KOCH-GLITSCH | MONTZ

A KOCH ENGINEERED SOLUTIONS COMPANY

DIVIDING WALL COLUMNS
NOVEL APPLICATIONS WITH CASE STUDIES

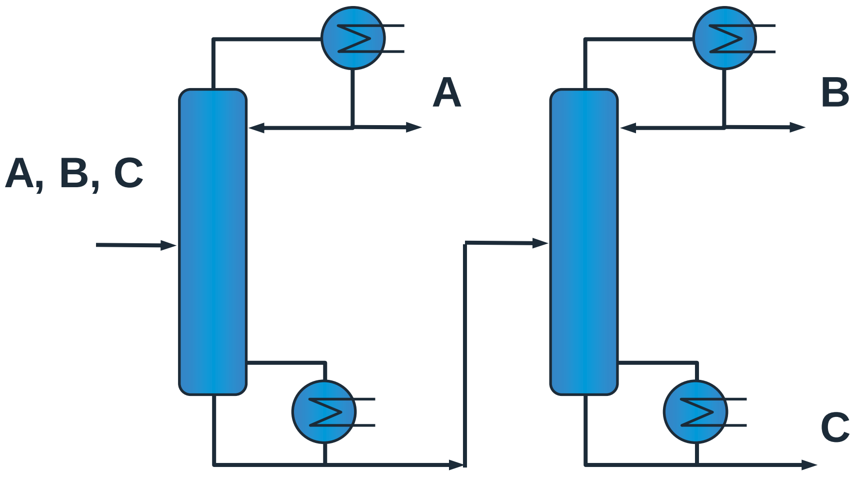
Dr. Robin Schulz

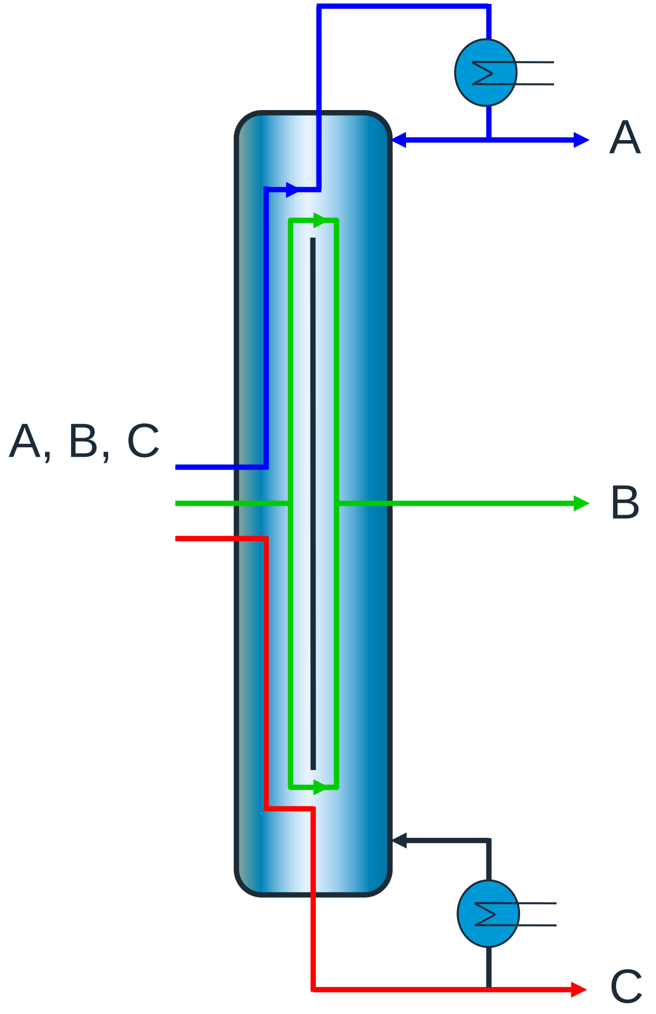
Kister Distillation Symposium

March 16th 2023

Dividing Wall Columns (DWC)

- Potential savings:
  - 20 to 30 % CAPEX
  - 20 to 50 % energy





KOCH ENGINEERED SOLUTIONS

Open Questions? Already Closed!

Revamping a conventional column?

Leakage flows?

Manways on both sides of the dividing wall?

Heat flow through the dividing wall?

Liquid split?

Vapor split?

Thermal expansion?

Installation of dividing wall?

Minimum diameter of a dividing wall column?

