Reduce Costs with Dividing-Wall Columns

These distillation columns can significantly reduce capital and energy expenses vs. conventional multicolumn arrangements.

**Michael A. Schultz,
Douglas G. Stewart,
James M. Harris,
Steven P. Rosenblum,
Mohammed S. Shakur
and Dennis E. O'Brien,**
UOP

Distillation is the primary separation process used in the chemical processing industries (CPI). While this unit operation has many advantages, one drawback is its significant energy requirement. The dividing-wall distillation column (DWC) offers an alternative to conventional distillation towers, with the possibility of savings in both energy and capital costs.

For example, two applications of DWC technology designed by UOP are now part of a new UOP linear alkyl benzene (LAB) complex that saved 9% of the total fractionation energy used in this complex. Based on a present world LAB production of 2.6 million m.t./yr, and a fuel value of $10.8/million kcal, a $12.8 million annual energy savings would be possible if these DWCs were used in place of conventional multicolumn trains in every complex.

In addition, the uninstalled equipment cost for the total complex is reduced by about 10%. The capital cost savings result from the reduction in the quantity of equipment (*i.e.*, one column, reboiler, condenser, etc., instead of two of each). There are also indirect benefits: a DWC requires less plot area and, therefore, shorter piping and electrical runs, a smaller storm runoff system and other associated benefits. The flare loads are reduced because of the smaller heat input and less fire-case surface, leading to a smaller flare system.

While a DWC is not suitable for every situation, clearly it can be an attractive alternative to conventional distillation. This article will review recent developments in DWC technology and provide guidelines for the design of these columns. Finally, two applications will be discussed to illustrate the design process.

DWC background

A DWC is not a new concept, having been introduced in 1949 *(1)*. However, lack of reliable design methods, and concerns about the operation and control of these columns have prevented their widespread application. Work being done in both academia and industry is helping to address these concerns. Several authors provide some good background for understanding the theory behind Petlyuk columns and/or DWCs *(2–11)*. A recap is provided here to show how a single DWC can replace an existing two-column sequence.

ABC split and Petlyuk evolution

Consider a mixture consisting of three components, *A*, *B* and *C*, where *A* is the lightest and *C* the heaviest. Figure 1a shows how this separation would be accomplished in a direct sequence of two distillation columns. For some mixtures, for instance when *B* is the major component and the split between *A* and *B* is roughly as easy as the split between *B* and *C*, this configuration has an inherent thermal inefficiency (Figure 2). In the first column, the concentration of *B* builds to a maximum at a

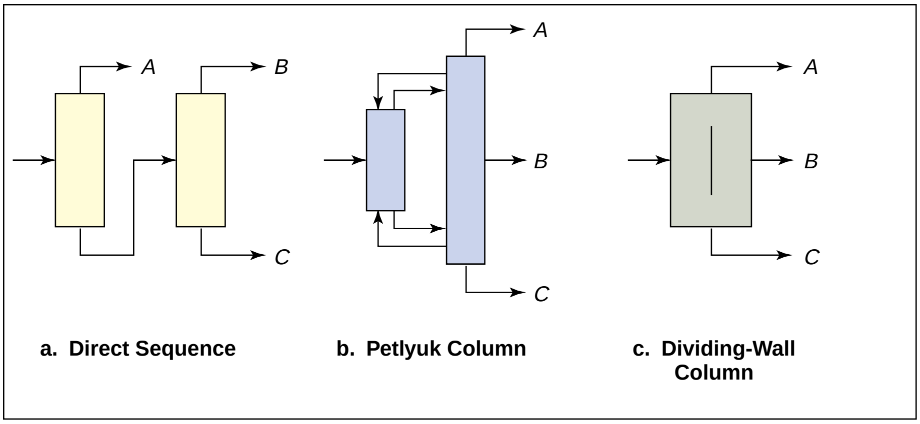


Figure 1.
Separating three components by distillation can be done in a variety of arrangements with one or two towers.

tray near the bottom. On trays below this point, the amount of the heaviest component *C* continues to increase, diluting *B* so that its concentration profile now decreases on each additional tray toward the bottom of the column. Energy has been used to separate *B* to a maximum purity, but because *B* has not been removed at this point, it is remixed and diluted to the concentration at which it is removed in the bottoms. This remixing effect leads to a thermal inefficiency.

