Netherlands Enterprise Agency

Wikisheet Divided Wall Column

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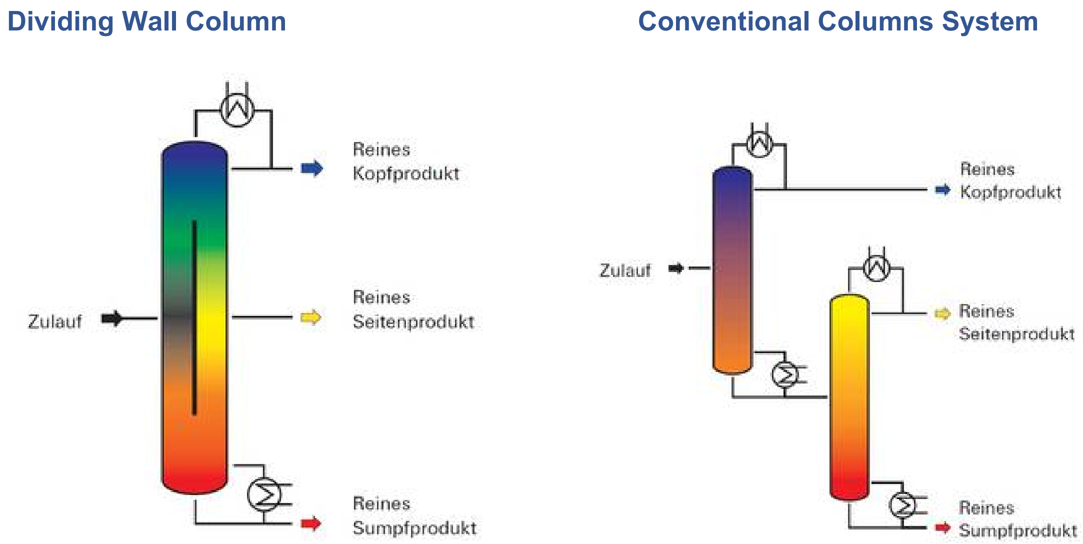
PIN-NL
Dutch Process Intensification Network

Wikisheet
Divided Wall Column



Objective	Contribute to energy efficiency program		
Background, project	Wikisheets Process Intensification within the PIN-NL program 2016		
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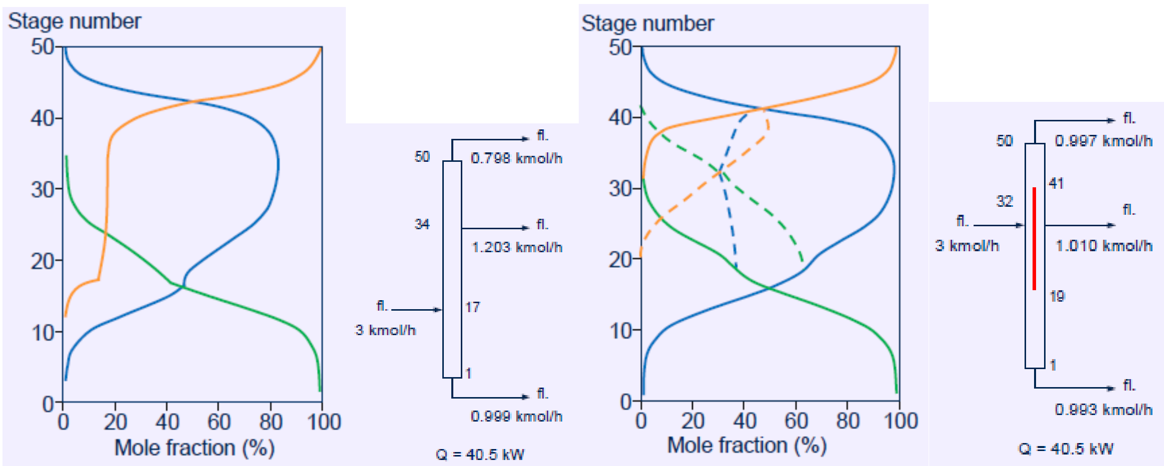
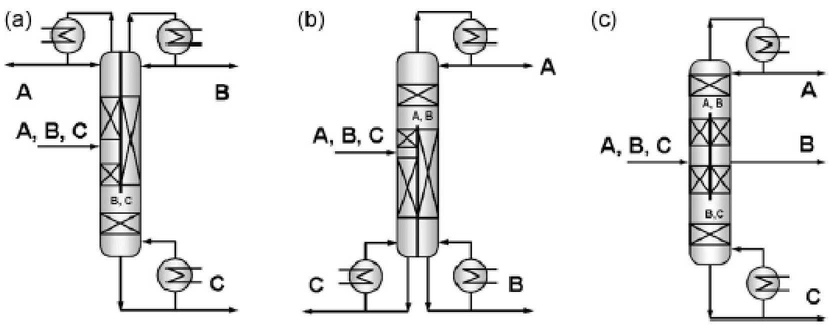
1. Description