KOCH ENGINEERED SOLUTIONS

Case Study 1

Packed DWC

KOCH ENGINEERED SOLUTIONS

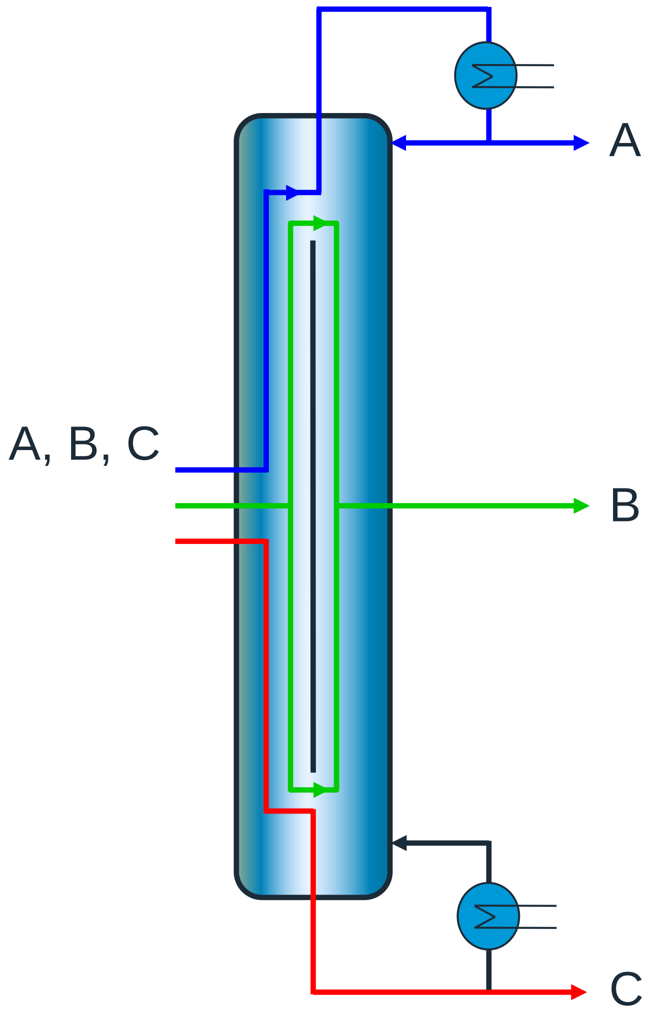
Design Basis

- Recycle of waste stream back into upstream process
- Insecticide products
  - Highly corrosive components
  - MOC: Alloy 59 (Ni-Cr-Mo) & Nickel 201 (>99 % Ni)
  - Temperature sensitive product defined max. system pressure of 45 mbar
- Brownfield installation with max. steel structure 1.5 m x 1.5 m (5 ft x 5 ft)
- Product purity specification
  - Distillate: min. 98.5 wt.-% A
  - Side-stream: min. 99.5 wt.-% B & max. 0.2 wt.-% C
  - Bottom: min. 92.5 wt.-% C & max. 0.01 wt.-% A
- Required scope of supply
  - Concept Engineering & Feasibility Study & 3D installation concept
  - Design and delivery of dividing wall column, FFE, condenser, reflux splitter
  - Installation support and commissioning