Figure 1b shows a configuration that eliminates this remixing problem. This prefractionator arrangement, or Petlyuk column *(11)* as it is commonly known, performs a sharp split between *A* and *C* in the first column, while allowing *B* to distribute between these two streams. All of *A* and some of *B* are removed in the overhead of the smaller prefractionation column, while all of *C* and the remaining *B* are removed in the bottoms of the prefractionation column. The upper portion of the second column then performs an *A*/*B* separation, while the lower portion separates *B* and *C*. During the design phase, the fraction of *B* separated in the overhead of the prefractionator can be set to prevent the remixing seen in the direct sequence of Figure 1a. The thermal inefficiency has been eliminated, leading to a significant energy saving of about 30% for a typical design and can reach 50% or 60% for unconventional ones *(3, 7, 12)*.

Figure 1b shows that the Petlyuk arrangement is thermally coupled. In other words, vapor and liquid streams from the second (main) column are used to provide vapor and liquid traffic in the prefractionator. This system has only one condenser and one reboiler, and both are attached to the second column. Because the Petlyuk arrangement has fewer pieces of major equipment than does the conventional two-column sequence, total capital costs may be reduced.

Integrating the prefractionation column into the same shell as the main column can further reduce the amount of equipment. This is the DWC (Figure 1c). Assuming that heat transfer across the dividing wall is negligible, a DWC is thermodynamically equivalent to a Petlyuk column. When compared to a conventional two-column system, a capital cost savings of up to 30% is typical *(3, 7, 12)*.

As discussed above, a DWC can be used to separate three products in a single column. In evaluating whether a DWC is a viable option, consider the thermodynamic properties, as well as the composition of the stream to be separated, in addition to the product requirements. Based on this information, some guidelines are useful to determine whether a DWC is a good candidate for accomplishing a particular separation:

- *Product purity*: the purity of the middle product is greater than can be achieved in a simple sidedraw column. Therefore, when a high-purity middle product is desired, a DWC should be considered. If strict purity specifications are not required for the middle product, a simple sidedraw column may be sufficient for the task. However, even for this case, a DWC may be advantageous as it may accom-

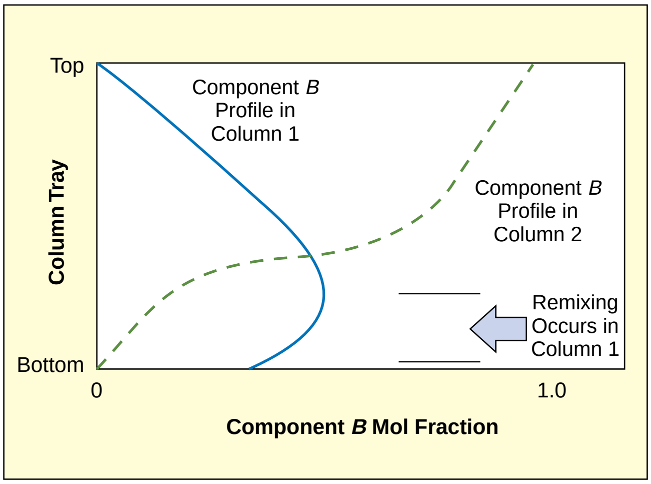


Figure 2. Remixing of Component *B* occurs in a conventional, two-column direct-sequence arrangement.

plish the separation in a smaller column using less energy compared to the simple sidedraw setup.

- *Feed composition*: Component *B* should be in excess, and components *A* and *C* should be present in fairly equal quantities. A typical rule of thumb is that a DWC is most advantageous when the feed consists of about 60–70 mol% *B*, with *A* and *C* then making up the rest of the feed in roughly equal amounts. It is important that this rule not be applied indiscriminately, though, because the relative volatility of the components is important as well. The relative volatility α_{ij} is a factor indicating the difficulty of separation of two components. The larger the value of this parameter, the easier is a separation for a given system.
- *Relative volatility*: When *B* is a significant portion of the feed, a DWC can be advantageous as long as the split between *A* and *B* is at least as difficult as that between *B* and *C* *(11)*. When the *A*/*B* split is fairly easy relative to the *B*/*C* split, the DWC's advantages may not be great enough to justify its selection over a simple direct sequence.
- *Revamp possibilities*: To increase the throughput through an existing simple sidestream column, a dividing wall can be inserted through a portion of the column. This is an extension of the first rule concerning product purity. In this case, however, if increased throughput is desired through an existing simple-sidestream column, it may be effected by inserting a dividing wall through a portion of the column.

As with any guidelines, there are exceptions, but these can be useful during the screening process.

