Dividing Wall Columns in Petrochemical Industry

“Taking Advanced Distillation into the Modern Era”
Manish Bhargava - Director Advanced Distillation GTC Technology
K Shreya – BPCL Mumbai
Most of the energy consumed in refineries is related to distillation.

Advanced separation techniques make substantial reductions in energy consumption and improvement in product specifications

- **GT-TDWC**: Top Dividing Wall Columns
- **GT-DWC™**: Middle Dividing Wall Columns
- **GT-BDWC**: Bottom Dividing Wall Columns
- **GTC Single Shell Absorption / Distillation Column**
BPCL started 1st Top Dividing Wall Column in Isom Unit at Mumbai in March 2017
• Conventional side draw column provides limited opportunity for heat integration
• Top dividing wall column gains the thermodynamic efficiency, plus affords meaningful heat integration.
FGH production requires a narrow cut of an intermediate product.

Options for application

- Conventional 2 Column System: DIH + FGH column
- Advanced Distillation Option: GT-TDWC
Conventional Option: DIH + New FGH Column

- Stable Isomerate
- Light Isomerate
- FGH Product
- Heavy Isomerate
- Total Isomerate
## Comparison: GT-TDWC℠ vs Conventional 2-Column System

<table>
<thead>
<tr>
<th></th>
<th>Conventional 2 Column System</th>
<th>GT-TDWC℠</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DIH Column</td>
<td>New FGH Column</td>
</tr>
<tr>
<td><strong>MP Steam Consumption</strong></td>
<td>52.4</td>
<td>17.0</td>
</tr>
<tr>
<td>(1000 x lb/Hr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total = 69.4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating Cost</strong></td>
<td></td>
<td>9.69</td>
</tr>
<tr>
<td>(MM USD/year) Steam only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Top Dividing Wall Column Installation at BPCL, India
Most of the energy consumed in refineries is related to distillation.

Advanced separation techniques make substantial reductions in energy consumption and improvement in product specifications

- **GT-DWC℠**: Middle Dividing Wall Columns
- **GT-TDWC**: Top Dividing Wall Columns
- **GT-BDWC**: Bottom Dividing Wall Columns
- **GTC Single Shell Absorption / Distillation Column**
Case Study 2:

- Three Cut FCC Naphtha Splitter revamped to GT-DWC
Existing Naphtha Splitter Configuration

Depentanizer Bottoms
Cut Point Range
161 to 373°F

Cut Point Range
147 to 212°F

Cut Point Range
223 to 376°F

Cut Point Range
288 to 388°F
Objectives for Revamp

- Increase Feed rate
- Reduce overlap of heavier components in side cut
- Keep LCO and HCO as the heating medium for the column.
Bottlenecks in Column Design with Reference to New Objectives

Intermixing of Feed with Side Cut

Smaller Diameter puts a restriction on Vapor/Liquid Loading
Revamp to GT-DWC℠

Heavies Product

Feed

Sidecut separated from feed; Better quality

Overhead Product

Sidecut Product

Heavies Product
Dividing Wall Column Trays
Installation of Dividing Wall

24.04.2015 16:35
GTC Internal Liquid Split Distributer

- Risers for vapor flow
- Provision for external splitting for future use
- Liquid split metering box (Maintains fixed liquid ratio on either side of wall)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Naphtha Splitter before Revamp</th>
<th>Naphtha Splitter after Revamp to GT-DWC&lt;sup&gt;SM&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Draw Flow Rate</td>
<td>lb/hr</td>
<td>398,000</td>
<td>353,000</td>
</tr>
<tr>
<td>D86 (IBP/FBP)</td>
<td>Deg° F</td>
<td>223 to 376</td>
<td>231 to 356</td>
</tr>
<tr>
<td>Overlap (Heart Cut Naphtha D86 95%-Heavy Cut Naphtha D86 5%)</td>
<td>Deg° F</td>
<td>99</td>
<td>27</td>
</tr>
</tbody>
</table>
• Client was planning to install a 2\textsuperscript{nd} column in sequence with the existing Naphtha Splitter.

