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# Delayed Coking Operational Optimization

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Coking.com

# Delayed Coking Operational Optimization

## *Foster Wheeler Delayed Coking Best Practices*

- FW employs a three prong approach

  1. Design details
  2. Operational techniques
  3. Operating instructions and training

- Most recommendations are good practice regardless of type of coke produced

Enclosed Slide Valve Bottom Unheading System

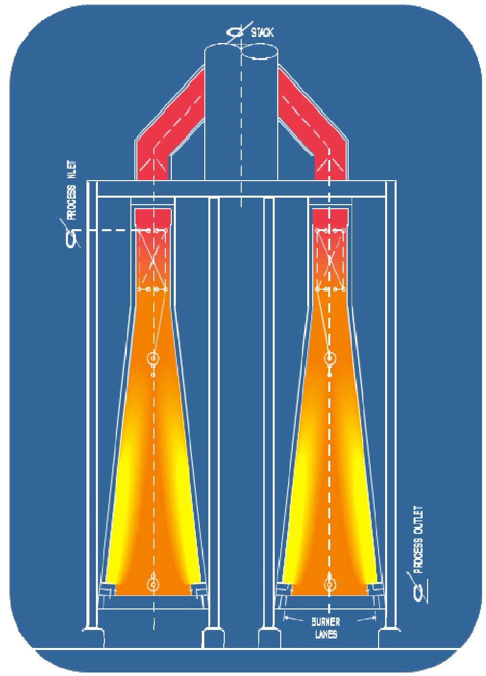
Courtesy of Delta Valve

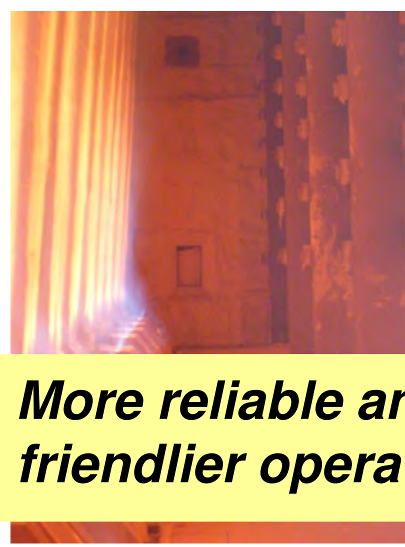
# Delayed Coking Operational Optimization

## *Design Details*

## *Heaters*

- Use of 6-pass double fired coker heaters for larger coke drum module capacities and 3-pass double fired coker heaters for smaller drum module capacities.
- Continually developing new burner technology for lower NOx and optimal flame pattern
- Better on-line spalling procedures; more effective and efficient resulting in increased run lengths. On-line pigging also possible.
- Over 5 years run length between turnarounds
- Fully modularized design for lower installed cost.