The case against DWCs

Although a DWC may offer the potential for a savings in both capital and energy costs, there are some situations in which two-column separations are preferable *(3, 6)*. For instance, a DWC contains a single condenser and reboiler to provide the entire reflux liquid and boilup vapor to the column. The condenser operates at the coldest temperature required for the separation, while the reboiler operates at the hottest temperature. Compare this to the two-column sequence, in which the reboiler on the first column and the condenser on the second are at intermediate temperatures, so some of the duty can be supplied at intermediate levels. This may be advantageous for heat integration purposes, or if less-expensive intermediate duties are available.

Further, the two columns may require significantly different operating pressures for reasons that may include restrictions on overhead or bottoms temperatures, due to the available duties or restrictions on the bottoms temperature because of fear of degradation or polymerization. The flexibility of operating at distinctly different design pressures might outweigh the savings possible with a DWC. Additionally, a DWC will likely be taller and have a larger diameter than either of the two conventional columns, and may surpass construction restrictions for a single tower. One solution to this problem is the use of high-performance trays. Such trays have a high capacity and efficiency, and can be spaced close together (as little as 300 mm), reducing the diameter and height of the DWC. Therefore, as in any design problem, it is necessary to evaluate the constraints and tradeoffs before proceeding with a more-detailed design.

Industry review

While theoretical studies have shown the economic advantages of DWCs in certain circumstances, industry has been hesitant to build these columns. One reason may be a lack of understanding of their design and control. In recent years, several academic groups have researched this area *(14, 15, 16)*. One group set up a pilot-scale column to study controllability and operability *(17, 18)*. This work has contributed to a better understanding of the design and control, and therefore a growing acceptance of DWCs within industry.

In 1985, BASF constructed and started up what is believed to be the first commercial DWC. BASF is also believed to be the leader in the total number of such columns in existence, with roughly 25 DWCs operating today *(3)*.

Various consulting and engineering and construction firms offer design and construction services for DWCs. Kellogg Brown & Root has designed at least two DWCs for BP, at least one of which is used to split a light kerosene stream *(13)*. Sumitomo Heavy Industries has been involved in designing at least six columns for undisclosed customers (the firm refers to its technology as a "Column in Column") using an onsite pilot-plant facility *(19)*. Linde AG has recently constructed the world's largest DWC for Sasol, an estimated 107-m tall and 5-m in dia. Finally, Krupp Uhde has designed a column to remove benzene from pyrolysis gasoline for Veba Oel. A similar column by Krupp Uhde will start up for Chevron in the near future *(19)*.

DWCs for detergent manufacture

DWC technology is suitable for use in the separation of streams in plants that produce detergents and aromatics, as well as in refining, hydroprocessing and reforming operations, among others. Two applications for detergent manufacture are discussed here to illustrate the steps involved in designing and constructing a DWC.

Once an application has been identified, the next step is to model the column. A general outline of the approach is given below. The explanation here will refer only to the simple *A*, *B*, *C* split described previously.

Steady-state modeling

The first step in studying a DWC is developing a static or steady-state simulation. This can be done using proprietary software or with standard packages, such as Aspen Technology's Aspen Plus or Hyprotech's HYSYS.Process. The latter do not include a basic dividing-wall column in their library of functions, although the user can build "custom" fractionation columns. This feature was used to model the DWC as a combination of individual tray sections, connected by internal vapor and liquid streams. For a conventional DWC, four column sections are needed: one for each of the sections above and below the wall, and one for each of the sections on either side of it. This DWC has five degrees of freedom (condenser, reboiler and three product streams). Typical specifications for design are three compositions plus the split-fraction of the vapor below the wall, and the split-fraction of the liquid above the wall.

Once the initial static simulation is developed and converges to the desired product specifications, the next step is to optimize the design. Column sections can be designed, similar to a conventional column, to balance the capital vs. energy cost trade-offs. This is more complicated than with a conventional column because liquid from the upper rectification section splits to either side of the wall. The reflux rate must be sufficient to satisfy the separation on either side.

DWCs typically separate a feed into three products. The middle one is purer then that from a sidedraw column.

As already noted, the key to the DWC advantage is that the middle component B is split in the prefractionation section, so that some B travels above the wall, while the remaining amount moves below the wall and out with the sidedraw stream. The split can be set to minimize the total reboiler-duty requirement by either adding or removing trays above or below the feed point, or changing the amount of liquid reflux that is sent to the feed-side of the column.

Consider a typical example, where B is roughly 60–70 mol% of the feed, A and C are present in equal proportions, and the difficulty of the split between A and B is roughly the same as that for the split between B and C. In the prefractionation section, the optimal design would result in B distributing so that half is recovered above the wall and the other half below the wall. If the feed deviates from any of these conditions, it may be necessary to take more than half of B either above or below the wall to optimize the design. Finally, both the vapor and liquid splits must be optimized, which will have a significant impact on the required reboiler duty.

