WHITE PAPER

A Network of Dividing Wall Columns For Whole Train Process Intensification

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A network of dividing wall columns for whole-train process intensification

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Dividing wall columns reduce the capital cost, energy use and plot space of multi-product distillation by performing in a single shell what conventionally requires two or more columns. Most commercial units to date have been applied one column at a time. This article describes the design and commercial operation of a network of four dividing wall columns that together replace a seven-column separation train in an acetone-derivatives unit — cutting capital cost by about 30% and utility consumption by 28% while meeting every product specification.

1 Introduction

Distillation is the workhorse separation of the refining and petrochemical industries, and among the largest single consumers of process energy on any given site. That energy is spent repeatedly boiling and condensing the same molecules to tease apart components of similar volatility, so any technology that performs the same separation with less energy has an outsized effect on both operating cost and carbon footprint.

Conventional distillation separates a multicomponent mixture one cut at a time. Splitting a three-component feed into three pure products requires two columns in sequence; a four-product separation requires three columns, and so on. Each column carries its own reboiler, condenser, reflux drum, pumps and controls, and each occupies plot space. A simple column sequence is also thermodynamically wasteful: an intermediate component is partially separated in the first column, remixed with a lighter or heavier stream, and then separated again in the next — remixing that destroys separation work already performed, at a cost the reboiler must pay twice.

The dividing wall column (DWC) removes this penalty. A vertical partition inside a single shell realises, in one vessel, the fully thermally coupled arrangement long recognised as the most efficient way to separate three or more components [1, 2]. Prefractionation and main separation share the shell; the intermediate is withdrawn as a clean side product before it can remix; and one reboiler and one condenser serve the whole system. First proposed in the 1940s and placed on a rigorous thermodynamic footing by Petlyuk and co-workers in the 1960s, the configuration moved from theory to routine commercial use as process simulation and column-internals design matured, and several hundred units are now in service worldwide [3, 4].

Almost all of those units, however, have been applied as point solutions: a plant identifies the single column with the most attractive economics and replaces it with a DWC, leaving the rest of the separation train untouched. This article examines what becomes possible when the same thinking is applied not to one column but to an entire train of closely coupled columns — a dividing wall column network — and illustrates the approach with a recently commissioned commercial installation. The following sections review the relevant DWC fundamentals and configurations, then describe the case-study process, the mapping of its seven-column train onto four dividing wall columns, and the resulting performance.

2 The dividing wall column

The advantage of a dividing wall column is that it attacks capital cost, energy cost and plot space simultaneously — three levers that usually trade against one another. The capital saving is structural: one shell, one reboiler and one condenser replace two or three of each. The energy saving comes from eliminating the remixing losses of a conventional sequence; a DWC typically reduces reboiler duty by 20--30% relative to the two-column sequence it replaces, with a corresponding reduction in condenser and cooling duty [3, 4]. Because fewer vessels mean fewer flanges, fewer relief scenarios and less structural steel and piping, the benefit extends through fabrication, installation and long-term maintenance.

The performance of a dividing wall column depends on getting two things right: the vapour and liquid split at the wall, and the internals that set the column's hydraulic and mass-transfer behaviour. The liquid split — how much reflux is directed to each side of the wall — is the principal control handle and must keep both sides properly irrigated across the operating range; the vapour split is fixed largely by the internals and wall geometry at the design stage. Where the split is mis-set, one side of the column is starved and its products drift off specification. This is why the internals, the wall placement and the split strategy must be engineered together as a single system rather than added to a generic column shell — an integration that becomes more important still when several dividing wall columns operate as a coordinated network.

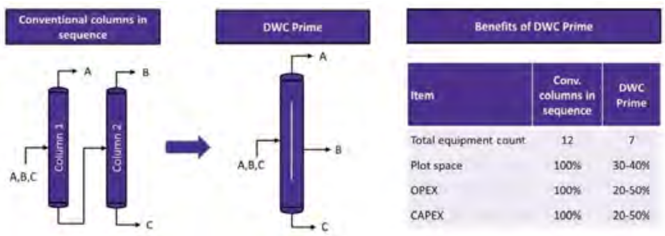


Figure 1. *Single-wall DWC versus a conventional two-column sequence. One dividing-wall column delivers the same three products as two columns in series, cutting the equipment count and roughly halving plot space, energy and capital.*

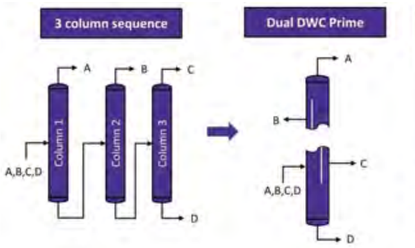
3 Principal configurations

The location and number of partitions, the presence of side draws and the condensing or reboiling scheme are all design variables, giving a family of configurations each matched to a particular separation duty. The principal ones are outlined below; the case study that follows uses the middle, dual and top variants.

