Dividing wall columns – which wall separates Dutch industry from application?

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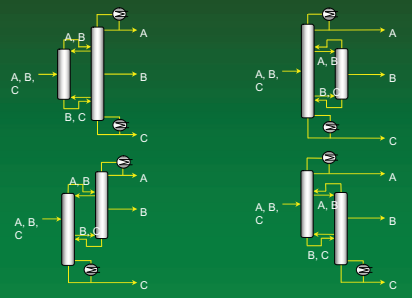
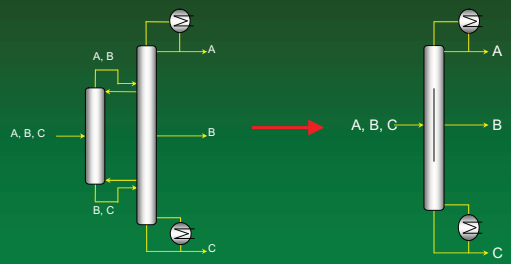
Contents

Dividing wall column: What‘s that and how it‘s working?

Thermodynamic basis: Brugma or Petlyuk Configuration

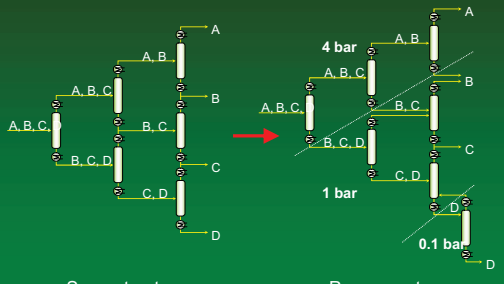


Equivalent thermodynamics, different construction



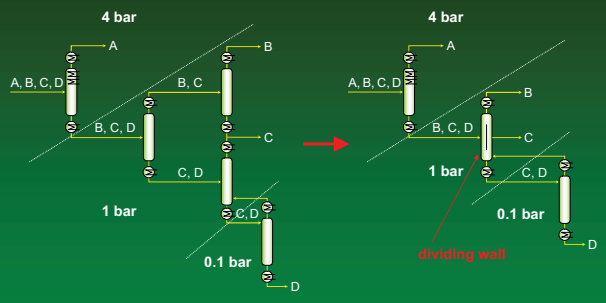
Design procedure

1) Process configuration



Superstructure Pressure steps

2) Process synthesis: Possibility for column integration?

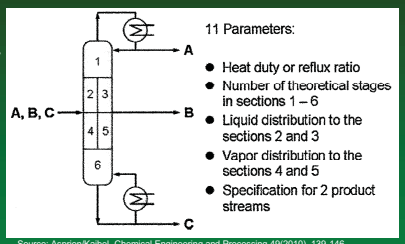


Selection of the sequence Final design

3) Process simulation:

programs suitable for complex simulation tasks needed:

To be specified:



11 Parameters:

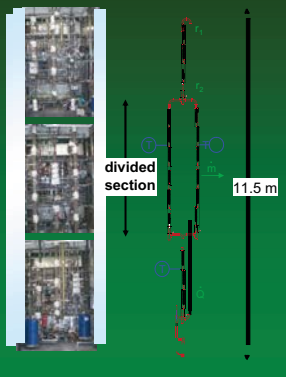
- Heat duty or reflux ratio
- Number of theoretical stages in sections 1 – 6
- Liquid distribution to the sections 2 and 3
- Vapor distribution to the sections 4 and 5
- Specification for 2 product streams

Source: Asprion/Kaibel, Chemical Engineering and Processing 49(2010), 139-146

Recommendation: Take equation based/simultaneous programs

4) Experimental validation:

miniplant scale normally sufficient



Example:

Eperimental set up with Petlyuk configuration

5) Control concept

- No principal differences to conventional column sequences
- Normally no control of the internal partition of gas and liquid streams (design parameter) but if necessary special parts are available

Reflux splitter from MONTZ

- Dynamic simulation is useful
- Model predicitve control has been testet

Result of steps 1) – 5): Process flowsheet

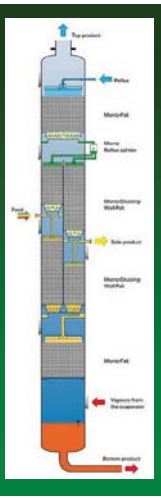
Construction:

Internals 1:

Structured packing
(usual design)

pictures from:

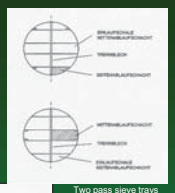
Montz



Sulzer

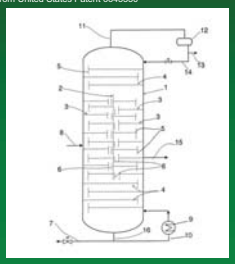
Internals 2:

- Trays
(developing fast)

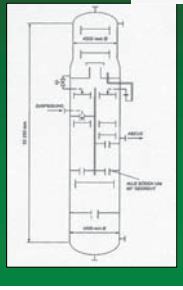


Two pass sieve trays

from United States Patent 6645350



pictures from sasol

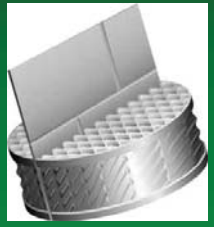


Construction of the column

Internals 3:

- Dividing wall:
may be welded in
or
unfixed

Source: Sulzer



The unfixed dividing wall has proved to be very advantageous and versatile.The patent pending design (co-operation agreement with BASF AG) offers significant advantages over fixed, welded-in walls.