KOCH ENGINEERED SOLUTIONS

Simulation Results & First Design

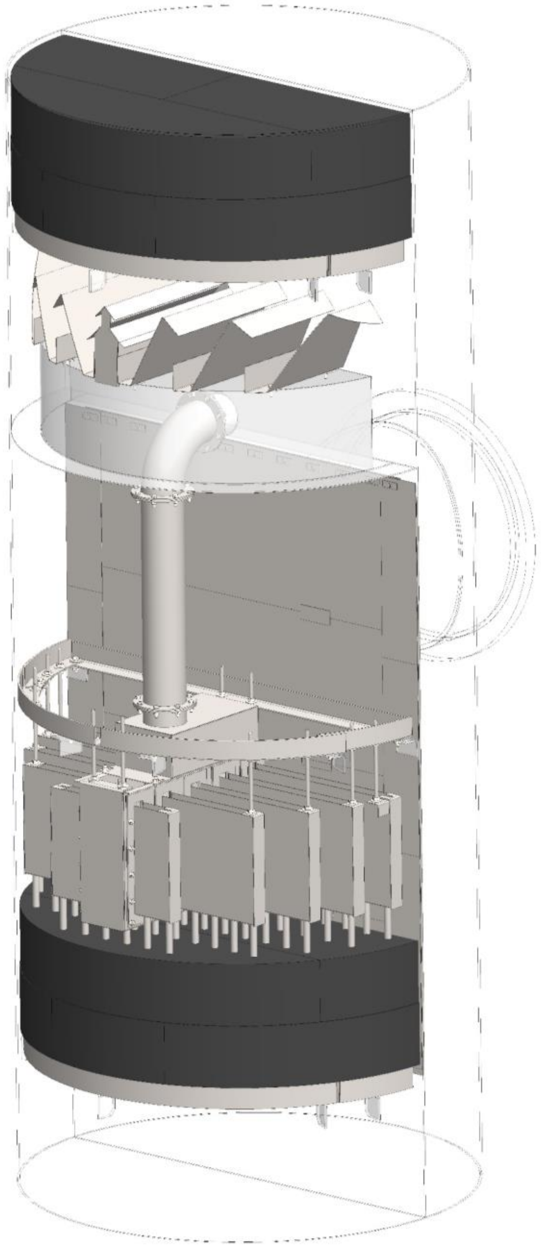
- Simulation based on v_{min} method[1]
  - Hydraulic profile
  - Temperature profile
  - Theoretical stages
- Column diameter 1,200 mm (4 ft)
- Column height 30 m (100 ft)
- Theoretical stages: 76
- High purity requirements
  - Welded or bolted dividing wall
  - No loose dividing wall



[1] Halvorsen, I. J.; Skogestad, S. Minimum Energy Consumption in Multicomponent Distillation. 2. Three-Product Petlyuk Arrangements. Ind. Eng. Chem. Res. 2003b, 42 (3), 605–615.

Bolted Dividing Wall

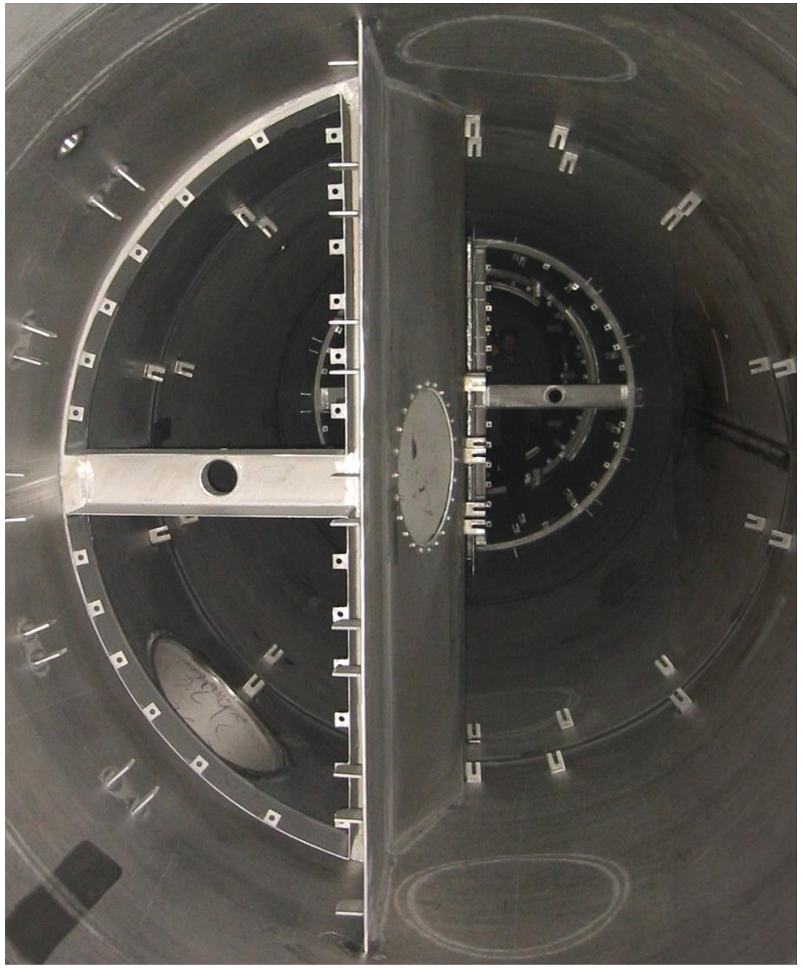
- Challenge for small column diameters
  - Very cramped with welded-in dividing wall
  - Installation of internals risky from a safety point of view
- Compensation for thermal expansion
  - Slotted holes allow thermal expansion
  - Significantly less effort for the column manufacturer



