figures 7.7 and 7.8. In both cases the functions of the prefractionator were (1) to remove essentially all of the low boilers out of the top, together with part of the...
FIGURE 7.6
(A) In the control system finally chosen, the toluene impurity content in the distillate product is controlled by the reflux ratio. (B) The five alternative sidestream tray positions and their controls, which regulate the benzene and xylene impurities in the sidestream drawoff, are shown in this blowup.
FIGURE 7.7
D–scheme
FIGURE 7.8
L-scheme
intermediate boiler, and (2) to remove essentially all of the high boiler out of the bottom, together with the remainder of the intermediate boiler. The two product streams from the prefractionator are fed to two different trays of the sidestream drawoff column. The intermediate product is then withdrawn from a tray or trays located between the two feed trays. Thus the heaviest and lightest components are detoured around the section of the column where the sidestream is withdrawn, and "pinches" are avoided.

Figure 7.7 has been designated by Doukas and Luyben as the "L" scheme. Sidestream drawoff location is used to control the concentration of the lightest component in the sidestream product. The "D" scheme of Figure 7.8 provides manipulation of the distillate product flow from the prefractionator to control sidestream composition.

Both of these schemes were shown to provide effective control for modest changes in feed composition. Since the D scheme is probably easier to implement, it is recommended for most systems.

7.7 OTHER SCHEMES

It is impractical to present here all possible schemes for controlling sidestream drawoff columns. A number of these are discussed briefly in a paper by Luyben.  

REFERENCES