• A spare column was available for this retrofit.

• Cost of Revamp to GT-DWC\textsuperscript{SM} was 1/4 of the alternate two-column design being explored by the client.
Case Study 3:

Existing Two Column FCC Naphtha Splitter Sequence

revamped to GT-DWC℠
Case Study 3: Two Columns Modified to Single Column

Feed

LCO

HCO

C5 Naphtha

Heart Cut Naphtha

LP Steam Generator

BFW

Heavy Naphtha 1

Heavy Naphtha 2

HCO / HP Steam

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Design Features in Original Configuration

- Use of low temperature heat duty via LCO in NS1. This requires a side reboiler in NS1 Column
- Minimize duty in NS1 by taking a side cut stream to NS2 column
- Elevate pressure of NS2 Column to generate LP steam
NS1 Column has a side reboiler which allows use of low temperature heat duty. The side reboiler forces a higher loss of C8s in the top product as the bottom section trays remain under utilized.
Design Features in Original Configuration - Minimize Duty in NS1 by Taking a Sidecut to NS2 Column

A Side stream as feed to NS2 Column lowers the energy consumption in NS1

A Sidecut from NS1 forces • higher C9 loss in Heavy Naphtha bottoms product
NS2 Column pressure is elevated to generate LP steam from the overhead vapors.

Higher operating pressure decreases the relative volatility between different components.

LP steam is generated at the expense of higher HP steam and hot oil consumption.
Revamp to GT-DWC℠

Naphtha Splitter-1 Revamped to GT-DWC℠

Naphtha Splitter II Idled

- Feed
- Light Naphtha
- Heart Cut Naphtha
- LCO
- Heavy Naphtha

- LP Steam Generator
- Heart Cut Naphtha
- HCO / HP Steam
- Heavy Naphtha 2
Benefits of Revamp to GT-DWC℠

- Reduce utility consumption for the separation.
- Produce heart cut naphtha in Naphtha Splitter-1 column, while removing Naphtha Splitter-2 from service.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Original Design (NS-I and NS-II)</th>
<th>Naphtha Splitter-I after Revamp to GT-DWC℠</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>lb/hr</td>
<td>679,000</td>
<td>679,000</td>
</tr>
<tr>
<td>Side Draw Flow Rate</td>
<td>lb/hr</td>
<td>363,700</td>
<td>363,500</td>
</tr>
<tr>
<td>D86 (IBP-FBP)</td>
<td>° F</td>
<td>231-338</td>
<td>231-337</td>
</tr>
<tr>
<td>Overlap (Side Cut D86 95%-Heavy Cut Naphtha D86 5%)</td>
<td>° F</td>
<td>8.1</td>
<td>7.0</td>
</tr>
<tr>
<td>Total Heating Duty</td>
<td>MMBtu/hr</td>
<td>151</td>
<td>111</td>
</tr>
</tbody>
</table>
## Comparison: Product Recoveries

**Existing Configuration vs GT-DWC**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Original Design (NS-I and NS-II)</th>
<th>Naphtha Splitter-I after Revamp to GT-DWC℠</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>lb/hr</td>
<td>679,000</td>
<td>679,000</td>
</tr>
<tr>
<td>C8/C9 (Naphthenes &amp; Aromatics)</td>
<td>lb/hr</td>
<td>243,900</td>
<td>243,900</td>
</tr>
<tr>
<td>Mid Cut</td>
<td>lb/hr</td>
<td>363,700</td>
<td>363,500</td>
</tr>
<tr>
<td>C8/C9 (Naphthenes &amp; Aromatics)</td>
<td>wt%</td>
<td>63.90</td>
<td>66.53</td>
</tr>
<tr>
<td>Concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C8/C9 (Naphthenes &amp; Aromatics)</td>
<td>lb/hr</td>
<td>232,404</td>
<td>241,860</td>
</tr>
<tr>
<td>% Recovery C8/C9 (Napthenes &amp; Aromatics)</td>
<td>wt%</td>
<td>95</td>
<td>98</td>
</tr>
<tr>
<td>Loss of C8/C9 (Naphthenes &amp; Aromatics)</td>
<td>lb/hr</td>
<td>25,280</td>
<td>18,230</td>
</tr>
<tr>
<td>Total heating duty</td>
<td>MMBtu/hr</td>
<td>151</td>
<td>111</td>
</tr>
</tbody>
</table>
Benefits of GT-DWC<sup>SM</sup>