KOCH ENGINEERED SOLUTIONS

Changing Wall Position

- Pressure drop requirements set the wall position
  - Challenge with different vapor loadings
  - Flashing feeds
  - Vapor feeds
  - Vapor side draw-offs
  - Subcooled reflux with condensation
- Changing wall position along the column
  - High knowledge of hydraulic behavior
  - Welded or bolted dividing wall

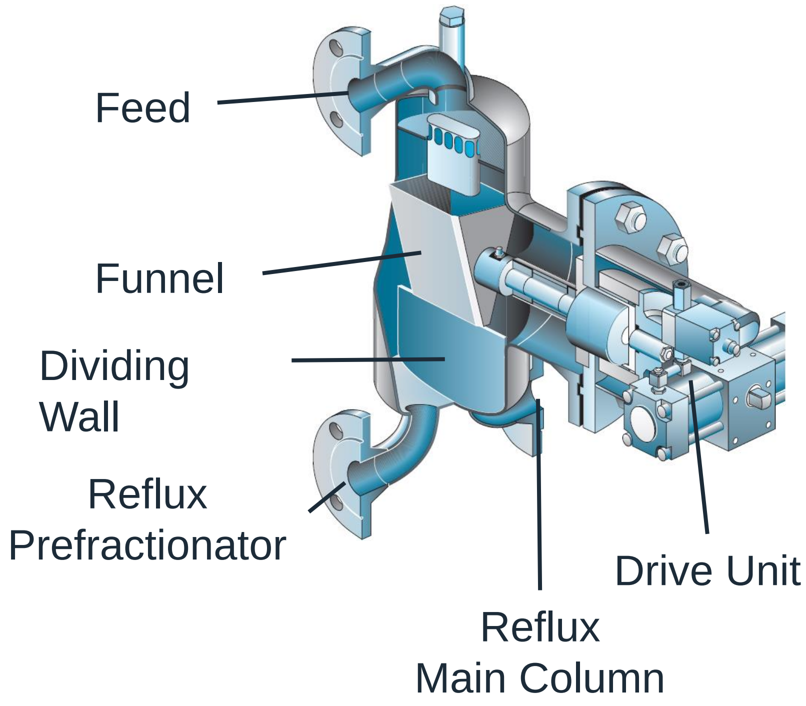


KOCH ENGINEERED SOLUTIONS

Liquid & Vapor Split

- External control of liquid split with Montz Reflux Splitter
  - Constant split ratio at any liquid flow rate due to timing control
  - Operating range 0.1 – 50 m³/h
  - Magnetically coupled drive unit

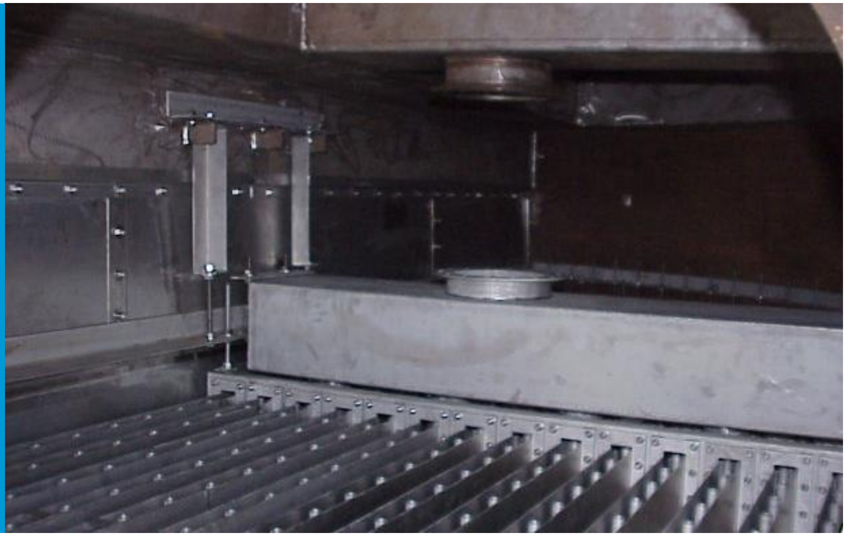
- Vapor distribution controlled by careful design of tower internals
  - Can be indirectly influenced by adjusting the liquid split above the dividing wall
  - No extra device necessary