Single-wall (side-cut) DWC. A single partition splits the shell into a prefractionation side and a main-separation side, delivering three products — a light overhead, an intermediate side draw and a heavy bottoms. It is the building block from which the other configurations are derived.

Middle DWC. The wall sits in the middle of the column — the ideal replacement for two columns in sequence, or for a single column with mid-column side-cuts. Coupling between the two halves is strongest, giving the largest utility savings, but the shared condenser and reboiler are driven to the extremes of the product temperature range, which must be weighed against the energy benefit.

Dual DWC. Two — sometimes overlapping — partitions merge three or more conventional columns into a single tower, delivering four or more high-purity products from one shell (Figure 2). Consolidating that much duty in one vessel gives an even higher thermodynamic efficiency, and a larger reduction in equipment count and footprint, than a single-wall column.



Item	3 Column Sequence	Dual DWC Prime
Columns	3	1
Pumps	6	4
Condensers	3	1
Reboilers	3	1
Drums	3	1
Total equipment count	18	8
Plot space	100%	40%
OPEX	100%	50%
CAPEX	100%	50%

Figure 2. *Dual DWC versus a conventional three-column sequence — the more advanced, higher-consolidation configuration. Two partitions in one shell replace three columns in series, cutting the equipment count and roughly halving capital and operating cost.*

Top DWC. The partition is confined to the upper section, so the column produces two separate overhead products, each with its own condenser (Figure 3). Because the two overheads condense at different temperatures, the configuration enables overhead-vapour heat integration and adds a degree of control freedom; it replaces a column-plus-side-stripper arrangement and suits duties where a lighter and a slightly heavier overhead must both be recovered cleanly.

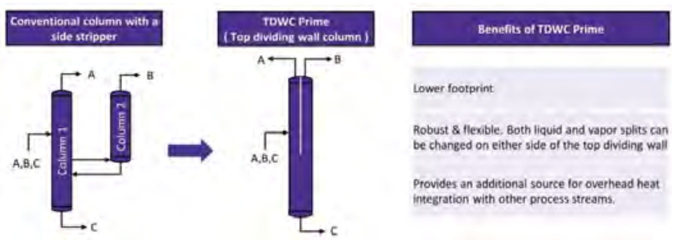


Figure 3. *Top DWC versus a conventional column with a side stripper. A wall confined to the upper section produces two independent overhead products, each condensed at its own temperature, replacing a column-plus-side-stripper arrangement.*

Bottom DWC. The mirror image of the top configuration places the partition in the lower section, so the column delivers two separate bottom products, each with its own reboiler (Figure 4). It replaces a column-plus-side-rectifier arrangement and suits duties where two heavier products must be recovered cleanly, again allowing the two reboilers to run at different temperatures for heat integration.

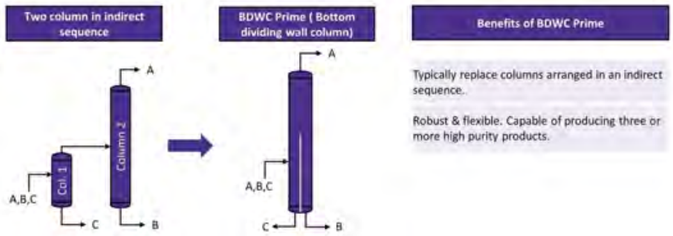


Figure 4. *Bottom DWC versus a conventional two-column indirect sequence. A wall confined to the lower section delivers the same three products as two columns in series, withdrawing two separate bottom products, each at its own temperature — the mirror image of the top configuration.*

4 From single columns to networks

When dividing wall columns are applied one at a time, real value is left on the table. In a train of closely coupled columns the largest prize is frequently not any single column but the interactions between them — the intermediate components that are separated, remixed and separated again as material passes from one column to the next. A point-solution DWC captures the remixing loss inside the one column it replaces; it does nothing about the remixing that occurs between columns.