- Heating duty reduced by ~ 26%
- HP steam usage eliminated
- Naphtha Splitter-II is idled
- 3% Higher Product recoveries
- Heart Cut Naphtha obtained in Naphtha Splitter-I
- Project Payback (Based on Energy Reduction benefits only) = 10 Months
Case Study 4: Grassroots Mixed Xylenes Recovery Unit at TonenGeneral (TG), Japan

- TG had an existing unit which produced C7+ product for gasoline blending.

- TG wanted to separate high purity petrochemicals (Toluene, Mixed Xylenes) from the feed.

- TG decided for a DWC solution against a two column configuration because of lower CAPEX and lack of plot space.
Case Study 4: Mixed Xylenes Recovery

Feed (T, X, C9+)

Toluene Column

Mix Xylene Column

(X, C9+)

(X, C9+)

T

C9+
GT-DWC℠ for Mixed Xylenes Recovery

- Reformate Feed
- Reformate Light Cut Column
- Reformate Heavy Cut Column
- C5 rich Cut
- C6 Rich Cut to Aromatics
- Clay Treaters
- GT-DWC Column
- Toluene
- Mixed Xylenes
- C9+ Cut
TX DWC is defined by three primary control loops:

- Fixed reflux rate
- Side draw product rate cascaded to TI on upper tray
- Heating Duty cascaded to bottoms temperature
Off Center Dividing Wall
Installation of GT-DWC℠ Column at Chiba Refinery, Japan
## Comparison: Two Column System vs DWC

<table>
<thead>
<tr>
<th>Product Specifications</th>
<th>Two-column sequence</th>
<th>DWC configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix-xylenes product, lb/hr</td>
<td>64,665</td>
<td>64,670</td>
</tr>
<tr>
<td>C8 aromatics, wt%</td>
<td>99.2</td>
<td>99.3</td>
</tr>
<tr>
<td>Reboiler duties, MMBtu/hr</td>
<td>85.6</td>
<td>68.2</td>
</tr>
<tr>
<td>Steam Reduction, 1000 x lb/hr</td>
<td>-</td>
<td>42.0</td>
</tr>
<tr>
<td>Operating cost savings, %</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Capital cost, $ million</td>
<td>26.0</td>
<td>21.0</td>
</tr>
</tbody>
</table>
Client Objectives

- Propane recovery in LPG > 97%
- No Refrigeration
Conventional Design of LPG Recovery Unit

- LPG Recovery - 55%
- Energy - 22 MMBtu/hr
GT-LPG MAX™ - Combined Absorption & Distillation in a Single Column

- LPG Recovery - 97%
- Energy - 20 MMBtu/hr
<table>
<thead>
<tr>
<th>Variables</th>
<th>Existing Configuration</th>
<th>GT-LPG Max™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Propane Recovery %</td>
<td>55 %</td>
<td>97 %</td>
</tr>
<tr>
<td>Total Duty MM Btu/hr</td>
<td>22.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>
Summary

• Unconventional distillation applications are an overlooked means to reduce refinery energy consumption

  – GT-DWC℠ reduces 20–30% OPEX through energy savings

  – GT-DWC℠ reduces 20–30% CAPEX by requiring a single column for multi-component separation

• Advanced Distillation schemes can offer CAPEX and OPEX reduction of more than 40% by combining multiple unit operations and heat integration opportunities.
RETHINK
Multi-Component DISTILLATION