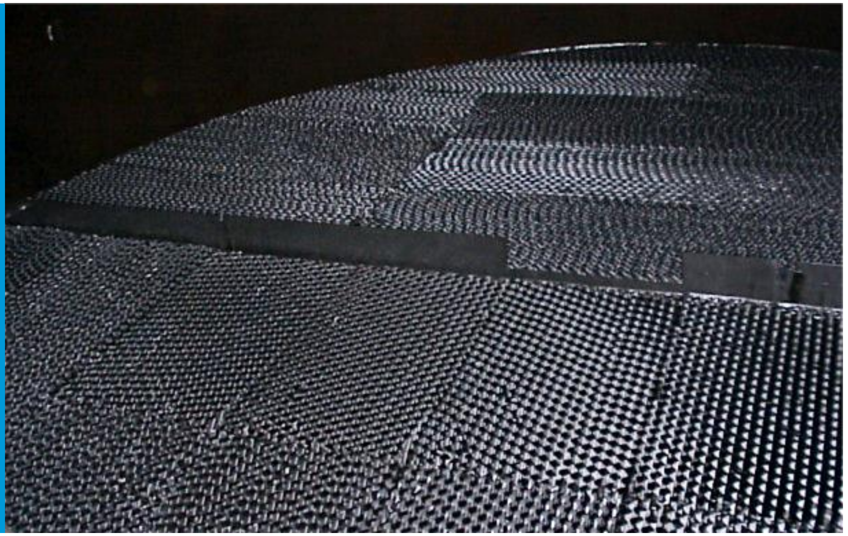
KOCH ENGINEERED SOLUTIONS

Design of Internals

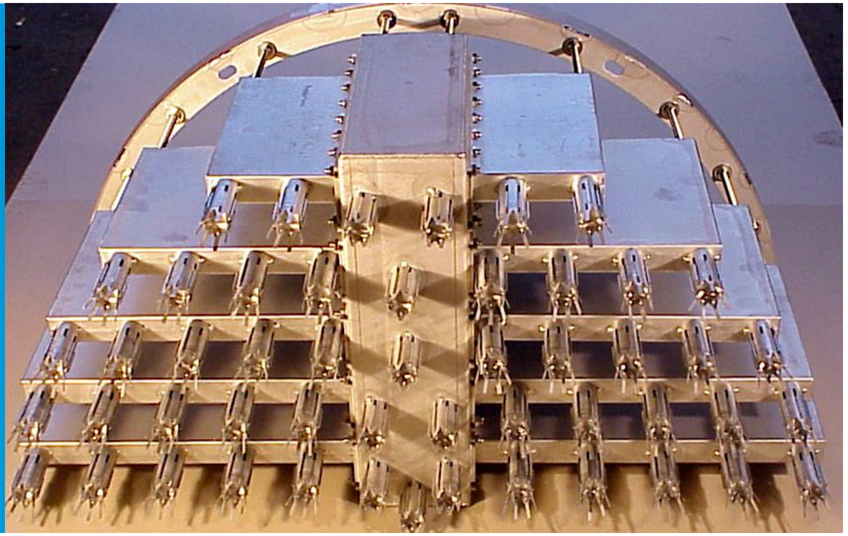
Redistribution Section



Packing Bed



Liquid Distributor



Support Grid

KOCH ENGINEERED SOLUTIONS

Summary Case Study 1

- Column diameter 1,200 mm (4 ft)
- Column height 30 m (100 ft)
- Theoretical stages: 76
- Packing type: A3-500M (FRI tested)
- Dividing wall: Bolted
- Liquid Split: Montz Reflux Splitter
- Specialties: Different wall positions
- Successful in operation since 2019
  - Purity of side-stream 99.8 wt.-% B
  - Specification: min. 99.5 wt.-% B & max. 0.2 wt.-% C

Case Study 2

Trayed DWC

KOCH
ENGINEERED SOLUTIONS

Xylenes Recovery

- Diameter
  - ~12 ft 6 in top (3800 mm)
  - ~14 ft 1 in bottom (4300 mm)
- Scope of Supply
  - Sieve trays
  - Tray blanking above and below dividing wall
  - 51 Trays
  - Liquid splitter tray
  - Flashing feed distributor tray
  - Dividing wall
- Designed for two operational modes