Source. Montz

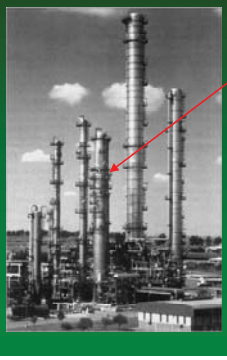
internals ⟶ externals:

which column is the dividing wall column?

Source: Sasol

internals ⟶ externals:

which column is the dividing wall column?



Column shell:
no differences in construction, piping, foundation etc.

Source: Sasol

Application fields and constraints

Application fields

- Total separation sequence has to be split in sequences for 3 or 4 components
- Petlyuk (heat integrated design) configuration must be possible (same pressure is a prerequisit)
- Comparable flow rates of the components to be separated are advantageous

Constraints

Wide range of boiling points among the components:

Temperature difference between condenser and reboiler may be high.

Operating pressure

No different pressure steps for the required separation possible

Column height:

A dividing wall column is always higher than either of the two alternative columns.

Hydraulic imbalances:

If the component in the side stream is too small, the hydraulics may be unequal on each side.

Rule of thumb: The bigger the side-stream part the better the dividing wall

Potential for process intensification

Petlyuk ***AND*** dividing wall columns:

- energy savings (10 – 30 %)

Dividing wall columns:

- lower investment: column, piping, heat exchangers, foundation….. (< 30 %)
- Reduced plot space (30 – 40 %)
- Reduced thermal stress for the components to be separated (lower residence time)

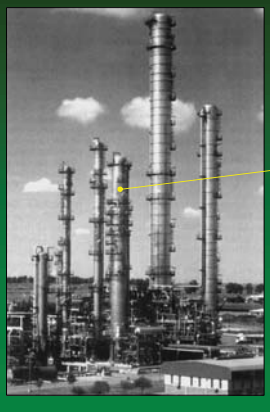
Examples

Industrial scale applications

Sector	Company - Process/Product name/type	Short characteristic of application	Production capacity/ Plant size	Year of application	Reported effects
Chemical company	BASF	Wide field of applications, 50 existing columns in production scale, 10 – 15 columns under construction or planned	No limitations with respect to capacity	First start-up in 1985	Energy savings, investment savings, reduced plot space, better product qualities, higher yields
Chemical companies	Sasol Sumitomo, Condea, Cognis, Bayer and others	Sasol: olefins chemicals	Sasol: up to 5.2 m x 107 m		Energy savings, investment savings, improved product purities
Refineries, chemical companies	Veba Ruhröl Chevron BP CEPSA ExxonMobil Aral Aromatics UOP and others	Pyrol. gasoline pyrol. gasoline aviation gasoline paraffins xylenes toluene hydrocarbons			Energy savings, investment savings, simple retrofits, extractive distillation

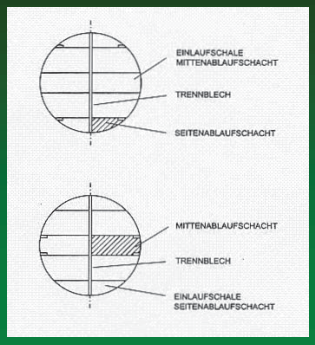
Source: Technology Report Kaibel 2007

Example for a tray column: Sasol Prefractionator

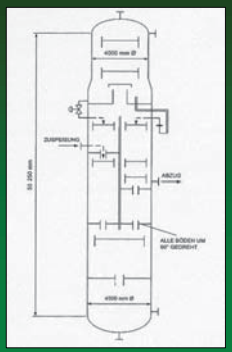


- Biggest column with diving wall (with trays)
- Built by Linde and Sasol in South Africa with BASF acting as a consultant
- Height of 64.5 m and a diameter of between 4 and 4.5 m