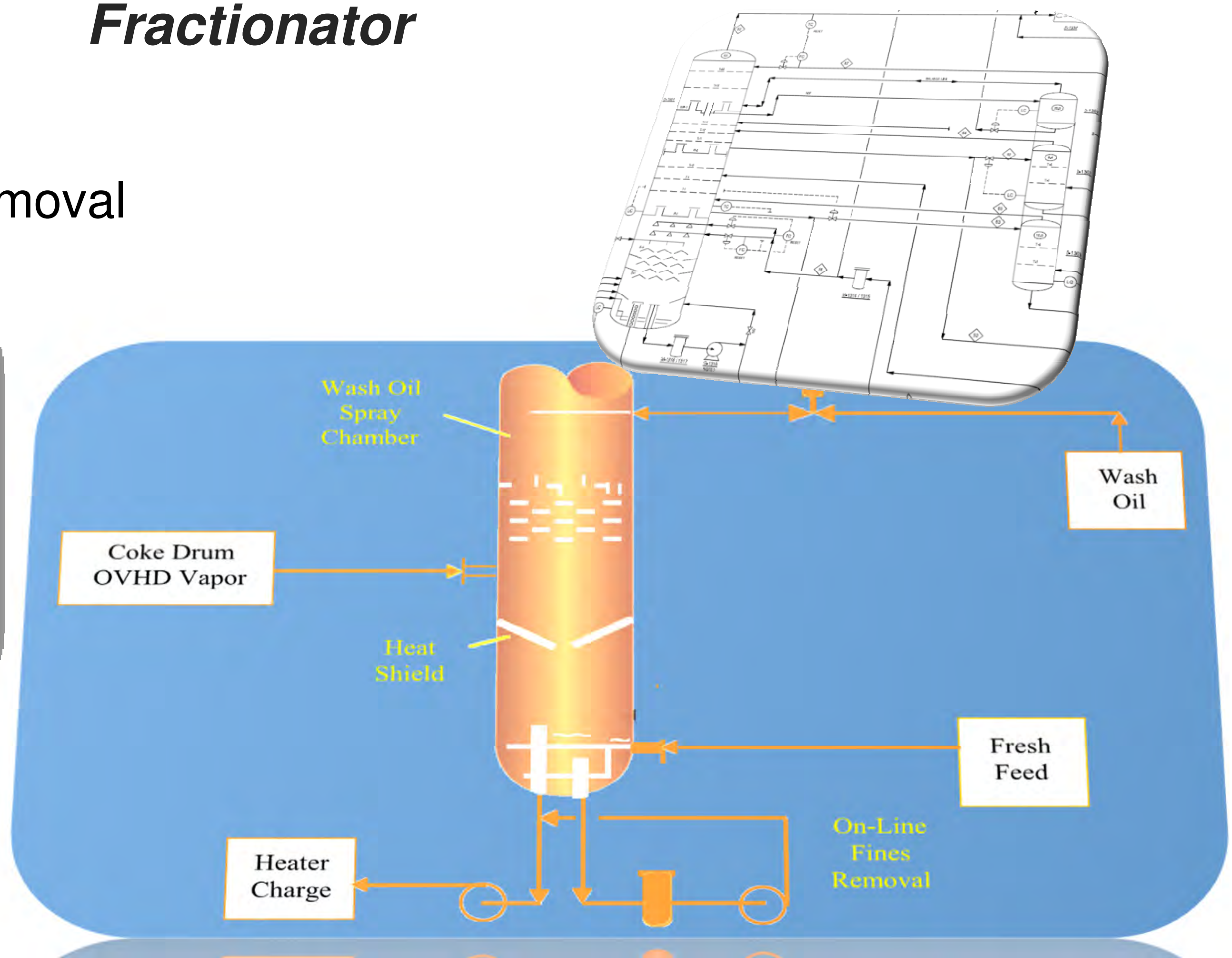
***More reliable and environmentally friendlier operation***

# Delayed Coking Operational Optimization

## *Design Details*

## *Fractionator*

- Water wash systems
- Wash oil spray chamber
- Fractionator bottom fines removal