Dynamic modeling

Next, a dynamic study is performed to ensure the successful commercialization of a DWC. One reason is to develop suitable control schemes for this unconventional system. Another reason is that a dynamic study helps in understanding the column operation.

In steady-state modeling of a distillation column, thermodynamics are a key concern. The column is designed using the appropriate property package and setting the feed flowrate and composition, as well as the column operating conditions, to meet the product specifications. Different considerations are important for a dynamic model. These involve the physical processes occurring in the column and include the weir heights for the trays, devices such as trapout trays and the wall static-head considerations, plus the actual equipment required to make the column work.

The dynamic simulation should be thought of as a true operating plant. Some preliminary equipment designs are developed using the steady-state modeling. If the steady-state model has a condenser that produces product streams and reflux, the dynamic model must include the overhead exchanger, the overhead accumulator and the reflux and/or product pumps. Control instrumentation is required and must be tuned. Further, the dynamic simulation should model the hydraulic network. Control valves need to be included in the lines as appropriate, and additional valves may be modeled to account for pressure drops. The dry-tray pressure drop across the column is determined by accounting for the static head. Equivalent weir heights and tray spacings must be included to accurately model liquid and vapor holdup when using theoretical stages.

The model must next be validated before using it to predict the column's dynamic behavior. One way of doing this is operating the dynamic model until it reproduces the results of the steady-state simulation. This "dynamic steady-state" can then serve as a baseline starting point for all subsequent testing. In reaching the dynamic steady-state, the controllers can be tuned and strip charts configured to record key process variables.

Once a dynamic model has been created, other disciplines should critique and try to improve it. Various groups such as operations, reactor design, instrumentation, etc., bring a unique perspective to the problem. After proving that the system will work, further testing should be done to determine the optimum location for the control points. Once a final design is set, the design team holds a final review meeting before anyone sizes and selects items such as rotating equipment, instrumentation and piping. The work process involves the following steps:

1. The design engineer responsible for process engineering creates the static model of the process.

2. Taking the model from Step 1, the dynamic simulator is used to match the steady-state model.

3. The dynamic model includes control schemes recommended by technical services personnel and the process control specialists. Optional features are offered at this stage to determine the best approach. These options may include actions such as moving the temperature-control points to better anticipate compositional changes within the tower. By having a working model of the system, each new idea is tested and the results are saved for review.

4. The dynamic simulator is used to determine the effectiveness of the proposed control scheme. Once this model has been debugged, alternative control features and process upsets are modeled.

5. At minimum, the product quality should be disturbed to verify that the control instrumentation will adequately measure off-specification conditions. Difficulties in selecting the proper measurement/control point should be resolved.

6. The results of this exercise should be discussed with the project team during a meeting to review the process flow diagram. Prior to starting project work, the flow scheme, including all control requirements, should be fixed and explained to the team by the process control specialist. It may be necessary to modify the control scheme during this step.

7. The technology is incorporated into the commercial design as engineered specifications are developed for the plant.

Control system and instrumentation

Because a DWC is not a traditional piece of process equipment, the tools used to evaluate the control scheme should be reviewed in detail to ensure that they are appropriate for the tower. In addition, the sophistication necessary for the process model, the best simulator package, and the required amount of control scheme testing must be reviewed, as well. The dynamic simulator can be adapted to study control systems in a concise, structured and organized fashion.

Once the best control scheme is determined, decisions about the instrumentation details are important. Many questions surround the issue of liquid/vapor traffic on each side of the wall.

Direct control of the liquid to each side of the wall is preferred. All liquid from above the wall is removed from the column, and then controlled so that a known flow returns to each side of the wall. Direct control of the vapor split was not required for the applications that we modeled. If vapor-split control were needed, a special tray would have needed be installed to handle this requirement.

Table 1. Cost savings for kerosene dividing-wall column.

	Capital Cost	Energy Cost
Two-Column Sequence	1.0	1.0
DWC	0.72	0.7

Kerosene prefractionation column

One application of a DWC within UOP is for a prefractionation of kerosene within a LAB complex. This is a full-range kerosene, containing C_7–C_{16} hydrocarbons. The separation removes a “heart cut” of mid-range material, typically in the range of C_{11}–C_{13}. Looking at the generic layout in Figure 1, then $A = C_{10}$ and lighter, $B = C_{11}$–C_{13} and $C = C_{14}$ and heavier.

