WHITE PAPER

DIVIDING WALL COLUMNS

For

NAPHTHA POOL UPGRADATION

DWC INNOVATIONS

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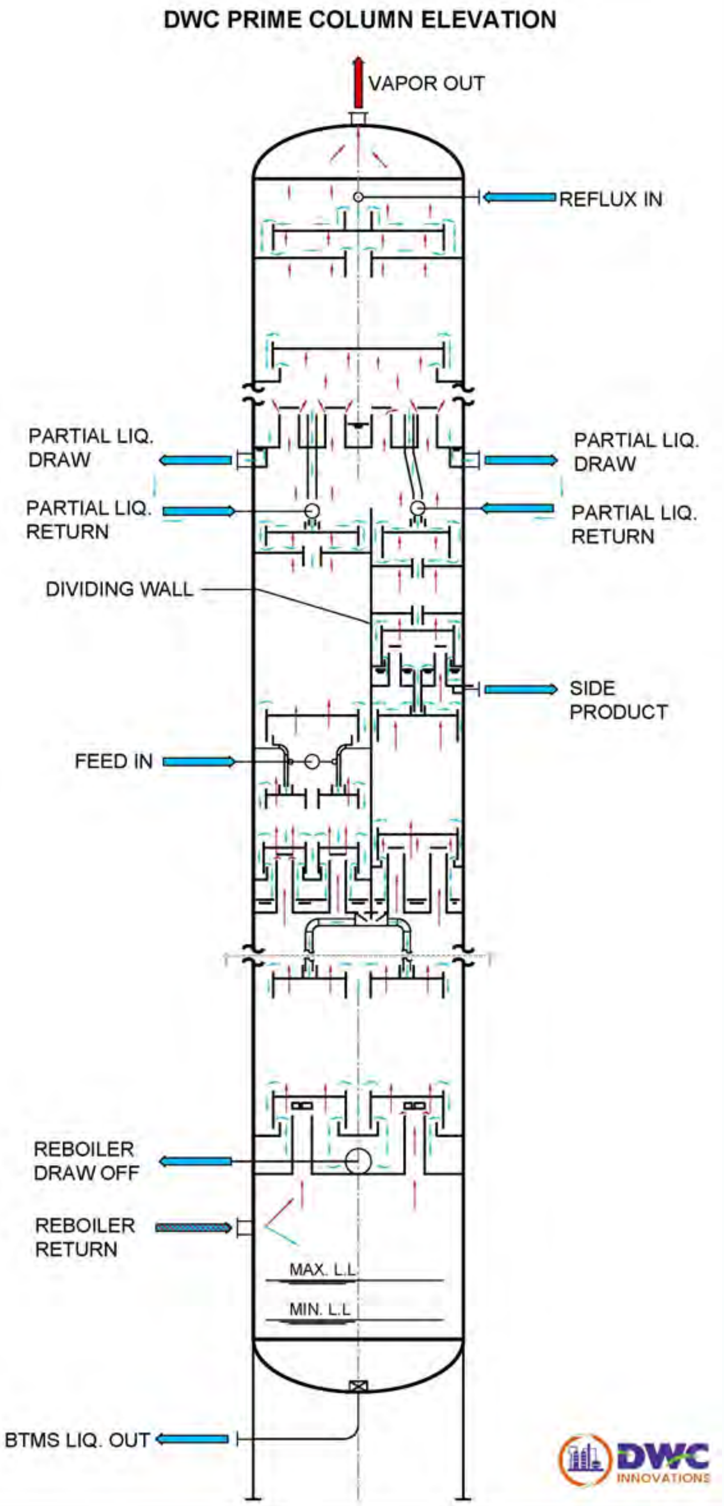
Using Dividing Wall Columns for Naphtha Pool upgradation

Dividing Wall Columns (DWCs) have been enjoying resurgence of late in the distillation world. These columns are new improved versions of conventional distillation columns, which form an integral part of the refining and chemical industries.The concept of DWCs is a well-established one with a lot of literature focusing on the simulation and control of these columns (Zhou et al., 2018, Wang et al. 2014, Dai et al, 2016). Some even discuss the industrial applications of DWCs in different grassroots and retrofit columns (Bhargava et al, 2017). These are highly customized process solutions that improve the energy efficiency and lower capital cost requirements by approximately 20-30% relative to conventional distillation columns (Yildrim et al, 2011, Wu et al, 2014, Kiss et al, 2009, Dai et al,2016 and Aurangzeb et al,2016).