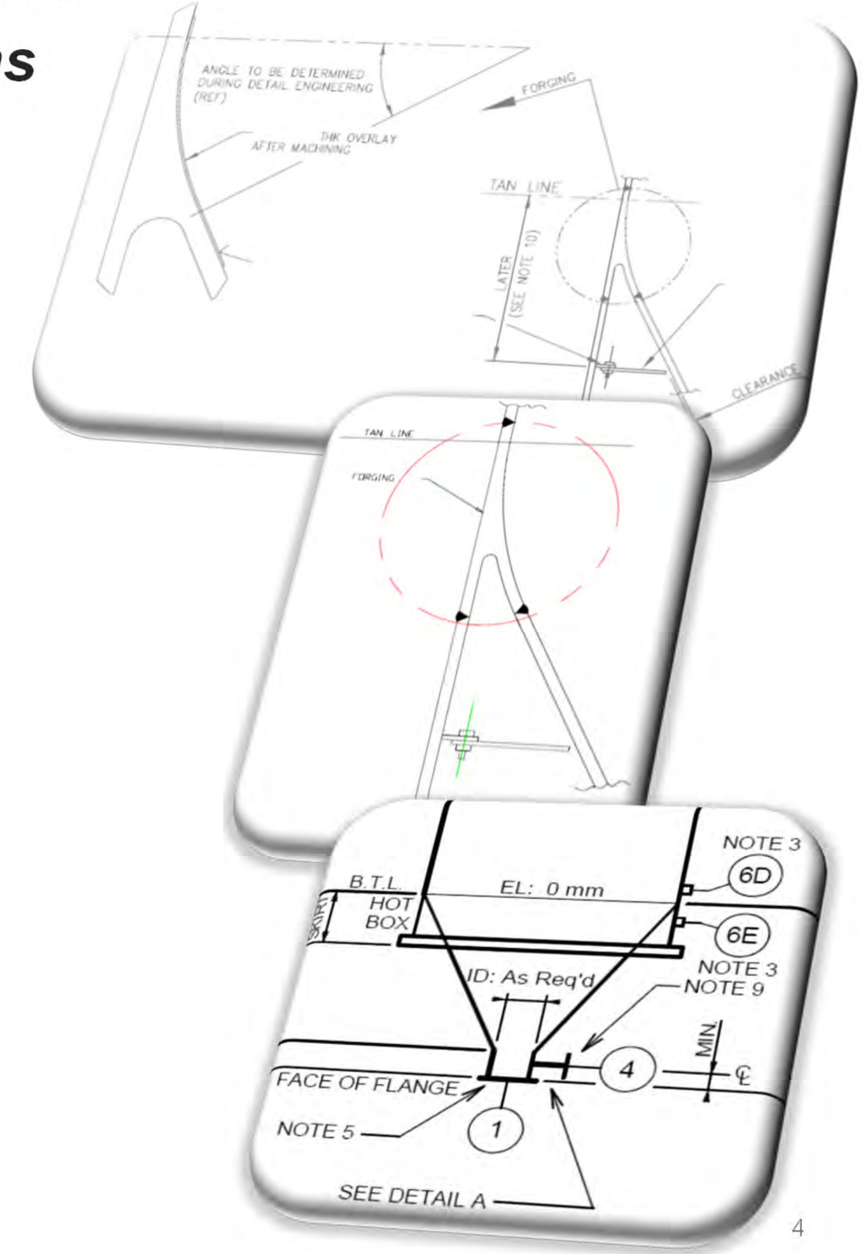

*Increase reliability. Reduce maintenance*

# Delayed Coking Operational Optimization

## *Design Details*

## *Coke Drums*

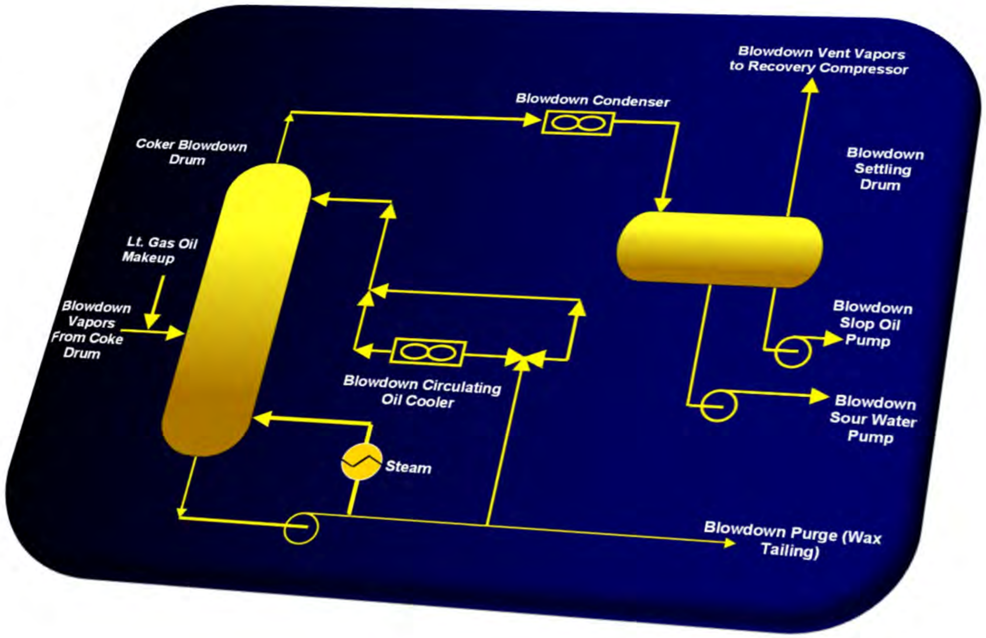
- Single thickness drum wall
- Optimized crotch radius for weld build up hot box cone/straight wall detail
- Integral forged ring skirt design on cone/ straight wall detail
- Use of anchor bolts with disk spring allows base plate flexibility