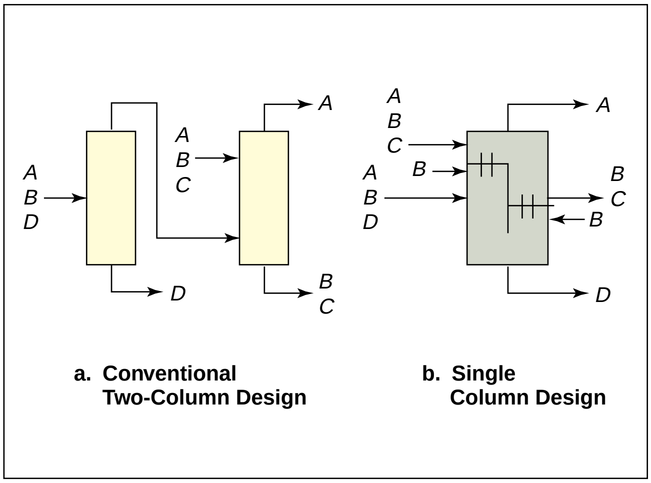
The heart-cut makes up roughly 60% of the kerosene, making this separation a good candidate for a DWC. Purity specifications are set both on the amounts of n-C_{10} and n-C_{14} in the middle product. A third specification is set on the recovery of n-C_{11}–n-C_{13} in the middle product. A study found that it is not possible to successfully operate and control a DWC with purity specifications on both the light and heavy components in the sidedraw product *(14)*, which appears to preclude the use of a DWC for this application. However, this study considered distillation of pure chemical species. In each case, the light, medium and heavy key components were adjacent, meaning that there are no components that boil at temperatures in between those of the keys. Also, *A*, *B* and *C* represent distinct chemical species, instead of a range of species, as with kerosene prefractionation.

For the kerosene prefractionation column considered here, the feed is fractionated into three product streams. The key components are the normal paraffins in the C_{10}–C_{14} range. Normal paraffins are desired in the range of C_{11}–C_{13}, while n-C_{10} is the light impurity and n-C_{14} is the heavy impurity. Hundreds of species are present that boil at temperatures between the light and middle products, and between the middle and heavy products. These distributing species are not important to the product quality, as they will be removed in a downstream separation. The column can therefore be designed so that the n-C_{10} and n-C_{14} will meet purity requirements.

Table 1 shows the capital and energy savings that result by replacing the conventional direct sequence with a DWC in a typical system. The DWC yields an energy saving of 30% and a capital saving of 28%, both of which roughly meet the rule-of-thumb for typical DWC designs. Because of this attractive cost saving, the DWC is now a standard offering at UOP for the kerosene prefractionation column in an LAB complex.

PEP fractionation

Here, the DWC is part of the fractionation section within our Pacol Enhancement Process (PEP) process



a. Conventional Two-Column Design

b. Single Column Design

Figure 3. PEP fractionation via a dividing-wall column offers advantages over using two columns in series.

Table 2. Cost savings for PEP dividing-wall column.

	Capital Cost	Energy Cost
Two-Column Sequence	1.0	1.0
DWC	0.65	0.5

unit, a sieve separation process that removes C_7+ aromatics from a desired C_7+ olefin/paraffin mixture (the "C_7+ olefins") *(20)*. This is a batch process that uses two regenerate streams to purge and desorb the sieve beds. The regenerated effluent streams are fractionated in a DWC to purify and remove the desorbed C_7+ aromatics and to purify and recycle pentane, one of the regenerate streams. A third product of the fractionation is a combination of the desorbant component, benzene, and "washed" C_7+ olefins. The DWC employs a novel trap tray and external refluxing scheme to prevent the C_7+ aromatics from mixing with the co-boiling component, the C_7+ olefins. Figure 3 compares the conventional two-column fractionation system to the single DWC. In this figure, Component *A* is pentane, Component *B* is benzene, Component *C* comprises the C_7+ olefins and Component *D*, the C_7+ aromatics.

Comparing this design to a standard configuration as shown in Figure 1, a typical DWC candidate would start with a single feed stream that requires fractionation into three product streams, each with it own distinct, non-overlapping boiling range. The DWC in the PEP process has three product streams, two feeds, two external reflux streams and two co-boiling groups that must be withdrawn separately in two of the product streams. This DWC therefore did not start as a typical candidate that could follow conventional rules for such a design. By building on previous work by others in this area, conventional design methods for DWCs were adapted to this system. Table 2 shows the economic advantage of the PEP DWC. This column uses high-performance trays, spaced at 310 mm.