The technology is quite versatile, and it is somewhat safe to say that no two DWC applications are quite the same so as to develop a standard protocol for designing these columns. These columns have been used in a variety of applications including gas plants, naphtha splitters, reformate splitters amongst others. However, the basis of every DWC design is to remove intrinsic remixing of components in conventional columns by incorporating a vertical wall within such columns. The remixing results in lower energy efficiency in conventional distillation techniques.

The paper discusses the commercialization of DWC technology for the upgradation of naphtha pool. The process design problems encountered are discussed here along with the insights on how DWC technology mitigates these problems to achieve new design objectives.DWC concept is being here implemented via the revamp of a depentanizer column. The column after revamp to DWC produces three products from a light Naphtha feed– an iC5 cut top product, a C5 mix side cut and a Naphtha product.



Typical Dividing wall column with a middle wall that seperates the column into two section.

Original Design and New Process Objectives:

The figure below shows the existing configuration of the Naphtha Splitter followed by a Depentanizer column at the facility in concern.

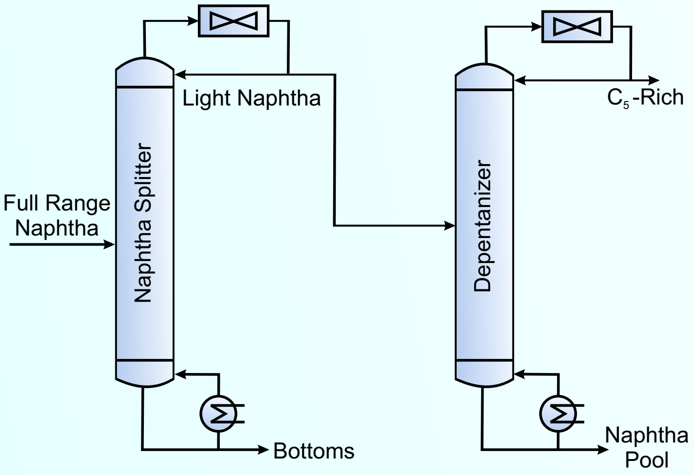


Figure 1: Original Design of Naphtha Splitter and Depentanizer Column

The light naphtha fraction consisted of about 15% nC5 and 14% iC5. Higher C6-C7 components made up the remaining light naphtha. Top product of light naphtha stream was routed to a depentanizer column, wherein the C5 productand the C6 Naphtha were separated.

To produce a premium gasoline product of RON 90, the client had decided to recover iC5 (90 wt. % purity)from the light naphtha feed as a separate product. The remaining nC5 were to be separated as a side cut product, while light Naphtha would be the bottom product.

For the Depentanizer, one of the main objectives of the retrofit was to maximize the utilization of the existing auxiliary equipment by limiting the modifications to the column internals. Since the Depentanizer column had to be modified from its original service, the approach was to reuse most of the equipment and use new cost-efficient equipment, which did not require lengthy lead times. The client looked at three possible solutions for the new product specification which are discussed below:

Option 1: Install a New Deisopentanizer column downstream of existing Depentanizer column

Option 2: Revamp the Depentanizer column to a conventional side cut column

Option 3: Revamp the existing Depentanizer column to DWC.

Option 1: Install a New Deisopentanizer column downstream of existing Depentanizer column.

This option involved installation of a new Deisopentanizer column downstream of the existing Depentanizer

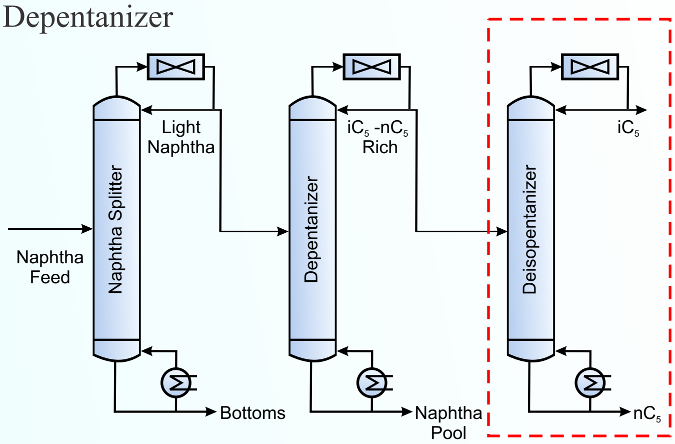


Figure 2: Installation of a New Deisopentanizer Column

Though this option met the client's objective of product requirements, but required substantial investment in CAPEX and OPEX.

Sequential distillation of components, column typically consumes additional energy due to remixing of components in the first column. Figure below shows the thermodynamic inefficiency involved due to the remixing in conventional distillation column sequences.