# Delayed Coking Operational Optimization

## *Design Details*
## *Blowdown System*

- Shed deck trays vs. disc and donut trays
- External steam heater
- Vent Gas recovery
- Wax tailings / Slop backwash to quench




***Easier to operate and maintain***

# Delayed Coking Operational Optimization

## *Design Details*

- Operating station – enclosed, ventilated, line of sight.
- Remote top and bottom unheading
- Remote coke cutting
- Multiple safe & protected egress options with fire barriers
- Water sprays
- Safety interlocks on cutting system
- Drill stem guides
- Top slide valve unheading device, with enclosure for cutting tool
- Coke drum nuclear level detector located to ensure water fill

***Safer to operate***

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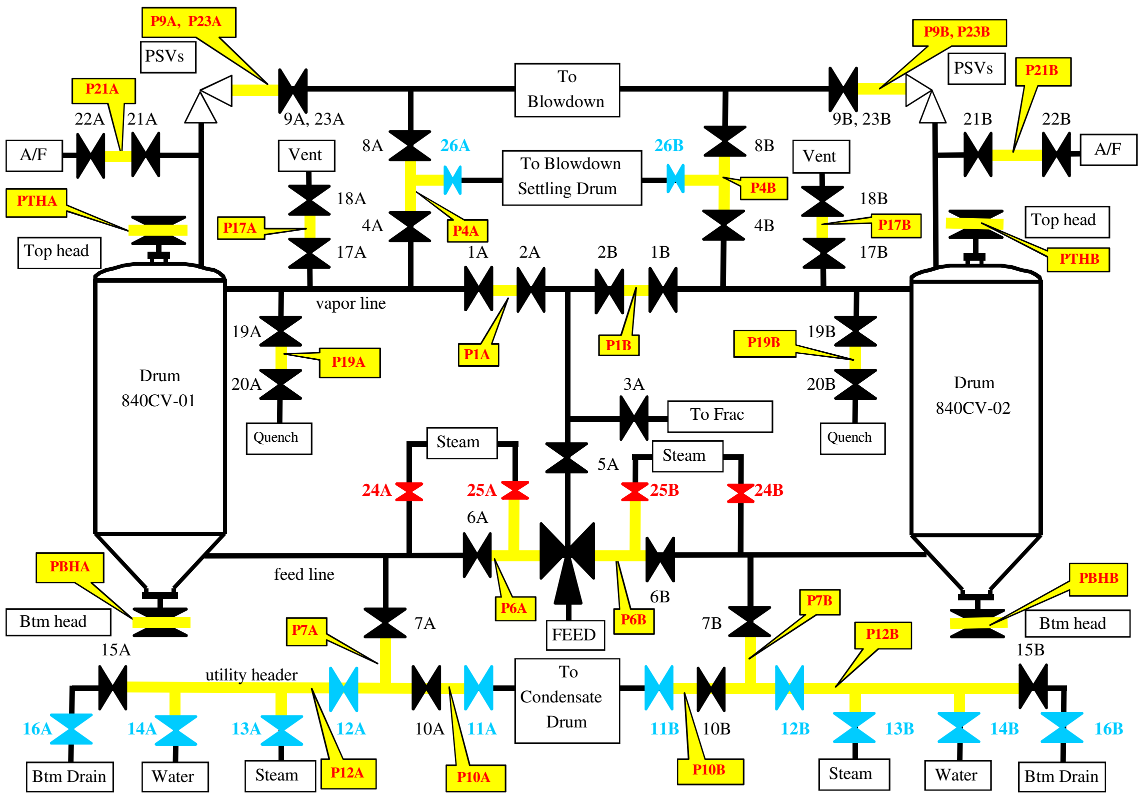
# Delayed Coking Operational Optimization

## *Design Details*

## *Total Automation of Coke Drum Operations*




***Safer to Operate: No scheduled operations on structure deck***

# Delayed Coking Operational Optimization

## *Fouling*

## *Causes*

- Feedstock
  - High sodium
  - High asphaltenes
  - Incompatible crude blends
- Coker Heater
  - Low velocity in tubes
  - Low velocity injection media rate and/or wrong location
  - Excessive temperatures (crossover and/or COT)
  - Poor burner operation
- Coker Fractionator
  - Low overhead temperatures → salting
  - High bottoms temperatures → coking (rare, typically seen with HHCGO product operations)