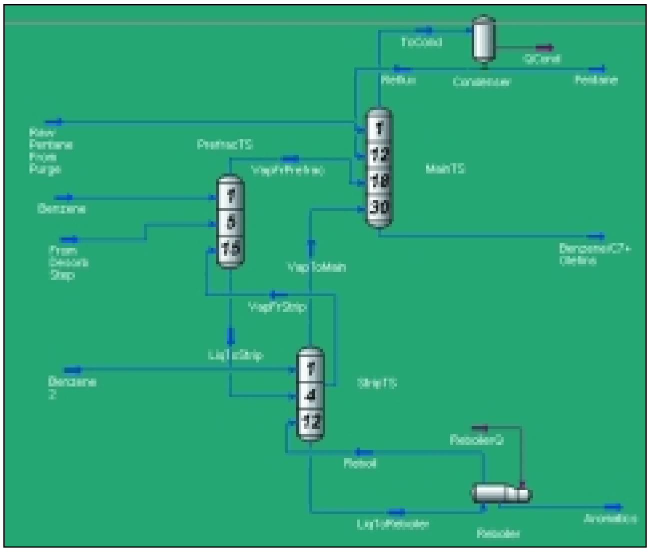


Figure 4. Screen shot of the steady-state simulation of the PEP DWC. A few changes were needed to use this model in the dynamic simulation.

KEY:

Feed Streams

Raw Pentane From Purge: Pentane (purge material) and desired C_7+ olefin/paraffin product
Benzene, Benzene 2: Raw benzene streams used as external reflux streams
From Desorb Step: Benzene (desorbant) and heavy aromatic material

Product Streams

Pentane: Purified pentane
Benzene/C_7+Olefins: Sent to downstream processing
Aromatics: Undesired heavy aromatic material

Equipment

PrefracTS: Feed side of the DWC
MainTS: Section above the wall, plus the section on the product side of the wall above the sidedraw stream
StripTS: Section below the wall, plus the section on the product side of the wall below the sidedraw stream

Modeling the column

The steady-state model consists of prefractionation, stripping and product sections (Figure 4). When converting this model to a dynamic simulation, a few changes were necessary. First, the dividing wall actually begins just below Stage 18 of the main section and ends just above Stage 4 of the stripping section. To properly investigate the effect of the liquid split above the wall and the vapor split below the wall, it makes sense to split the main column and the bottom fractionation section each into two sections, one below the wall and one above it.

Liquid from the newly created rectification section above the wall is fed to the upper product section, simulating the total trapout tray above the wall. Vapor from the newly created stripping section splits and feeds the bottom of the prefractionation and lower-product sections. Liquid from the newly created upper product section is drawn out of the tower by a total trapout tray. This trapout tray can be modeled as a vessel with a level controller.

The generic overhead condenser is removed and replaced with an air cooler, accumulator vessel and reflux/product pump. Other feed and product pump circuits are added. One unique aspect of the PEP separation is the cyclic nature of the feed composition. This could not be adequately modeled with a steady-state model, and, therefore, was programmed into the dynamic model. Finally, complete control instrumentation for all lines was included.

Handling upsets

Once the dynamic model was configured and validated, testing began, in which the column behavior was studied under normal and upset conditions. Offspec product must be either eliminated or minimized throughout any reasonable operation or upset. Different control configurations are tested under various upset conditions. The response to feed changes, loss of reflux, reaction to weather changes, etc., are among the upset conditions tested. As a result of this testing, a control system was designed to react quickly to upsets and be easily implemented and operated.

As already mentioned, the column design can be further optimized during the dynamic simulation study. For instance, trays can be removed from a section to study the effect on product quality. Opportunities for optimization that were not apparent from the steady-state model were identified during the dynamic study of the PEP DWC. A few items to consider beyond the product-quality goal of this column were:

- Incorporating the feed system into the model to simulate real-life upsets that are expected.
- Maintaining a reasonable heat balance.
- Evaluating the level of vaporization common during each feed upset.

The heat evaluation was also important to the success of this column, and required a study independent of all other reviews. Thermal fluctuations come from many sources. Because the feed fluctuates cyclically, a constant influence could not be anticipated. This variation causes fluctuations in the product streams, requiring a more complex model than that used in the static approach. A study evaluated the option of reboiling either side of the wall independently. This showed promise during the theoretical stage of the project, but was less attractive as the operating principles became