A Dividing Wall Column is a distillation column which combines the operation of two conventional columns in one shell. Separation of a three component mixture in the individual components is made possible by the installation of a vertical wall in the middle of the column. On one side of the wall the column the column feed affects the concentration profile, on the other side of the wall a high concentration of the middle boiling component is achieved. The result is that three components are separated in one single column. See picture below (Kenig 2014, Asprion 2010). The development to industrial application was mainly done by BASF.
In the conventional set up we need two columns and two reboilers and two condensors. The DWC needs only one reboiler and one condenser. Energy, capital and plot place savings of 30% and more have been achieved (see e.g. Schoenmakers 2010, Kaibel 2007).



Asprion and Kaibel (2010) mention that the internal wall can be connected to the top or the bottom of the column. See figure below. They call (a) a site rectifier, (b) a side stripper and (c) a fully thermally coupled column. Type (a) and (b) can be considered for azeotropic separations.



2. Process envelope

The DWC has shown its advantages clearly in many applications, typically for liquid mixtures for equal amounts of three volatile components and for cases where a high amount of middle boiling component has to be separated from smaller amounts of lights and heavier components. Rule of thumb: The bigger the side-stream part the better the dividing wall (Schoenmakers 2010). DWCs have a spectrum of application from low quality separation (e.g. solvent recycling) to high purity separation (e.g. for electronic-grade). (Kenig 2014). Cameretti et al. (2015) report the work of other researchers showing that DWCs are especially favorable for the separation of small quantities of light and heavy boilers from the main middle-boiling product. The research of Cameretti et al. is about pilot studies for separation of small amounts of middle boiling component.
More complex DWCs – e.g. more walls - can be used for the separation of multicomponent mixtures.
A DWC column integrates: heat streams, material streams and equipment.

3. Advantages and limitations

Several authors mention the following advantages of DWCs compared to the two column set up:
- Reduction of investment (up to 40%) and reduction of operational costs (up to 30%)
- Lower energy consumption
- Less space required

Limitations in application can be: (Kenig 2014, Asprion 2010),
- Operation pressure variation between column sections is not possible
- Higher temperature difference between reboiler and condenser compared to a two column set up for a three component mixture
- Increased column length compared to two separate columns in parallel
- Generally more complex modelling, design and control
- Non ideal mixtures, require specific research

Jansen (2016) mentions: may be a lack of established design procedures and fear of unstable operation.
Dimian, Bildea and Kiss (2014) mention that the shell diameter needed for a DWC is often more than for the conventional column.