A network approach instead treats the entire separation section as one design problem. For each separation duty in the train it asks which dividing wall configuration is the best thermodynamic and mechanical fit, and how the duties can be re-grouped so that coupled separations share a shell. The reward is access to the inter-column remixing losses that a single-column revamp cannot reach; the difficulty is that the columns interact — the operating point of each affects the feeds and recycles seen by the others — so the network must be simulated and optimised as an integrated system, with every wall placed and every set of internals sized for the specific vapour and liquid loads it will see. The remainder of this article describes a commercial installation in which this was done for a complete seven-column train.

5 Case study: an acetone-derivatives separation train

Acetone-derived solvents are widely used across industry, and the units that produce them face sustained pressure to lower energy consumption, unlock capacity and limit the capital spent on debottlenecking. Their separation sections are natural candidates for intensification: equipment-heavy, energy-intensive, and built around the closely boiling, multi-product separations at which dividing wall columns excel.

The unit in this case study is a plant producing a family of acetone-derived solvents — a principal product together with several co-products spanning a range of boiling points. The main product is made from acetone in a reaction section operating at elevated temperature and pressure over a catalyst, followed by a fractionation section that recovers each stream to specification and returns unconverted acetone to the front of the process. After light-ends conditioning, the reactor effluent reaching fractionation is a multicomponent mixture of unreacted acetone, water, the main product and a range of lighter and heavier by-products, each of which must be split out at high purity.

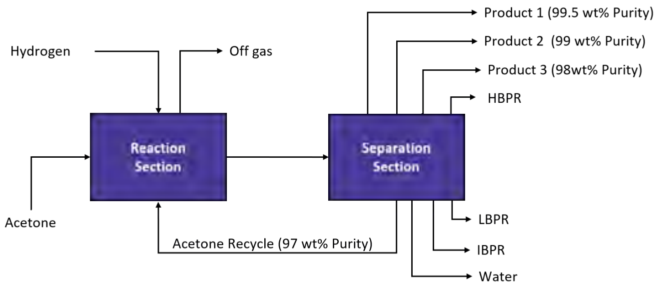


Figure 5. *The acetone-derivative process at a glance: a reaction section followed by a separation section that delivers three high-purity products (99.5, 99 and 98 wt%) along with light, intermediate and heavy by-product streams, and returns a 97 wt% acetone recycle to the reactor.*

Figure 5 sets out why this train is demanding. The separation section must deliver three products at high purity — 99.5, 99 and 98 wt% — while returning unconverted acetone to the reaction section at 97 wt%. That recycle is the crux: because it closes a loop back to the reactor, every column feeding it must stay on specification for the recycle itself to remain on specification. Should any one dividing wall column drift off its cut, impurities are carried back to the reactor and accumulate pass after pass, eroding conversion and loading still more impurity onto the separation — a deterioration that feeds on itself and makes the whole process progressively worse. In a four-column network this sharpens the coupling rather than easing it: all four walls must hold their splits at once, which is why the train had to be designed and simulated, and its internals sized, as a single integrated system rather than column by column.

In the conventional design this is done by a train of seven distillation columns (Figure 6): an acetone-recovery column that also removes water from the crude main product, low- and intermediate-boiling by-product recovery columns (LBPR and IBPR), and a series of dedicated product columns delivering the main product, its intermediate and heavy co-products, and a heavy by-product (HBPR) stream. Each column carries its own reboiler, condenser, reflux system, pumps and instrumentation, and together they dominate the plot area, capital budget and energy bill of the section.

The product specifications leave little room to compromise: the main product must be recovered at 99.5 wt%, the intermediate co-product at 99 wt%, the heavy co-product at 98 wt%, and the acetone recycle at 97 wt%. Several of the products are heat-sensitive, so the heavier separations are run under vacuum to hold bottoms temperatures down and avoid thermal degradation. Any intensification had to hold every one of these targets, and respect the temperature limits, while removing equipment. These fresh products are not the only streams that must be held pure. The network also returns several recycles to the reaction section — chief among them an acetone recycle of about 97 wt% — and because they close a loop back to the reactor, any imprecision in the separation would let impurities accumulate pass after pass. The design therefore had to deliver not just on-specification products but recycles clean enough to keep that loop stable.