Literature Cited

1. **Wright, R. O.,** U.S. Patent 2,471,134, Standard Oil Development Co., Elizabeth, NJ (May 24, 1949).
2. **Ennenbach, F., *et al.*,** "Divided-Wall Columns — A Novel Distillation Concept," *Petroleum Technology Quarterly*, pp. 97–103 (Autumn 2000).
3. **Becker, H., *et al.*,** "Partitioned Distillation Columns — Why, When and How," *Chem. Eng.*, **108** (1), pp. 68–74 (Jan. 2001).
4. **Dünnebier, G., and C. C. Pantelides,** "Optimal Design of Thermally Coupled Distillation Columns," *Ind. Eng. Chem. Res.*, **38**, pp. 162–176 (1999).
5. **Hernández, S., and A. Jiménez,** "Design of Energy-Efficient Petlyuk Systems," *Comp. Chem. Eng.*, **23**, pp. 1005–1010 (1999).
6. **Lestak, F., and C. Collins,** "Advanced Distillation Saves Energy and Capital," *Chem. Eng.*, **104** (7), pp. 72–76 (July 1997).
7. **Triantafyllou, C., and R. Smith,** "The Design and Optimisation of Fully Thermally Coupled Distillation Columns," *Trans. IChemE*, **70, Part A**, pp. 118–132 (Mar. 1992).
8. **Carlberg, N. A., and A. W. Westerberg,** "Temperature-Heat Diagrams for Complex Columns: Part 3: Underwood's Method for the Petlyuk Configuration," *Ind. Eng. Chem. Res.*, **28**, pp. 1386–1397 (1989).
9. **Agrawal, R., and Z. T. Fidkowski,** "Thermodynamically Efficient Systems for Ternary Distillation," *Ind. Eng. Chem. Res.*, **38**, pp. 2065–2074 (1999).
10. **Nikolaides, I. P., and M. M. Malone,** "Approximate Design and Optimization of a Thermally Coupled Distillation Column with Prefractionation," *Ind. Eng. Chem. Res.*, **27**, pp. 811–818 (1988).
11. **Glinos, K., and M. F. Malone,** "Optimality Regions for Complex Column Alternatives in Distillation Systems," *Chem. Eng. Res. Des.*, **66**, pp. 229–240 (1988).
12. **Petlyuk, F. B., *et al.*,** "Thermodynamically Optimal Method for Separating Multicomponent Mixtures," *Int. Chem. Eng.*, **5**, pp. 555–561 (1965).
13. **Parkinson, G., *et al.*,** "The Divide in Distillation," *Chem. Eng.*, **106** (4), pp. 32–35 (Apr. 1999).
14. **Halvorsen, I. J., and S. Skogestad,** "Optimal Operation of Petlyuk Distillation: Steady-State Behavior," *J. Process Control*, **9**, pp. 407–424 (1999).
15. **Wolff, E. A., and S. Skogestad,** "Operation of Integrated Three-Product (Petlyuk) Columns," *Ind. Eng. Chem. Res.*, **34**, pp. 2094–2103 (1995).
16. **Serra, M., *et al.*,** "Control and Optimization of the Divided Wall Column," *Chem. Eng. and Proc.*, **38**, pp. 549–562 (1999).
17. **Abdul Mutalib, M. I., and R. Smith,** "Operation and Control of Dividing Wall Distillation Columns: Part 1: Degrees of Freedom and Dynamic Simulation," *Trans. IChemE*, **76, Part A**, pp. 308–318 (1998).
18. **Abdul Mutalib, M. I., *et al.*,** "Operation and Control of Dividing Wall Distillation Columns: Part 2: Simulation and Pilot Plant Studies Using Temperature Control," *Trans. IChemE*, **76, Part A**. pp. 319–334 (1998).
19. **Parkinson, G.,** "Drip and Drop in Column Internals," *Chem. Eng.*, **107** (7), pp. 27–31 (July 2000).
20. **Schultz, M. A., *et al.*,** "Design and Control of a Dividing Wall Distillation Column for the Fractionation Section in the Pacol Enhancement Process (PEP)," paper presented at 2001 Spring AIChE National Meeting, Houston, TX (Apr. 22–26, 2001).

more apparent. A single reboiler with a stable heat source was selected as the best way to meet the requirements of this fractionation. As proposed, the design adjusts the vapor to the wall indirectly by manipulating the liquid traffic on each side of it. A small upset in the differential pressure across the trays will make the necessary vapor flowrate adjustment. The major benefit of this is the column's ability to meet the challenges imposed by variable feeds.

Shell fabrication and tray design

Adding a vertical partition to a conventional distillation column presents some challenges to fabricating the shell and trays. If the temperature gradient across the wall is too great, it may be necessary to install an insulated wall to prevent heat transfer that could affect the separation. Additional manways may be needed in a DWC, so that the column is accessible on either side of the wall.