Sasol Prefractionator 2: Technical Details

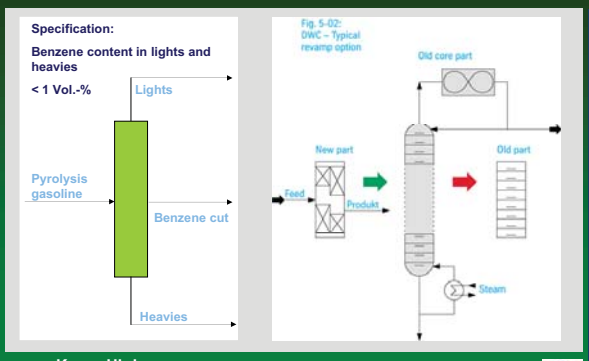


Two pass sieve trays



Construction of the column

Example for a Revamp: Krupp Uhde Revamp Project 1



A company of ThyssenKrupp Engineering Krupp Uhde

Implementation of the Ruhr Oel (Veba)
Münchsmünster Benzene Removal Project

ThyssenKrupp

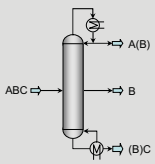
Krupp Uhde Revamp Project 2

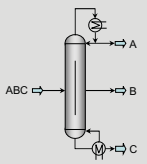
A company of ThyssenKrupp Engineering Krupp Uhde

Implementation of the Ruhr Oel (Veba)
Münchsmünster Benzene Removal Project

ThyssenKrupp

Krupp Uhde Revamp Project 3





	Conventional Column (before revamp)	Divided-Wall Column (after revamp)
Throughput:	16.0 t/h	20.0 t/h
Steam consumption:	3.9 t/h	4.2 t/h
Benzene content in mixed gasoline:	5.2 wt.%	0.76 wt.%
Benzene yield in side draw:	86.6 wt.%	99.1 wt.%

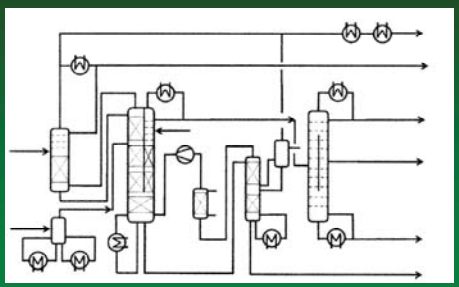
A company of ThyssenKrupp Engineering Krupp Uhde

Performance Results of the Ruhr Oel (Veba)
Münchsmünster Benzene Removal Project

ThyssenKrupp

Example for a complex process:

BASF's new **Butadiene Extraction Process**



Source:
Asprion/Kaibel,
Chemical
Engineering
and Processing
49(2010), 139-146

Actual status of industrial application of divided wall columns

- **„Normal“ Dividing wall Columns (3 component separation):**
  - BASF: more than 60 columns worldwide (packed columns) diameter up to 4 m, height up to 80 m
  - Sasol: 2 Tray columns, diam. up to 6 m, height up to 107 m
- **Complex dividing wall Columns**
  - BASF: off-center DW, additional side stream column, trays and packings mixed
  - Sasol: separation of 4 components in a tray column
- **Patents:**
  - actually (2009) 68 patents: 23 from BASF, 19 from other chemical companies, 19 from suppliers

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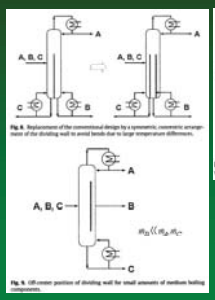
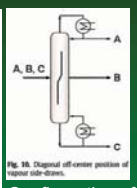
New applications

1) More complex arrangements of the dividing wall

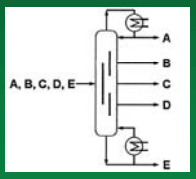




Configurations for non standard separation tasks (unequal flow rates)

Source: Asprion/Kaibel, Chemical Engineering and Processing 49(2010), 139-146

Another good view on new developments:
Olujic, Jödecke, Shilkin, Schuch, Kaibel
„Equiment improvement trends in distillation“
Chemical Engineering and Processing 48 (2009), 1089-1104



Separation of more than 3 Components (more DW's)

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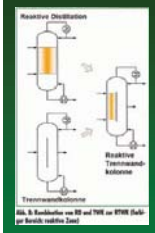
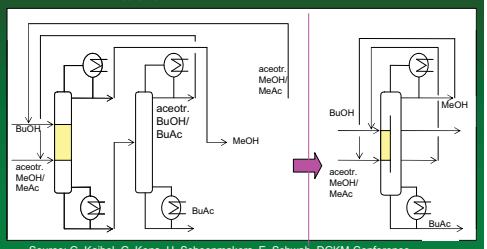
2) Combination of reactice distillation and dividing wall



Source: Großmann, Kenig, CITplus 5/2007, 38-41

New process testet in miniplant scale:
Transesterification of butanol with an aceotropic mixture methanol/methyl acetate to produce butyl acetate and methanol



Source: G. Kaibel, G. Kons, H. Schoenmakers, E. Schwab, DGKM-Conference „Chances for Innovative Processes at the Interface between Refining and Petrochemistry“, October 9 – 11, 2002 Berlin, Germany

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Conclusions

- Dividing wall columns are introduced in the industrial practice
- The design procedures and the construction are well established
- Experienced equipment suppliers exist
- Constraints exist in the application, thus DWC's are not a solution for every separation task
- There are new and extended applications, partly realised, partly under investigation

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Thus the choice of a dividing wall column for a separation task is a question of readyness for decision making, it's not really a risk, neither for construction nor for operation.

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