# Delayed Coking Operational Optimization

## *Fouling Prevention/Mitigation*

- Feedstock
  - Minimize injection of caustic downstream of desalter
  - Ensure crude is well desalted
  - High softening point feeds may need diluent
  - Add aromatic feedstock (slurry / decant oil) to heavy oil residues to dilute fouling properties
  - Limit feedstock sodium to 10 wppm max (15 wppm max peaks)
  - Test feed blends for compatibility
- Coker Heater
  - Double-fired
    - Longer run lengths if processing heavy feeds
    - On-line spalling more effective
    - Better temperature control with individual convection sections
  - Off-line decoking: steam-air, pigging

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# Delayed Coking Operational Optimization

## *Fouling Prevention/Mitigation*

- Coker Fractionator
  - Salting
    - Provide water wash system at the top of the tower
    - Increase overhead product endpoint
  - Coking
    - External quench for HHCGO product draw

# Delayed Coking Operational Optimization

## *Operational Techniques*
## *Furnace Fouling*

Fouling and coking will occur; The best chance to control it is to monitor the heater operations:

- Fouling Monitoring
  - Heater Skin Temperatures
  - Firing Rate (Fuel Consumption)
  - Oxygen
  - Velocity Media
- Process feed changes
  - Rate
  - Quality
- Draft
- O2
- Burner monitoring
- Firing rate/inlet temperature – fouling of upstream exchangers
- Prepare for the eventual decoking operation and use the method best for your situation

# Delayed Coking Operational Optimization

## *Operational Techniques*

## *Furnace Media Injection Rates*

## *Fact or Fiction*

- Never too much steam / condensate injection
- The rate is fixed and does not have to be varied
- Do not need to change injection locations
- Steam or condensate. It does not matter.

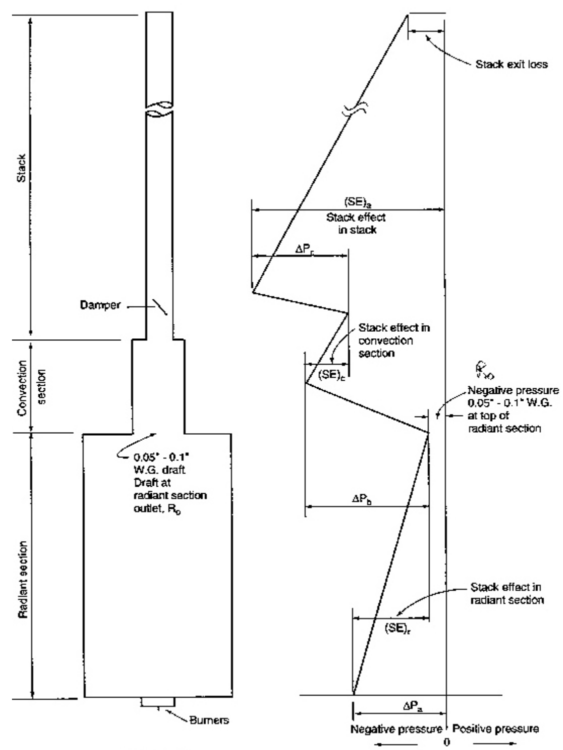
- **Fiction**: Especially with Condensate. It overloads the firing and pumps. No benefits
- **Fiction**: As the feed drops the injection, medium must increase to maintain velocities
- **Fact**: Unless the pumps are at capacity all the injection medium at heater inlet is preferred
- **Fact**: But for spalling condensate is the preferred medium

## *Operational Techniques*

## *Furnace Draft Control*

- Draft should be measured under the first row of convection tubes
- High Draft causes more air leakage and lowers the heater’s efficiency, the higher the draft higher the leakage.
- High draft changes the burner flame pattern-longer flames.
- High draft can cause a heater to be firing/flue gas limited.
- Low draft could mean a positive and dangerous fire box, especially the sight doors

API Publication 535




$(SE)_r + R_o = P_a$
$(SE)_a + (SE)_c = P_b + P_c$ + Stack exit loss $+ R_o$
$\Delta P_a$ = Pressure drop across burners (draft available at burner level).
$\Delta P_b$ = Flue gas pressure drop across convection section.
$\Delta P_c$ = Losses due to damper, stack friction, stack entrance.

