Reliability Ranking and Life Extension of Coke Drums

Bobby Wright, PE
Charles Becht V, PE

We Solve Problems
Engineering From An Owner’s Perspective
Introduction

- Coke Drums are batch operated, the reliability and profitability are heavily influenced by how they are operated every day.
- US coker operation today is heavily influenced by “opportunity” crudes and running 10-16 hour cycles.
- Industry needs:
  - an approach for ranking and optimization of process & operations versus reliability and profits
  - a tool to allow better planning for maintenance, TAR and capital spending at the refinery and across many different sites.
  - Reliable life extension of the coke drums and entire unit
Why Coke Drum Reliability Matters
Approach - Critical Factors

- Estimated drum life is set by a combination of critical factors, specific for each drum.
- Critical factors are needed for different drum regions:
  - Shell - girth seams
  - Skirt-to-shell junction
  - Skirt
- Factors:
  - Design, maintenance and inspection practices.
  - Operations and Process – switch and quench severity
  - Observed damage – existing condition
- Critical factors drive assessment predicts and extends useful life of the drums (If you actually do something!)
Critical Factors Cause Cracking and Bulging
Approach with Site Personnel

**1. Reliability, Safety and Profitability**

- **SME’s** - process, operation, inspection, mechanical for site review
- “Actionable” plan for inspection, maintenance and repairs
- Proactive planning maintenance and capital spending
- Optimize daily operations versus drum damage
- Present operating & process practices condition
- Measure local stresses and temperature gradients - HMS
- Reliability “score” ranking provides guidance on damage
Critical Factors - Process and Operations

• Operating review is not just about data – it is an opportunity to **Optimize Process and Improve Daily Operation**
  • Steam and water flow rates are reviewed and optimized for both operation / process efficiency and to reduce damage, cracking, and bulging.
    – Allow better conversion of feed, minimize hot spots
    – Improve consistency through better understanding
    • Inconsistent switch and quench procedures can cause significant stress and fatigue damage in shell and skirt.
  • Measuring “actual” drum thermal gradients and strain gauges is imperative.
    – Accurately measure local drum response, linked to operation.
    – Evaluate effect of inlet types: side, dual, bottom, center.
    – Relate operations to stresses & damage.
• Closing the loop by teaching and training “inexperienced” operators.
Axial Strain: Skirt-to-Shell Junction, 0 deg

Time (minutes)

Temperature (°F)

Microstrain

Thermocouple and Strain Gage Locations
Critical Factors – Switch Temperature

Preheat/Switch Temperature Effect
Critical Factors - Operating Data

Temperature at Start of Fill
Average Cycle = 458.4°F
Critical Factors – Improved Quench

(from PDVSA)
Pulling It Together

- Critical factors are combined to estimate fatigue life
- The combination is based on calibration to numerous case histories
  - Time to initial cracking and bulging
  - Time to first through-wall crack
- Maximize the reliability of the drums and minimize the lost opportunities
  1. **Provide near, mid, long-term** recommendations TAR(s)
  2. Reduce cyclic stress magnitude, damage, going forward
  3. Strategic and proper mechanical repair of damage
Case History - Drum Assessment Tool

1. Idea is that there are defined stages of coke drum life
2. Analysis tested/ultimately calibrated against industry and Becht data
3. Critical Factors: Shell, cone and skirt, welds, switch and quench, cracking, bulging, cycle length, coke type, inlet nozzle type, thickness etc.

- **Stage I: Minor Problems**
  - Proactive maintenance
  - Baseline and routine inspection

- **Stage II: Predictable Crack Growth**
  - More inspection
  - Planned repairs
  - Additional shutdown time required

- **Stage III: Maintenance Intensive**
  - More frequent shutdowns
  - Higher risk of unplanned outages

Goal Planned Spending versus unplanned
Case History - Girth Seam Results

• Results are provided as “quantitative”

• But goal is forward-looking 1-2 TARs out

<table>
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<th>Year</th>
<th>Accumulated Cycles</th>
<th>Retirement Life Fraction Consumed*</th>
<th>Comment</th>
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<td>0.53</td>
<td>TAR</td>
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<td>0.64</td>
<td>Reduce run length to help ensure no through-wall cracking</td>
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<td>0.85</td>
<td>Plan for replacement</td>
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<tr>
<td>27</td>
<td>5585</td>
<td>0.96</td>
<td>Likely replacement</td>
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* Based on retirement cycle life estimate of 5,830 cycles corresponding to no supplemental PAUT/TOFD inspection
Deliverables

1. Process/operations GAP analysis and review
2. Inspection/Reliability GAP analysis and review
3. Critical Factors Ranking and Risk Prioritization
4. Things to optimize or improve from 1 & 2
5. Update Best Practices
6. Develop action plan and TAR plan for next 2 TARs
Summary

• **Optimization** of drum performance to meet production, reliability and profitability goals $$$$
• Can **extend** useful drum life
• **Brings people together – Best Practices** Integration of inspection, maintenance, process and operations personnel for better decisions
• **HMS** findings must be continually **updated** and incorporated
• **Proactive** planning for **maintenance, TAR and capital spending** across one or multiple sites based on risk
Special Thanks

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  - 40 years experience – Becht Coker Process SME
  - Formerly BP - Process and Operations SME Coking worldwide

- **Mitch Maloney**
  - 40 years experience – Becht Coker Process SME
  - Formerly ExxonMobil – Process and Operations SME Coking Worldwide

- **Dave Dewees, PE**
  - 18 years experience - Becht Mechanical SME
  - Fatigue, high temperatures, thermal-stress analysis, crack growth

- **Bob Brown, PE**
  - 30 Years experience – Senior Fellow - Becht Mechanical SME and FFS Specialist
  - Fatigue, high temperatures, thermal-stress analysis, crack growth

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  - 30 years experience - Becht Delayed Coking SME
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  - 36 years experience - Becht Materials and Corrosion SME
  - Formerly Phillips 66 - Director Pressure Equipment Mechanical Integrity

- **Chuck Becht V, PE**
  - 15 years experience – VP Engineering
  - Fatigue, high temperatures, thermal-stress analysis, crack growth

- **Bobby Wright, PE**
  - 39 years experience – Becht Manager Refinery Services
  - Formerly Tosco and 29 years coke drum reliability
THANK YOU

Bobby Wright PE
Manager Refinery Services
bwright@Becht.com
281-723-4940

Charles Becht V, PE
Vice President, Engineering
CB5@becht.com
908-727-0976