A Fresh Look at 3 Drum Cokers

Coking Safety & Reliability Seminar
Moody Gardens
Galveston, TX
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Outline

- Introduction
  - Common terms & historical trends
- Design Advantages for Adding A 3rd Coke Drum
  - 1. Cycle Advantages
  - 2. Operation Advantages
  - 3. Fatigue Advantage
- Economical Advantages for Adding A 3rd Coke Drum
  - New Coker unit
  - Existing Coker unit
- Summary & Conclusions
Why do Coke Drums fail?

Severe Cyclic Thermal Conditions due to
- Minimal Preheat Temperature
- Aggressive Heat Up Rate
- Aggressive Quench Rate
What do we do to Stop Failures?

◆ Modify Operations
  – Increase preheat temp
  – Control cool down
  – Increase cycle time

◆ Improve Equipment
  – Innovation with new geometry and designs
  – Better materials
  – Manufacturing controls
  – Modify inlet flow conditions

◆ Most efforts are focused on trying to improve equipment because when the operations are modified we slow down the process, lose throughput and profits!

Why Install A 3rd Drum?

◆ Higher than expected maintenance costs
◆ Need shorter drum cycles or more throughput
◆ Severe thermal cycles with a 2 drum unit – Reduce thermal impact
◆ Difficulty producing a design for the full design life
◆ Lower cost and improved reliability
Historical Data & Trends

- Historically – The heat up rates controlled fatigue design
  - Heat up rates have not changed significantly
- Recent Trend – Shorter coke drum cycles
  - Less preheat
  - More aggressive quench

Historical Data & Trends

- Cyclic stresses are produced from large temperature differences between adjacent components
Historical Data & Trends

- Historical Data – Quench Rate

First Advantage
Drum Cycle
2 Drum Coker Cycle Advantage

3 Drum Coker Cycle Advantage

Reduced Number of Cycles per Drum
3 Drum Coker Cycle Advantage

- 2 Drum System
  - 30 Year Life
  - ~15 hr Cycle
  - 9,000 Cycles Per Drum
  - 18,000 Cycles Per Unit
    (9,000 * 2 Drums)

- 3 Drum System
  - 30 Year Life
  - ~15 hr Cycle
  - 18,000 Total Unit Cycles
  - 6,000 Cycles Per Drum
    (18,000 / 3 Drums)

- 1.5 X Life Advantage for 3 Drums (9,000 / 6,000)
  - Each drum experiences 1/3 less cycles over a 30 year period
3 Drum Coker
Cycle Advantage – Example

шение of Coker

- Repairs are Performed After 10 Years

- Identical operating conditions as 2 drum coker
- Would not expect to perform the same repairs until after 15 years (10 * 1.5) due to the reduced number of cycles per drum

Second Advantage
Operations
With a 3 drum coker there is twice the amount of time between coking to perform the following:
- Quench, Dehead, Cut, Rehead, Steam Test & Preheat

Possible to block in 1 drum for a short period of time to perform:
- Routine maintenance
- Drum inspection and repair
- Deheading replacement and repair
- Severely damaged drum – possible to operate on 2 drums until next turn around
Third Advantage

Fatigue

3 Drum Coker
Fatigue Advantage – Example 1

Alternating Stress = 0.5*Stress Range
No Stress Reversals

Alternating Stress = 0.5*Stress Range
Full Stress Reversals
3 Drum Coker
Fatigue Advantage – Example 1

+ 60,000 psi  
- 0 psi  
Range = 60,000 psi
Sa = 30,000 psi
Cycles = ?

+ 60,000 psi  
- 60,000 psi  
Range = 120,000 psi
Sa = 60,000 psi
Cycles = ?