Figure 15—Typical Draft Profile in a Natural Draft Heater

# Delayed Coking Operational Optimization

## *Operational Techniques*
## *Furnace Burner Issues*

- Poor flame pattern
  - Draft too high or too low?
  - O2 too high or too low?
  - Burner registers opened/closed?
  - Burner tips plugged?
  - Considerably different fuels?
  - High fuel pressure?
  - Flame impingement?
  - Burners shut off?
  - Air temperature from preheater

# Delayed Coking Operational Optimization

## *Operational Techniques*
## *Coke Drum Quench to Minimize Hot Spots*

- Completely fill with water to about 3 meters above coke bed
- Use slow, optimized quench ramp rate based on experience
- 1/2 to 1 hour soak time
- Track quench and blowdown system water flows to verify that the coke drum is flooded with water
- Maintain controlled back pressure

# Delayed Coking Operational Optimization

## *Operational Techniques*
## *Dynamic Manipulation*

- Increase heater outlet temperature 2 to 3℃ for final 2 hrs before switch
- Switch techniques: maintain forward flow (steam downstream of SP-6)
- Hold switch valve at midpoint for 15 mins during drum switch
- Switch from steamout to quench: continue steam until water enters drum (calculated value)

# Delayed Coking Operational Optimization

## *Operating Instructions*
## *Shot Coke Management*

- Attention to audible & light alarms during structure operations
- All non-essential personnel to be off drum structure
- Do not unhead top until drum is vented & drained
- Be alert for telltales of possible hot spots

# Delayed Coking Operational Optimization

## *Operating Instructions*

- Remain in shelter when the cutting system is pressurized
- Ensure sufficient positive forward flow of steam and/or water as feed is switched
- Use safety precautions when blowing the transfer line clean with steam
- Cutting operators to verify that coke handling operators are notified that coke will be exiting from the coke chute

# Delayed Coking Operational Optimization

## *Causes of Foaming*

- Sudden depressurization of drums
- Inadequate heating / early switch / short cycle time
- Low Coker Heater coil outlet temperature (COT)
  - High fouling tendency or high VCM coke operations
  - Sudden shutdown of burners and relighting
- High velocity in drums
  - Higher feed rate / lower coking pressure
  - Excessive velocity medium / steam purges
- Suspected feedstock
  - High solid / fines content
  - High paraffinic feeds – cracks quicker than aromatic feeds
  - High sodium feeds – can increase the rate of cracking / rate of gas going through the liquids in the drum

# Delayed Coking Operational Optimization

## *Foaming Prevention/Mitigation*

- Design
  - Provide adequate Coke Drum outage
  - Provide adequate Coke Drum diameter (make note of maximum vapor velocity limit)
  - Provide adequate number and type of Coke Drum level detectors
- Operation
  - Optimize antifoam injection –
  - Reduce unit feed rate to reduce vapor velocity in drum
  - Increase Coker Heater coil outlet temperature (COT)
  - Increase/introduce aromatic feed
    - Increase recycle → reduces foam height since recycle is aromatic
    - Add decant oil → lowers feed blend paraffinicity, viscosity, and surface tension but not enough to do away with silicone injection