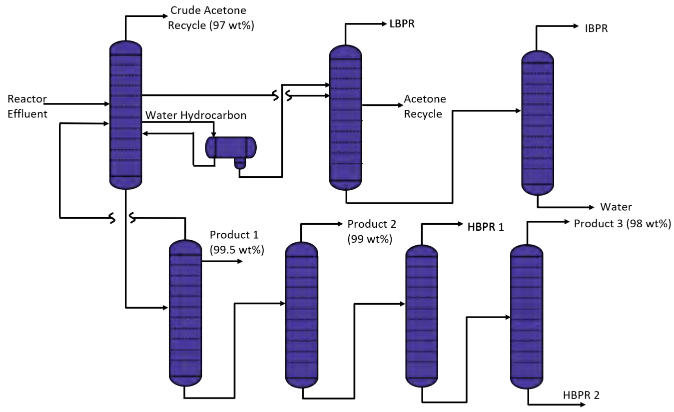


Figure 6. *The conventional route — a sequence of seven distillation columns, each dedicated to a single separation duty. Products 1, 2 and 3 denote, in order of increasing boiling point, the main product, the intermediate co-product and the heavy co-product.*

6 Mapping the train onto four dividing wall columns

Rather than intensify the single most expensive column, the separation section was treated as one design problem. Each conventional duty was assigned to the wall arrangement best suited to it, and the duties re-grouped so that coupled separations shared a shell. The result is a network of four dividing wall columns — a combination of two advanced dual DWCs and two conventional single-wall DWCs (one middle, one top) — that together perform the duty of the seven conventional columns while holding every product on specification (Figure 7). The columns span a wide pressure and temperature range, from a slightly pressurised front end to deep vacuum on the heat-sensitive heavy ends; their duties and operating points are summarised below.

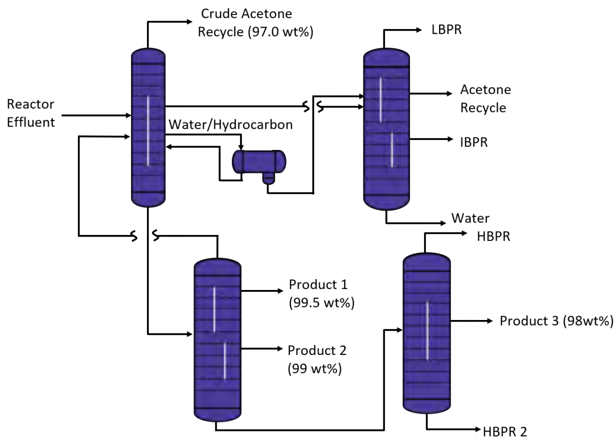


Figure 7. *The intensified route — four dividing wall columns deliver the same on-specification products (1, 2 and 3, as defined in Figure 6) as the seven-column train.*

The four columns and their duties

Acetone stripper — middle DWC. Front-end column. The mid-section wall lets feed enter the prefractionation side without mixing into the product side. Takes stripped acetone overhead, draws an intermediate-by-product-rich acetone side-cut, removes water from the crude main product, and sends it from the bottoms onward. Operates near 0.5 kg/cm^{2}g, bottoms ~135 °C.

LBPR recovery — dual DWC. Consolidates the light- and intermediate-by-product recovery duties in one shell. Two walls make three separations at once — an LBPR overhead, an IBPR side-cut, recycle acetone and a waste-water bottoms. Operates near 0.5 kg/cm^{2}g, bottoms ~118 °C.

Main product column — dual DWC. Delivers the on-specification products from a single vacuum column. The upper wall splits recycle IBPR from the 99.5 wt% main product; the lower wall yields the 99 wt% intermediate co-product over a heavy-by-product bottoms. Operates under vacuum (~230 mmHg), bottoms ~133 °C to protect the heat-sensitive products.

Heavy product column — top DWC. Recovers the heaviest ends. A wall from the top down to the upper trays forms two independent overhead systems — one drawing the 98 wt% heavy co-product, the other concentrating heavy by-product into the bottoms. Operates under deeper vacuum (~91 mmHg), bottoms ~163 °C.

Two features of the mapping are worth noting. First, two separate dual DWCs were used — one on the light- and intermediate-by-product recovery duty, one on main-product purification — because each sub-section involved three or more coupled cuts that a two-wall shell could absorb in a single vessel. Second, it is the character of each separation, not merely its position in the train, that sets the configuration: a mid-column side-draw duty went to a middle wall, multi-cut recovery duties to dual walls, and the heavy end — where two products leave over the top at different temperatures — to a top wall and its twin-overhead scheme.