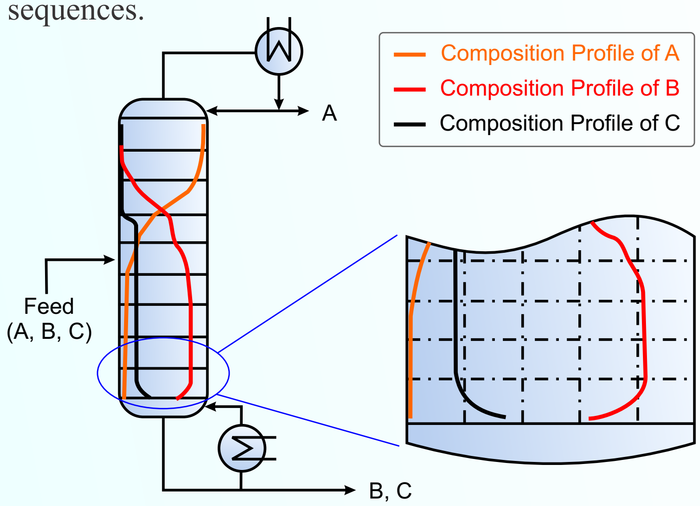


Figure 3: Thermodynamic inefficiency of mixing in conventional column sequences

Option 2: Revamp the Depentanizer column to a conventional side cut column

The client explored this option by converting the column into side-cut column with new column internals to produce iC5 rich product at the top.

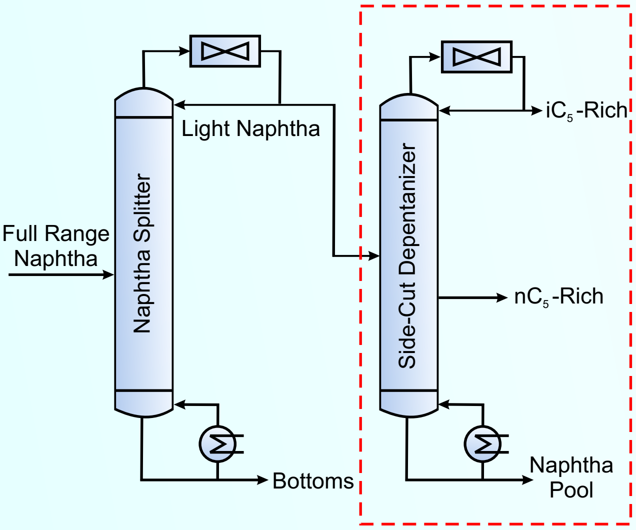


Figure 4: Revamp Depentanizer to a Conventional Side Cut Column

Like sequential distillation, remixing of components would also be encountered in conventional side-cut columnas shown in figure below. This led to poor product quality. Improvement in product purity could be achieved via increased reboiler duty.

A compromise between product quality and duty could be achieved by optimizing the location of the side-cut to below the feed nozzle. In case of the existing Depentanizer column, an iC5 rich stream would be removed as the top product. However, it was realized that a good amount of C6s would spillover to the side-cut affecting the quality of other two products.

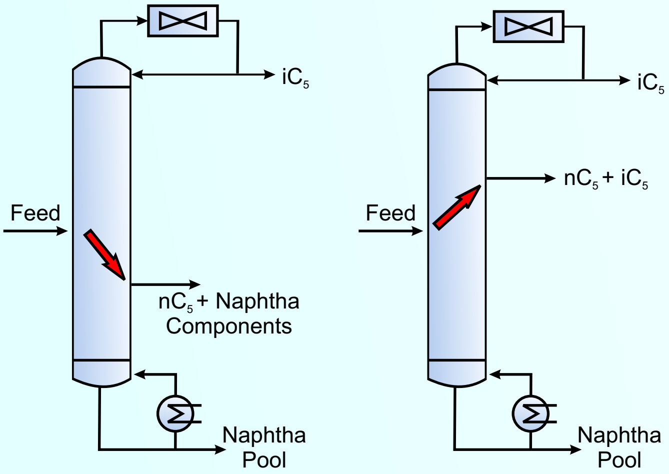


Figure 5: Intermixing in Conventional Side Cut Column

Option 3: Revamp the existing Depentanizer column to DWC.

Drawbacks of the two options made the client take the decision of converting the column into DWC. The existing Depentanizer was retrofitted with new column internals and converted to middle type DWC. The new column will produce high purity iC5 as the top product without a significant increase in reboiling energy.