3 Drum Coker
Fatigue Advantage – Example 1

- ASME Section VIII Division II Carbon, Low-Alloy Steel
SN Fatigue Curve
3 Drum Coker Fatigue Advantage – Example 1

+ 60,000 psi  Range = 60,000 psi
- 0 psi  Sa = 30,000 psi
Cycles = 23,500

+ 60,000 psi  Range = 120,000 psi
- 60,000 psi  Sa = 60,000 psi
Cycles = 2,500

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3 Drum Coker Fatigue Advantage – Example 1

- Exaggerated Skirt Displacements (10X)

Coking Heat-up
Quench Cool-down
3 Drum Coker
Fatigue Advantage – Preheat and Quench

2 Drum Coker
15 hr Coke Fill Cycle
15 hr Window

3 Drum Coker
15 hr Coke Fill Cycle
30 hr Window

Preheat Temperature
Quench Rate

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3 Drum Coker
Fatigue Advantage – Example 2

9 Cases are evaluated using the typical skirt to shell juncture

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Increasing the preheat has a small effect on the stress range since most stress in this region is due to coke being introduced into the vessel.

Reducing the quench rate has a large effect on the stress range since the reversal is directly affected.

Stress Range = Heatup Stress - Quench Stress

N1 = Number of Cycles for Initial Quench Rate
N2 = Number of Cycles for Target Quench Rate
Cycle Ratio = N2 / N1
Total Est Life Extension = 1.5 \cdot \text{Cycle Ratio}

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<th>Target Rate</th>
<th>Cycles</th>
<th>Cycle Ratio</th>
<th>Drum Factor</th>
<th>Total Est Life Extension</th>
<th>Existing Life (yr)</th>
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Economical Advantages for Adding a 3rd Coke Drum
3 Drum Coker Economics Advantages – Assumptions

- No Escalation
- No Inflation
- Production Losses - $10 Million
- Estimated Maintenance Costs - $28 Million / Life of Drums

3 Drum Coker Economics Advantages – Assumptions

New Coker

- Entire 2 Drum Coker Unit $1.38 billion
  - Upstream Process Units, Coke Drum Area, Coke Pit, Coke Handling and Conveying System & Downstream Process Units
  - Coke Drum Structure Portion $180 million
    ▲ Drums, Foundations, Bottom Unheading Device (BUD), Top Unheading Device (TUD), Drill Derricks, Jet Pumps & Piping

- Additional 3rd Drum $80 million
  - Drum, Foundation, BUD, TUD, Drill Derricks & Piping
3 Drum Coker Economics Advantages – Assumptions

Existing Coker

- **2 Drum Coker Replacement** $70 million
  - News Drums, Remove Derricks, Remove Drums, Remove Associated Piping, Remove TUD, Remove BUD, Replace Drums, Replace Derricks, Replace Associated Piping, Replace TUD & Replace BUD

- **Additional 3rd Drum** $90 million
  - Drum, Foundation (pre-T/A), BUD, TUD, Derrick, Piping & Tie-Ins During T/A

3 Drum Coker Economics Advantages – Assumptions

- **Typical Coke Drum Maintenance Cost**
3 Drum Coker Economics Advantages

- New Installation

- Existing Installation
3 Drum Coker
Economics Advantages – Summary

- **Initial Investment VS. Long Term Savings**

<table>
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<th>Modification to Existing Unit</th>
<th>New Unit</th>
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<td>Initial Investment</td>
<td>-$90MM</td>
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<tr>
<td>Long term savings 1 Drum Replacement</td>
<td>+18MM</td>
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<tr>
<td>Long term savings 2 Drum Replacement</td>
<td>+$127MM</td>
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- **Once all factors are considered both cases can be shown to provide long term savings**

3 Drum Coker
Summary & Conclusions

- **3 Drum Coker Advantages**
  - Reduce the need to spend additional money on improved equipment designs
  - Ability to increase throughput without severely impacting the thermal cycle
  - More time between drum cycles for operations
  - Reduced maintenance costs and drum replacements
  - Ability to block in 1 drum for maintenance or repairs
  - Substantial fatigue live advantage by adding 1 drum to the cycle and reducing the thermal impact
  - Over the life of the unit the 3rd drum will pay for itself due to reduced maintenance costs and drum replacements
  - Improved reliability
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