WHAT IS AFPM WEBINAR SERIES?

• As we embark in developing The Summit, Excellence in Plant Performance, there will be more opportunity for member engagement

• There will be one webinar a month until the August Summit:

  May 20 - 21, 2020 - “Learning Teams” - A Two Part Series
  - Michael Vopatek, Maintenance Manager, LyondellBasell
  - Sahika Korkmaz, Senior Human Performance Advisor, Chevron
  - Chelsea Miller, Human Performance Advisor, Chevron

  June - Gasoline Processing

  July - Operational Planning, Control & Automation Technologies
GIVE US YOUR FEEDBACK!

• Please fill out this quick survey:

https://www.surveymonkey.com/r/XTNB3SB
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- 30 years experience in design, troubleshooting, revamping, field consulting, control and startup of fractionation processes and equipment
- Author of 3 books, distillation equipment chapter of Perry’s Handbook, distillation chapter in the Kirk-Othmer Encyclopedia of Chemical Technology, over 120 articles
- Taught the IChemE-sponsored “Practical Distillation Technology” course over 530 times in 26 countries
- Recipient of several engineering awards
- BE and ME from the University of New South Wales in Australia
- Fellow of AIChE, IChemE, member of the US National Academy of Engineering
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Reboiler Circuits
Part 1: Reboiler Selection

Fractionation Research Inc.
Design Practices Committee

AFPM Webinar April 30, 2020
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Introduction

Tower bottoms and reboiler circuits should be considered as key tower internals.

Overall tower performance is dependent on a proper design of both tower bottoms and reboiler.

Taken together they are thought to be the second-most common cause of tower problems.

Example of a complex geometry: Recirculating horizontal Thermosiphon with constant head internal baffle.
Reboiler Selection Considerations

- Thermosiphons should be considered first
  - Gravity flow systems – utilize the density difference between the feeding liquid and mixed phase fluid in the return
  - Tend to be the most economical
    - Compact – smaller heat exchangers
    - Minimum plot space for vertical exchangers
    - Require no pumps
  - Low to moderate fouling tendency
  - Low residence times
  - Most widely used type in distillation
- Not applicable to all systems
  - High liquid viscosity (>10 cP)
  - Heavily fouling systems
  - Adequate driving head not available
  - Large operating load variation
  - When high reliability is critical

Thermosiphons can sometimes be problematic in vacuum where small liquid head variations largely impact the boiling point, leading to large & head-dependent preheat zone in the reboiler. Can be mitigated by a constant head and good design.
Circulating Vertical Thermosiphon

Diagram showing a vertical thermosiphon with labels for V (vapor), L (liquid), Bottoms Product, and Heating Fluid.
Circulating Horizontal Thermosiphon
Vertical or Horizontal?

- Literature gives confusing accounts
  - Vertical exchangers predominate in chemical industry
    - Limited in tube length
  - Horizontal are more common in refining applications

- Vertical Preferred
  - Minimum plot space
  - Minimum return piping
  - Fouling process side
  - High pressure process side
  - Less expensive

- Horizontal Preferred
  - Large heat transfer area
  - Minimize skirt height
  - Fouling heating side
  - High pressure heating medium
  - Better access for maintenance
Standard Kettle

Bottoms Product

Heating Fluid
Kettle?

- Kettles are the next most widely used reboiler types
  - Reliability – composition instability & large flow operating load variation
  - Small driving head requirements (smaller skirt height)
  - Ability to handle large surface areas in a single shell

- Kettles have the following disadvantages:
  - High capital cost – low heat transfer rate
  - Not recommended for process fouling services
  - Not recommended for high viscosity liquids
  - High residence time
Forced Circulation?

- Forced circulation – the reboiler feed liquid is pumped through either the tube side of a vertical or shell side of a horizontal exchanger

  - High heat transfer rate
  - Good for high viscosity liquids
  - System of choice for fouling systems
  - Good for instability type systems
  - Additional operating and capital cost
    - Pump – cost, maintenance, sparing
    - Controls
    - Piping, valves
    - Additional skirt height for pump NPSH
  - Safety – potential for leaks and fire
Internal Reboiler?

- Internal reboiler – exchanger tubes are submerged either in a tub or liquid bottom sump inside the tower
  - Not widely used
  - Clean system
  - Low heat transfer
  - Low surface area
  - Mechanical design of internal supports and vessel flange must be considered
  - Additional tower height
  - Difficult to maintain – access only through vessel

- Advantages:
  - Low capital cost – no pressure vessel, no process piping
  - No plot space
Reboiler Circuits
Part 2: Tower Bottom Arrangements

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Design Practices Committee

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Recirculating Vs. Once-Through

- In once-through, bottom tray liquid traverses through reboiler once

- Recirculating portion of the reboiler effluent mixes with the reboiler feed
Circulating Vertical Thermosiphon

![Diagram of a Circulating Vertical Thermosiphon]

- **V**: Vapour
- **L**: Liquid
- **Heating Fluid**
- **Bottoms Product**
Circulating Horizontal Thermosiphon
Once Through Thermosiphon Trapout
Once Through Thermosiphon Trapout

V < 0.3 L_{in}

L_{in}

Bottoms
Product

L_{out}
Once Through Thermosiphon Trapout

Colder

Bottoms
Product

One Stage
Once Through Thermosiphon Trapout

Bottoms

Product

Little Liquid

Reboiler Starved
Once Through Thermosiphon Trapout

Diagram showing a thermosiphon trapout system with labels for Little Liquid, Reboiler Starved, Bottoms Product, and N.C.
Once Through Thermosiphon Collector Tray

Bottoms
Product
Once Through with Baffle

N.C.

Bottoms
Product
Preferential Baffle

From Reboiler

To Reboiler

Bottoms Product
Constant Head with Reboiler Baffle

Reboiler Return

Bottoms Product

To Reboiler
Constant Head with Reboiler Baffle

Reboiler Return

Short Circuiting

Bottoms Product

To Reboiler
Constant Head with Reboiler Baffle

- Reboiler Return
- Splash
- Leakage
- Bottoms Product
- To Reboiler
Constant Head with Reboiler Baffle

- Reboiler Return
- Splash
- Leakage
- Bottoms Product
- To Reboiler
- N.C.
Standard Kettle
Standard Kettle

Correct Force Balance
- Entrainment
- High Residence Time
- Fouling
- Expensive

Heating Fluid

Bottoms Product

V
Trapout Kettle

Optional

Heating Fluid

Bottoms Product

Product
Trapout Kettle

- Optional
- Heating Fluid
- Correct Force Balance
- High Residence Time
- Fouling
- Expensive

Bottoms Product
If Trapout NOT Chimney tray…
Leakage
Reboiler Starved
Undersized Draw

Optional

Heating
Fluid

Correct Force Balance
High Residence Time
Fouling
Expensive

Bottoms
Product
Poor Vapor Return Orientation
NOT RECOMMENDED

Bottoms Product
Vapor Return Through Downcomer
NOT RECOMMENDED

Bottoms Product
Questions?

Reboiler Return

Bottoms Product

To Reboiler