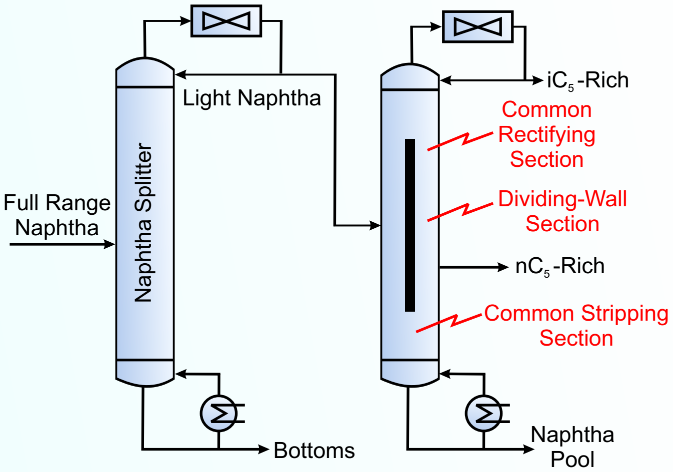


Figure 6 : Revamp of Depentanizer column to DWC

A DWC works primarily by eliminating remixing in conventional columns due to the presence of a vertical barrier (wall). It's a mechanical and thermal integration of a Petlyuk column (Wolff et al, 1995 and Kiss et al, 2009), which reduces remixing by introducing a prefractionation and main fractionation regions in a single shell.

The middle DWC has three separation zones within a single shell. A common rectifying (or enriching) section is followed by a dividing wall section and finally, a common stripping section. The feed enters on the prefractionation side of the dividing wall. The lightest key in the feed (iC5 mainly) travel up the column along with some amount of nC5. The heaviest key (remaining nC5 and C6+) move down the column. In the common rectifying section, the majority of nC5 is pushed down towards the dividing wall main fractionation side. High purity iC5 is recovered as the top product.

Similarly, the nC5 which had travelled down with the C6+ are pushed up in the common stripping section. As a result, a concentration peak is achieved somewhere in the middle of the column on this side of the dividing wall. A mix C5 cut is obtained as the side cut product, while Naphtha is removed at the bottom.

Results and Discussion: The column specifications for various options are given in Table 1.

Case Description	Units	Two Column Sequence		Side Cut Column	DWC
		Depentanizer (Existing)	Deisopentanizer (New)		
No of Trays	-	50	75	75	75
Column Diameter	M	4.6	3.7	4.6	4.6
Condenser Duty	MMKcal/hr	14.6	15.6	18.7	19.1
		30.2			
Reboiler Duty	MMKcal/hr	18.4	15.8	23.5	23.5
		34.2			

Table 2 given below shows the recoveries / flowrates of the product streams

Case Description	Units	Two Column Sequence	Side Cut Column	DWC
Feed				
Rate	kg/hr	225,000	225,000	225,000
IC4/NC4	wt%	0.45	0.45	0.45
IC5	wt%	13.97	13.97	13.97
NC5	wt%	15.59	15.59	15.59
i-C5 Product				
Rate	kg/hr	23,193	20,500	23,193
IC4/NC4	wt%	4.36	4.91	4.36
IC5	wt%	90.00	90.19	90.03
NC5	wt%	5.45	4.72	5.45
n-C5 Rich Side draw				
Rate	kg/hr	51,776	84,638	51,776
IC5	wt%	20.30	15.25	19.98
NC5	wt%	59.79	36.90	60.10
C6+	wt%	19.91	47.85	19.92
Naphtha Product				
Rate	kg/hr	150,031	119,862	150,031
IC5	wt%	0.03	0.02	0.13
NC5	wt%	1.91	2.40	1.80
C6+	wt%	98.07	97.58	98.07

After evaluating the various options, the DWC option had been found to be the most profitable for the client. The acceptance of DWCs is steadily increasing in refineries and petrochemicals on account of the following benefits :

- Higher recovery of the desired product.
- Better product quality for the side-cut and bottom products.
- Lower reboiler and condenser duties.
- Equipment modifications are usually minimum which reduce the capital investment for the project.
- Dividing wall columns are quite robust and flexible.
- Are very suitable for separating multicomponent mixture into three or more high purity product streams in a single column.
- Lower foot print as equipment count is reduced by half.

Though each DWC application is unique and tailormade for the service, the revamp illustrated in this article gives a procedure for retrofitting Deisopentanizer/Depentanizer columns for upgrading Naphtha products. The same can also be used for grassroots columns. Using DWCs in place of regular distillation columns saves the refineries both capital and utility costs there by producing a lower carbon foot print.

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