KOCH ENGINEERED SOLUTIONS

Process Design

- Re-use existing condenser / reboiler & maintain same number of trays
- Design variables:
  - Trays above & below dividing wall
  - Location of feed and draw
  - Liquid split at top and vapor split at bottom of dividing wall
- Draw taken as liquid
  - Saves energy
  - Reduces vapor load
- Economics dictated two very different design cases
- Sensitivity cases also run
  - Effect of wall leakage
  - Effect of errors in assumed tray efficiencies
  - Effect of errors in calculated vapor split

KOCH ENGINEERED SOLUTIONS

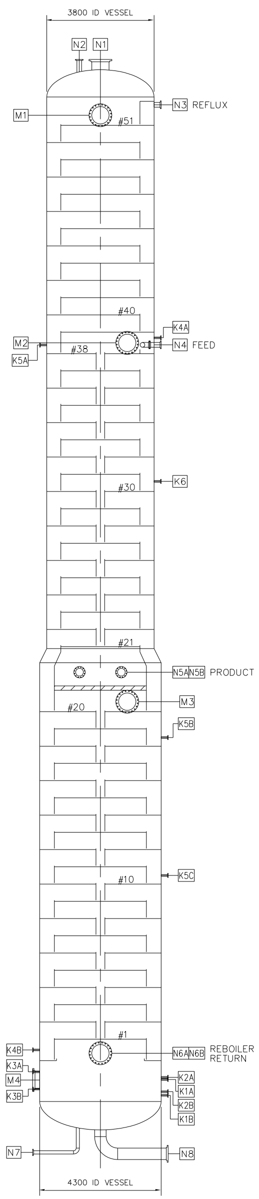
Sensitivity Analysis Results

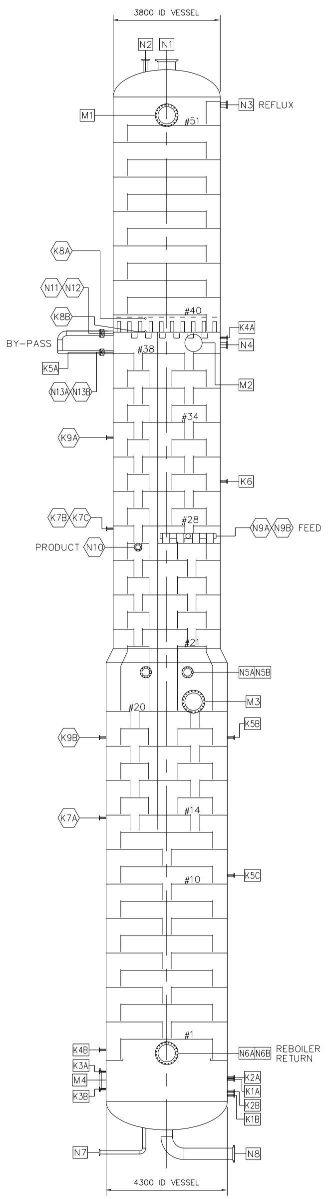
- Seal of wall only critical around the feed and draw
  - They are directly adjacent to each other
  - Potential for short circuit
- Varying liquid split at top of wall required to operate at all design conditions
  - Also mitigates errors in vapor split
- Reasonable errors in tray efficiency will not jeopardize performance
- Key finding
  - Errors in vapor split prediction can be corrected by varying liquid split
- Case 1: Energy savings of over 50%
- Case 2 operation (higher feed rate): Energy savings of over 25%

KOCH ENGINEERED SOLUTIONS

Hydraulic Design

- Design not severely challenged by capacity
  - Trays at ~80% flood at the max throughput case
- Operability was primary concern
  - Tray design optimized for each section of column
  - Sieve trays chosen due to extensive data on Δp
- Offset of dividing wall key to obtaining proper vapor split and balanced floods
  - Perpendicular to downcomers
- Simplicity of design also an issue
  - Re-use of tray rings and downcomer bars
  - Existing trays above and below dividing wall checked and re-used with some blanking