The wall within the DWC effectively changes the tray design, creating two distinct noncircular sections. Also, if the wall is not exactly in the center of the column, the tray design becomes nonsymmetrical. A high-performance tray is used and is suited for this application because it has a 90-deg. tray-to-tray orientation that makes designing easy within the noncircular section and asymmetrical sections. The tray is designed for uniform flow distribution across the tray deck, which is important when the section is noncircular.

Future thoughts and conclusions

Advances in the theory of design, control and operation of a DWC have contributed to a better understanding of these columns and have led to commercial developments. As the base of commercial experience continues to grow, the number of applications should increase for both conventional and unconventional cases. Computer models will be an important part of this process, as advanced tools allow a more-complete analysis of these columns.

Chemical engineers should look for unconventional applications of DWC technology. Simply because a fractionation system does not meet the single-feed, three-key-component, three-product criteria, does not mean that DWC technology cannot be adapted to the separation. The UOP application for the PEP DWC is an example of this.

As academic research improves the understanding of dividing-wall columns, and industry finds new applications, these columns should become more common in the plant. Although it took roughly 50 years for the DWC to gain limited acceptance by some companies, perhaps the next 50 years will be a time when the DWC becomes a standard piece of equipment in the CPI. CEP

MICHAEL A. SCHULTZ is a process research specialist in the UOP Engineering Science Skill Center (25 East Algonquin Road, Des Plaines, IL 60017-5017; Phone: (847) 375-7895; Fax: (847) 375-7904; E-mail: MASCHULT@UOP.com). He has four years of experience with UOP in a variety of process research projects. His work focuses on technical and economic analysis, process development, and process optimization of both developing and existing process technologies. He also serves as a resource for the assessment and application of UOP's dividing-wall column technology, as well as for other fractionation issues. Schultz holds a BS in chemical engineering from the Univ. of Michigan-Ann Arbor, and a PhD in chemical engineering from the Univ. of Massachusetts-Amherst. He is a member of AIChE.

DOUGLAS G. STEWART is a senior design engineer in the UOP Engineering Dept. (Phone: (847) 391-2904; E-mail: DGSTEWAR@UOP.com). He has 24 years of experience with UOP, including field service and engineering dept. assignments in a variety of UOP process technologies. He currently is involved in UOP's detergent process technologies. Stewart holds a BS in chemical engineering from the Univ. of Minnesota.

JAMES W. HARRIS is a process control coordinator in the UOP Technical Services Dept. Skill Center (Phone: (847) 391-1366; E-mail: JWHARRIS@UOP.com). He has 12 years of experience with UOP, including field service and engineering dept. assignments in a variety of UOP process technologies. He is a technical leader for safety-instrumented-system applications; additional activities include supporting training for new-hire instrument engineers, interfacing with field service personnel on technical issues, maintaining company procedures for specifying instrumentation, and developing new procedures to sustain technical leadership of the company. Harris holds a BS in chemical engineering from SUNY-Buffalo. He is a member of AIChE, as well as ISA, and is an active member of the ISA SP84 committee and API's subcommittee on instrumentation and control systems.

STEVEN P. ROSENBLUM is a senior process modeling specialist in the UOP Engineering Dept. (Phone: (847) 375-7182; E-mail: SPROSENB@UOP.com). He has 25 years of experience in the CPI with the last five at UOP. During his tenure at UOP, he has undertaken advanced process control and optimization, and engineering dept. assignments in a variety of UOP process technologies. He serves as an applications-support group leader for all outside vendor simulation software. Rosenblum holds a BS in chemical engineering from Cornell Univ. and an MS in chemical engineering from Northeastern Univ.

MOHAMED S. M. SHAKUR is a product manager in the process equipment group of UOP (Tonawanda, NY; Phone: (716) 879-7601; E-mail: MSSHAKUR@UOP.com). He has 13 years of experience with UOP, mainly in the distillation design group, focusing on the design and commercialization of column internals, column startup, troubleshooting and optimization. He markets UOP column internals worldwide and develops new products to complete the UOP product portfolio of high-performance column internals. Shakur holds a BEng in chemical engineering from the City College of New York.

DENNIS O'BRIEN is a detergents technology specialist in the UOP Engineering Dept. (Phone: (847) 391-2802; E-mail: DEOBRIEN@UOP.com). He has 31 years of experience with UOP, in the field service, engineering and computer departments, with assignments in a variety of UOP process technologies. He currently is a technical specialist for detergents and provides engineering support for adsorbents. O'Brien holds a BS in chemical engineering from the Univ. of Tulsa, and a MBA from Roosevelt Univ. He is a member of AIChE.