4. Commercial status / TRL level

More than 120 DWC have been installed worldwide, the majority at BASF and developed by Montz (Yildirim, Kiss, Kenig 2011). The majority for ternairy systems. Development of DWCs for multicomponent, azeoptropic, extractive and reactive separations are also reported, but implementations are limited. The component systems are often undisclosed (Dimian, Bildea, Kiss 2014). We can safely assume that DWCs are used in many applications such as hydrocarbons, alcohols, aldehydes, ketones, acetals, amines and others (Yildirim, Kiss, Kenig 2011).
A substantial increase was seen after the introduction of the non-welded internal wall (Dejanovic 2010) in mid 1990s.

DWCs are engineered and manufactured by Montz, Sulzer, Linde, Sumitomo Heavy Industries, Kyowa Yuka, Koch-Glitsch, UOP. TRL level is 9.

Schoenmakers – who was linked to BASF - (2010) concluded: Thus the choice of a dividing wall column for a separation task is a question of readiness for decision making, it's not really a risk, neither for construction nor for operation.

5. Examples of application

In 2010 Schoenmakers formulated the 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: (2009) 68 patents: 23 from BASF, 19 from other chemical companies, 19 from suppliers

Dejanovic (2010) reports in detail about reported and patented applications, this is in line with the information given by Schoenmakers.

Yildirim, Kiss, Kenig (2011) report the revamp of conventional columns into four DWCs. Recently Jansen et al. (2016) reported in detail about the conversion of conventional tray column sequences into a packed DWC. The reduction in energy and vapor load enabled this transition and allowed an increase of production capacity of 60%.

6. Technology and developments

Modelling and design can be done by flowsheet programs considering four or six separate sections in the DWC or by graphical techniques. The following list of heuristics provides good initial estimates for both shortcut and detailed simulations (Dejanovic 2010, Dimian, Bildea, Kiss 2014) :
- Design a conventional two-column system as a base case (e.g. in-/direct sequence).
- Take the total numbers of stages for DWC as 80% of the total number of stages required for the conventional two-column sequence: N_{DWC}=0.8 (N1+N2).
- Place the partition (i.e. dividing wall) in the middle third of the column (e.g. 33–66% H).
- Set the internal flow rates in the DWC, as determined by the reboiler or condenser duty, at 70% of the total duties of two conventional columns: Q_{DWC}=0.7 (Q1+Q2).
- Use equalised vapour and liquid splits (r_L=0.5, r_V=0.5) as initial values.

Several publications focus on the control of a DWC. Dejanovic (2010) states that although control is more difficult compared to conventional columns, industrial experience indicate that the control of a DWC is satisfactory. Kiss and Bildea (2011) make a similar conclusion.

Application to four and more components using more than one wall in a column have been reported. See e.g. Halvorsen (2013).
Research and development are ongoing for absorptive and extractive use of DWCs and reactive distillation. See e.g. Sun and Bi (2014) and azeoptropic mixtures, see Shi et al (2015)
Dejanovic (2010) stated that dimensioning of DWCs is still propriety knowledge of a few companies.

7. Potential applications for industrial branches

- Chemical process industries (MJA3 + MEE)
- Oil and gas producing industry (MJA3)
- Refineries (MEE)
- Potato conversion industries (MJA3)
- Breweries (MEE)
- Animal Food industry (MJA3)
- Dairy industries (MJA3)

8. Self assessment for application

- Consider ternary and quarternary liquid mixtures in your process which are now separated by distillation, consider regular distillation and removal of impurities
- Analyze vapor-liquid equilibria if they are not too far from ideal
- Analyze existing operation – prepare mass and energy balances –
- Make a quick design of a DWC using heuristic rules given above
- Consider profit of 30% energy reduction and potential profit for improved separation
- Check literature for data of application of the specific mixture or similar
- Check vendor documentation of Montz, Sulzer, Koch-Glitsch
- Contact consulting and design companies like Montz, Sulzer

9. Tags

Process intensification, more efficient distillative separation of multicomponent mixtures.

10. References

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Vendor info:

http://www.montz.de/en/products/montz-dividing-wall-columns/ visited 25/19/16

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