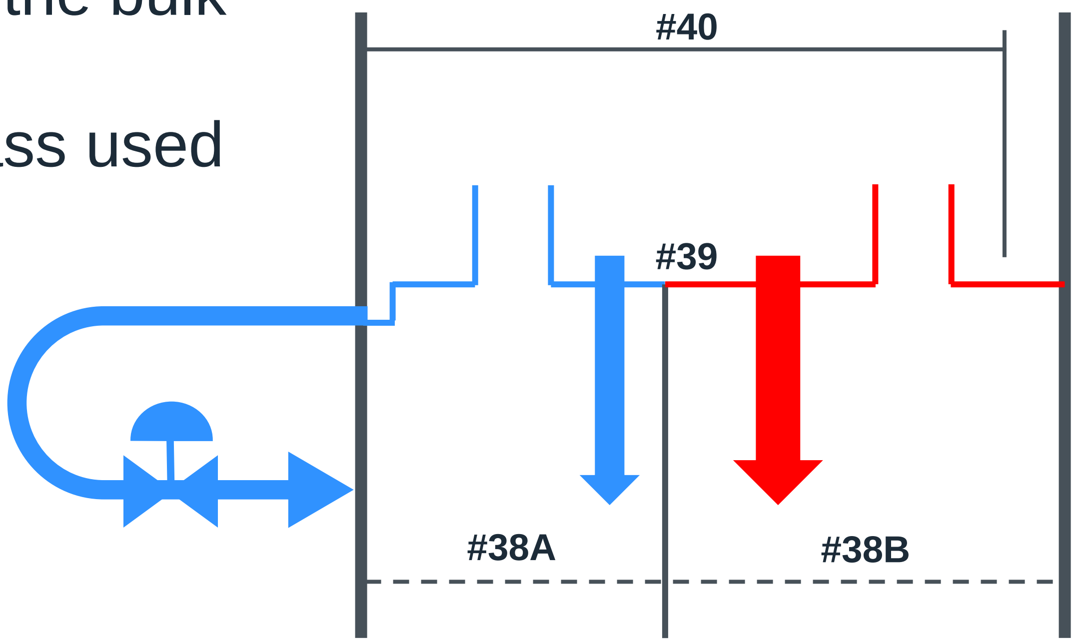




KOCH ENGINEERED SOLUTIONS

Liquid Split above Dividing Wall

- Hybrid liquid split design at top of wall
  - Internal splitter tray #39 meters the bulk of the liquid flow internally
  - Controlled external gravity bypass used to trim the split



- Adjusting liquid split indirectly controls the vapor split below the dividing wall
  - More liquid flow to 'A' side ⟶ More vapor flow to 'B' side

