Improving Light FCC Product Recovery

Eric R Hutchins
Chemical Engineer
Process Consulting Services, Inc.
Houston, Texas
EHutchins@Revamps.com

Presentation Overview

• Basic principles
• Potential problems areas
• Design considerations
• Provide insights based on global Process Consulting Services experience – Articles
• Facilitate interactive discussion
• Broad audience speaker dilemma

• Don’t start with solution – understand problem
Presentation
Take-Aways

• Get out of your office and measure what is actually happening in the field
  – Everywhere we go we see more and more people trying to troubleshoot their units from the comfort of their air-conditioned offices (Example – DHDS)
• P3>P2>P1
• The newest high-tech widget is not always the best solution
Basic Principles
Product Fractionation

- Product fractionation is controlled by liquid/vapor ratio (L/V) in each fractionation section
- The number of fractionating trays or amount of packing is important
- But without adequate reflux (L) fractionation will be poor
- Location and amount of heat removal set L/V
- Heat balance determines fractionation assuming column internals operating correctly

Column Internals
General

- Valve and sieve tray are used in most new FCC designs by all licensors
- Structured packing and grid is primarily used for revamps, although a few new units have been designed with packing
- Structured packing has been used for more than 30 years in the Main Column and Gas Plants
- Poor liquid distribution single biggest cause of poor packing performance
Packing Benefits/Debits

- Reduced pressure drop
- Higher capacity than trays
- More expensive
- As a revamp tool it is unmatched; replacing a column is very expensive

Fractionation Efficiency

- Well designed trays that are not flooding have an efficiency of ~ 65-70%
- Structured packing (0.5” crimp) has approximately a 24” HETP assuming good liquid and vapor distribution
- Packing efficiency is primarily a function of liquid distribution
- Poor liquid distribution can increase 0.5” crimp HETP from 24” to 10 feet! Yes, 10 feet!!
Wet Gas Compressor System

- Compresses main column overhead gas to gas plant operating pressure
- Maintains reactor pressure and raises outlet pressure so C₅’s and lighter can be recovered using cooling water
- Higher gas plant operating pressure improves C₃ recovery but increases compressor discharge pressure and power consumption

Gas Plant Operation

- Primary absorbers recover the C₃’s and heavier
- Strippers reject C₂’s and H₂S to fuel gas
- Debutanizer, C₃/C₄ splitter and gasoline splitter separate the stripper bottoms for downstream processing and/or blending

- SIMPLIFY
- GET OUTSIDE - SURVEY
- DEFINE - WHAT ARE YOU TRYING TO ACCOMPLISH?
Primary Absorber

- Temperature, pressure and L/V affect C₃’s and heavier recovery
- Minimizing temperature important: inter-coolers and refrigeration are sometime used
- Pressure depends on equipment design
- L/V depends on dry gas rate, gasoline yield and debutanizer recycle
Primary Absorber Liquid

- Main column overhead liquid is the main source of liquid (L) in the primary absorber.
- Recycling debutanized gasoline increases liquid rate, improving LPG recovery by raising L/V.
- The recycle must flow through the stripper and debutanizer, increasing column loadings and reboiler duty.
- When gasoline production is high and dry gas low, C3 recovery is high because L/V is high -- even with no recycle!

Primary Absorber Inter-coolers

- Primary absorber lean oil absorbs gases.
- Latent heat of absorbed gases increases the liquid temperature.
- As temperature rises the liquid absorbs less gases.
- Inter-coolers reduce temperature increase allowing more gas to be absorbed.
- Adding an inter-cooler increases C3 recovery by ~ 3%.
Absorber

Inter-coolers

- Primary Absorber Pre-saturator
  - Used to increase C₃ recovery
  - Contact the leanest gas with the leanest liquid
  - Temperature rise from gas absorption is eliminated in exchanger reducing absorber lean oil temperature
Maximizing $C_3$ Recovery

- Maximum $C_3$ recovery is ~ 99%
- This requires chilled water or refrigeration
- Next slide shows all the bells and whistles used to increase $C_3$ recovery
Chillers and Pre-saturators

Stripper Column

- Strippers reject C$_2$’s and H$_2$S to fuel gas
- Water can form inside the column due to low feed temperature OR
- Free-water can be present in the feed
- If free-water forms or is in the feed then column capacity suffers
- At low column loading, water can be tolerated, and at high loadings it cannot
Stripper -- Sources of Water

1. Other streams
2. Water in feed
3. Some water leaves with overhead
4. Properly designed water draw
5. With no water draw, water must leave with bottoms

Primary absorber

Poor water/oil separation

Entrained water

Three-phase inlet

Water

Preheat

Sour water

Debutanizer feed

Poorly Designed Water Draw

1. Low residence time
2. No water draw
3. No water/oil

Since the sump has little residence time and because bottom of the downcomer is well mixed, little water is withdrawn to the external pot.
Well Designed Water Draw

Stripper Column

- Minimizing feed temperature and optimizing reboiler duty improves $C_2$’s rejection
- Low feed temperature can lead to water entrapment
- Stripper columns with low feed temperature need a water draw or heat feed
- Trade off reboiler duty and tower loading vs recovery and water problems
General Comments

• Sponge Absorber
  – LCO foams more than heavy naphtha in the sponge absorber
  – Tray spacing is critical
  – “Credibility Precipice”

• Debutanizer
  – Never pack the debutanizer -- all attempts have failed (avoid being next!)
  – WHY?
  – Debutanizer Reboiler Fouling

Debut Shell-side Fouling
Debutanizer Reboiler Shell-side Fouling

- Debutanizer reboiler shell-side fouling is caused by heat source temperature, reboiler design and di-olefins content
- Keeping heat source temperature below 600°F is essential
- Reboiler needs to be designed to minimize phase separation in baffle window

REMEMBER
UNDERSTAND THE FUNDAMENTALS
PRINCIPLES>PROCESS>PROBLEM
GET OUTSIDE AND TEST IT!

THANK YOU