The dividing wall technology, including the process design of the integrated network and the proprietary column internals that most directly govern whether each column meets its guarantees, was provided by DWC Innovations LLC. The plant entered commercial operation in June 2026 and is, to the authors' knowledge, the first commercial installation in which multiple dividing wall columns replace an entire conventional distillation sequence within a single process.

7 Operating flexibility

A common concern with process intensification is that it trades flexibility for efficiency — that folding several columns into one leaves the plant unable to cope with changing feed or product slates. Here the opposite was engineered. The same four columns serve four distinct operating cases: two feed-conversion regimes spanning the catalyst's life, each able to run with the heavier co-products either recovered as saleable product or recycled, with no change in hardware. That flexibility is built into the columns as additional feed points and side-draw locations active only in certain cases, redundant draw trays, and vacuum and reflux systems sized for the full range of loads. A dividing wall column network can therefore absorb operating flexibility that a conventional train would distribute across many more vessels. Precision and flexibility go hand in hand in a network of this kind: the walls must hold each cut — and each reactor recycle — tightly enough to prevent impurity build-up, yet shift cleanly between operating cases as the feed and product slate change.

8 Results

Consolidating seven columns into four delivered intensification benefits across capital, energy and footprint at once. Because each eliminated column removes its reboiler, condenser, pumps, drums and structural steel, the savings compound well beyond the reduction in column count (Table 1).

Metric	Conventional train	DWC network
Main separation columns	Seven	Four
Plot space	≈ 3,400 m² (≈ 40% more)	≈ 2,400 m²
Installed capital cost, ISBL	≈ US$ 28 million	≈ US$ 20 million (≈ 30% lower)
Steam consumption, base case	≈ 26 t/h	≈ 18 t/h (28% lower)

Cost basis: installed capital is an ISBL study estimate on a US Gulf Coast basis (AACE Class 4, ±35%), escalated to 2024/25

Table 1. *Performance of the dividing wall column network relative to the conventional seven-column train.*

Capital. Installed capital cost fell by roughly 30% relative to the conventional seven-column design. The reduction reflects not only the three fewer columns but the associated saving in rotating equipment, exchangers, foundations, structural steel and interconnecting piping, together with the smaller plot the section occupies — which on a congested brownfield site can be as valuable as the equipment saving itself. For this client, in fact, plot space was the decisive factor: the unit sits on a congested brownfield site with no room to grow, and the conventional seven-column train would have needed about 40% more plot area — roughly 3,400 m^2, against about 2,400 m^2 for the four-column network (Table 1). It was this footprint saving, as much as the economics, that made the debottleneck feasible at all. On an installed-capital (ISBL) basis the network is estimated at about US$20 million, against roughly US$28 million for the conventional design.

Energy. Utility consumption fell by 28%. In base-case operation this is about 18 t/h of steam for the network, against roughly 26 t/h for the conventional train. This is the dividing wall column's characteristic benefit realised across an entire train: by eliminating the repeated remixing inherent in a long column sequence, the network performs the same separation with substantially less reboiler and condenser duty, giving a permanent reduction in operating cost and in the carbon intensity of the process.

Payback and operability. Together, the capital and utility savings give an expected simple payback of about four months. Beyond the economics, four columns are simpler to operate and maintain than seven: fewer control loops, fewer relief scenarios, fewer maintenance items and a smaller footprint to inspect. These figures are design and early-operation estimates for the specific unit and will vary with feedstock, product slate and local costs.

9 Conclusions

This project demonstrates that dividing wall columns need not be deployed one at a time. By treating an entire distillation train as a single design problem and mapping each separation duty to the DWC configuration best suited to it, the technology can be extended from the column scale to the process scale. In this case the approach reduced the column count from seven to four, cut capital cost by roughly a third and utility consumption by more than a quarter, and held every product specification the conventional design was required to meet.

The principle is not specific to acetone derivatives. Any process built around a train of closely coupled distillation columns — aromatics recovery, isomerisation and reformate handling, solvent recovery and many petrochemical fractionation trains — is a candidate for the same treatment. Wherever several columns in sequence perform separations that a dividing wall arrangement could couple, there is potential to collapse the train and reduce its energy, capital and footprint. The economic case is strongest where energy is expensive, plot space is constrained, or a debottleneck would otherwise require new columns; a rigorous integrated simulation of the candidate train is the appropriate next step to confirm the opportunity in any specific application.

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DWC Innovations LLC (Houston, Texas, USA) develops and licenses dividing wall column process technology and column internals for refining and petrochemical applications (dwcinnovations.com).