KOCH ENGINEERED SOLUTIONS

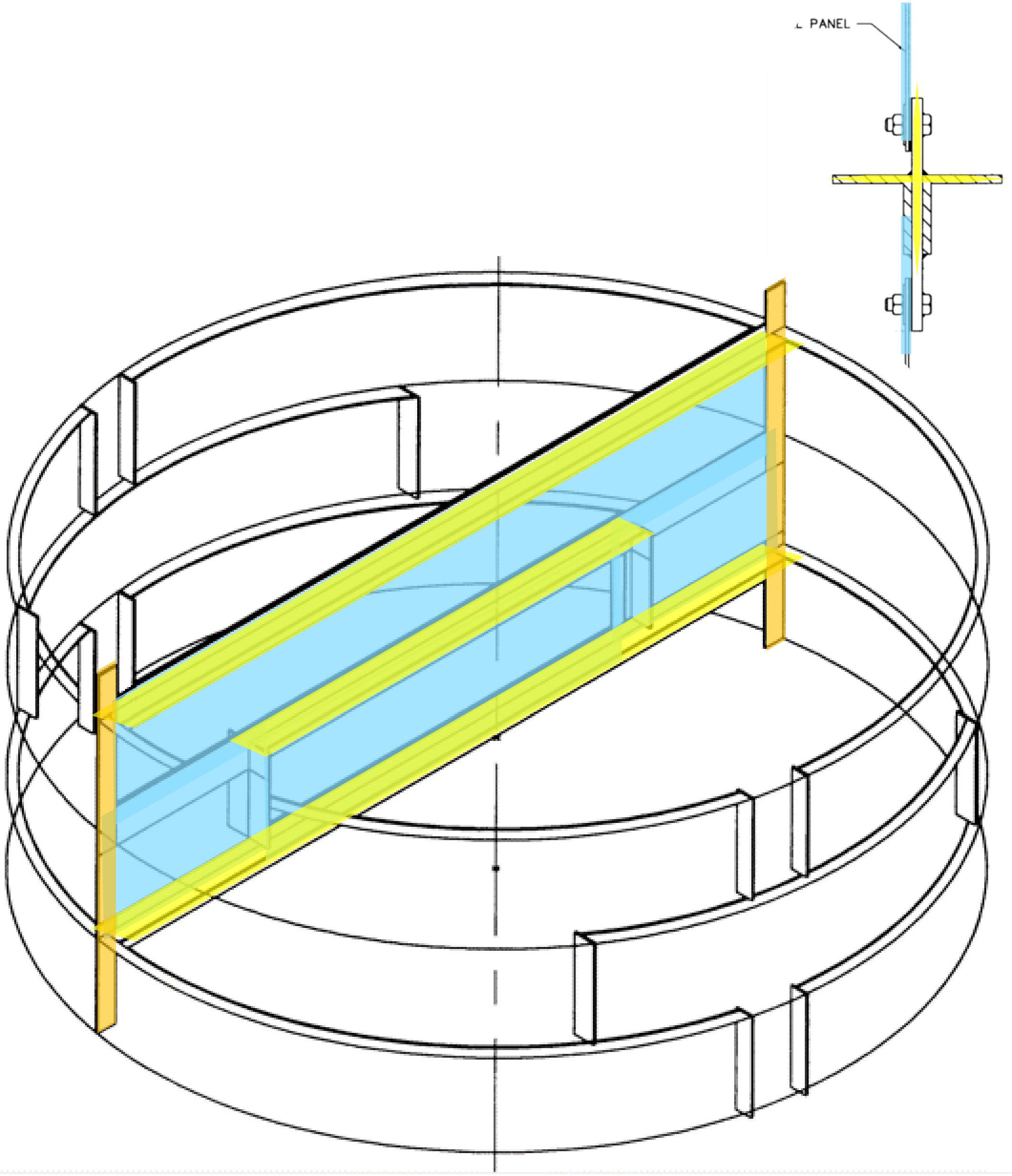
Mechanical Design

- Dividing wall has a critical mechanical design
  - ~57 ft tall (17 m) / ~8800 lb (~4000 kg)
  - Revamp schedule
    - Needs safe and quick installation
  - Must provide adequate sealing
  - Provides horizontal tray support ledges
  - Includes side downcomer bolting bars
    - Vertical support bars
  - Boxed center downcomers at the dividing wall
    - Simplifies attachments
    - Reduces heat transfer across wall

KOCH ENGINEERED SOLUTIONS

Mechanical Design

- Bolt bars to support dividing wall on each side of the column
- Cruciform support members welded between bolt-bars to provide support ledges for trays
- The Dividing Wall sections were bolted between the bolt bars and cruciform sections
- Seal welded in vicinity of the feed and draw-off trays
  - Most critical zones where leakage must be minimized



 |

Installation & Operation

- Performed safely and on-schedule by Koch-Glitsch
  - Surrounded by live plant
- Hot work restrictions at times
- Existing energy balance control scheme was retained
  - Temperature control point relocated to below the Dividing Wall

- Column operation was very stable
- Column responded as expected to external bypass
- Test runs confirmed performance goals met at all operating conditions

KOCH ENGINEERED SOLUTIONS

Conclusions

- Koch-Glitsch / Montz has supplied equipment for over 200 dividing wall columns

- For almost all process and mechanical challenges there are already proven solutions on an industrial scale available

- **Dividing Wall Column is a State-of-the-Art Technology**

KOCH ENGINEERED SOLUTIONS

Important Notice

The information contained in this presentation has been prepared for information purposes only. You should conduct your own investigation and analysis of Koch Industries, Inc., Koch Holdings, LLC, Koch Engineered Solutions and/or their respective affiliates (each a, “Koch company” and collectively, the “Koch companies”) and the information set forth in this presentation. No Koch company makes any representation or warranty as to the accuracy or completeness of the information in this presentation and shall have no liability for any other representations or warranties (express or implied) contained in, or for any omissions from, this presentation.

Without limiting the foregoing, this presentation includes certain statements, estimates and projections with respect to the anticipated future performance of one or more Koch companies. Such statements, estimates and projections reflect various assumptions concerning anticipated results, which may or may not prove to be correct. No representations are made as to the accuracy of such statements, estimates or projections, and the Koch companies have no obligation to update any such information.

You agree that all of the information contained in or divulged during the course of this presentation is confidential and that you will not disclose such information to any third party and will use such information only for your internal review purposes.

KOCH ENGINEERED SOLUTIONS

Thank You!

KOCH ENGINEERED SOLUTIONS