## *Foaming*

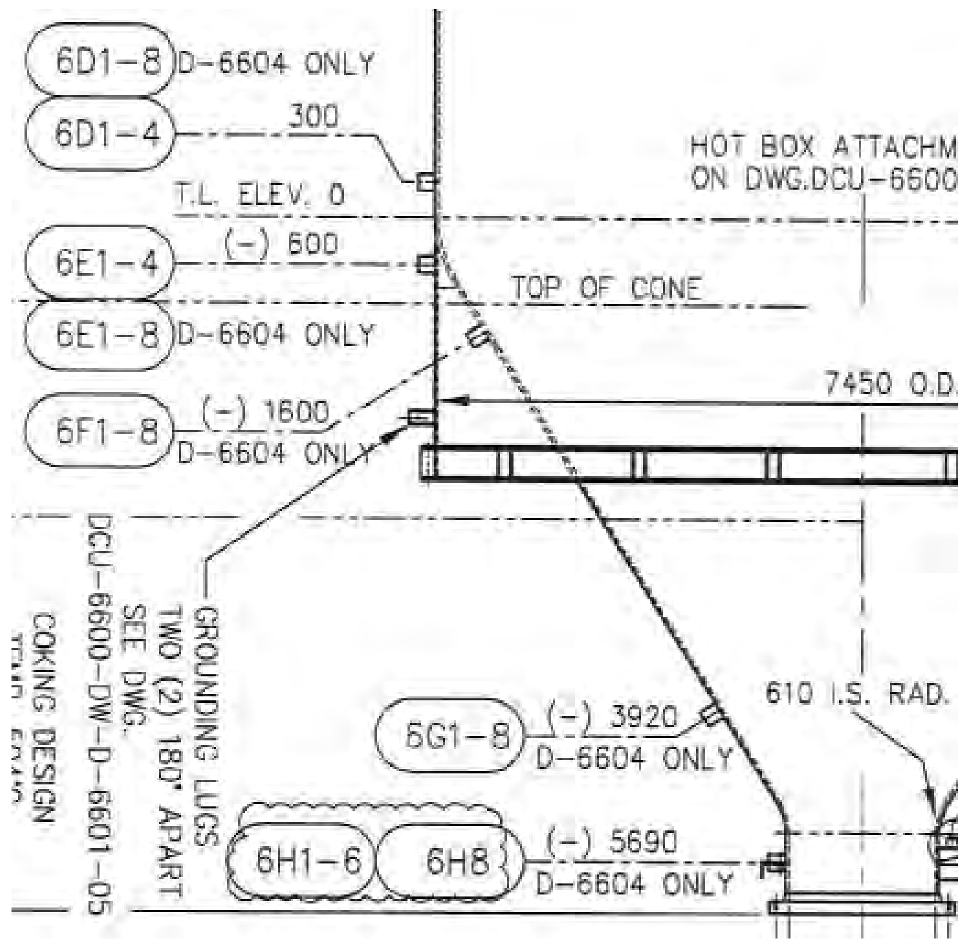
## *FW Guidelines for Antifoam Injection*

- FW guidelines for injection rates and flows
  - 50% injection at 2 hours before switch / 80% of gamma level range
  - 100% injection at 80% of gamma level range
  - Continue injection until steamout to Blowdown operation and Coke Drum pressure has stabilized

# Delayed Coking Operational Optimization

## *Cycle Time Optimization - Minimizing Thermal Stress*

- Long slow quench ramp
- Automated quench programs (step versus ramp)
- Maximize preheat (minimum coke drum skin temperature)
- Coke drum TI monitoring program
  - Additional 32 TI's
  - Monitor gradient (coking & quench)
  - Monitor max temperature differential

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# Delayed Coking Operational Optimization

## *Cycle Time Optimization*

- Unheading
  - Manual (more time required than automatic)
  - Automatic
  - Remote operation
- Automated Cutting Systems
  - Vendor supplied (Flowserve and Ruhrpumpen)
- Pressure Test
  - 15 minutes minimum even with slide valves
  - Ensures that water vaporized from drum walls during depressure
  - Minimize water going to coke condensate and blowdown
  - Too much water may lead to pump cavitation
- Drum Switch

# Delayed Coking Operational Optimization

## *Maximization of Distillate Yields*

- Coker yields are dependent on feedstock quality, operating conditions, recycle, and cycle time
- Several operational procedures are available to optimize the unit during the coking cycle
- Addition of aromatic feed can be beneficial in some cases
- Additive study applications are still in development

# Delayed Coking Operational Optimization

## *Maximization of Distillate Yields*

- Crude type / source
- Feedstock quality
  - TBP cutpoint / distillation
  - API gravity
  - Viscosity
  - Concarbon Residue (CCR)
  - Asphaltenes (heptane insolubules / HIS)
  - Sulfur
  - Nitrogen
  - Metals / ash
- Operating conditions
- Coking cycle time

# Delayed Coking Operational Optimization

***Effect of Operating Conditions***

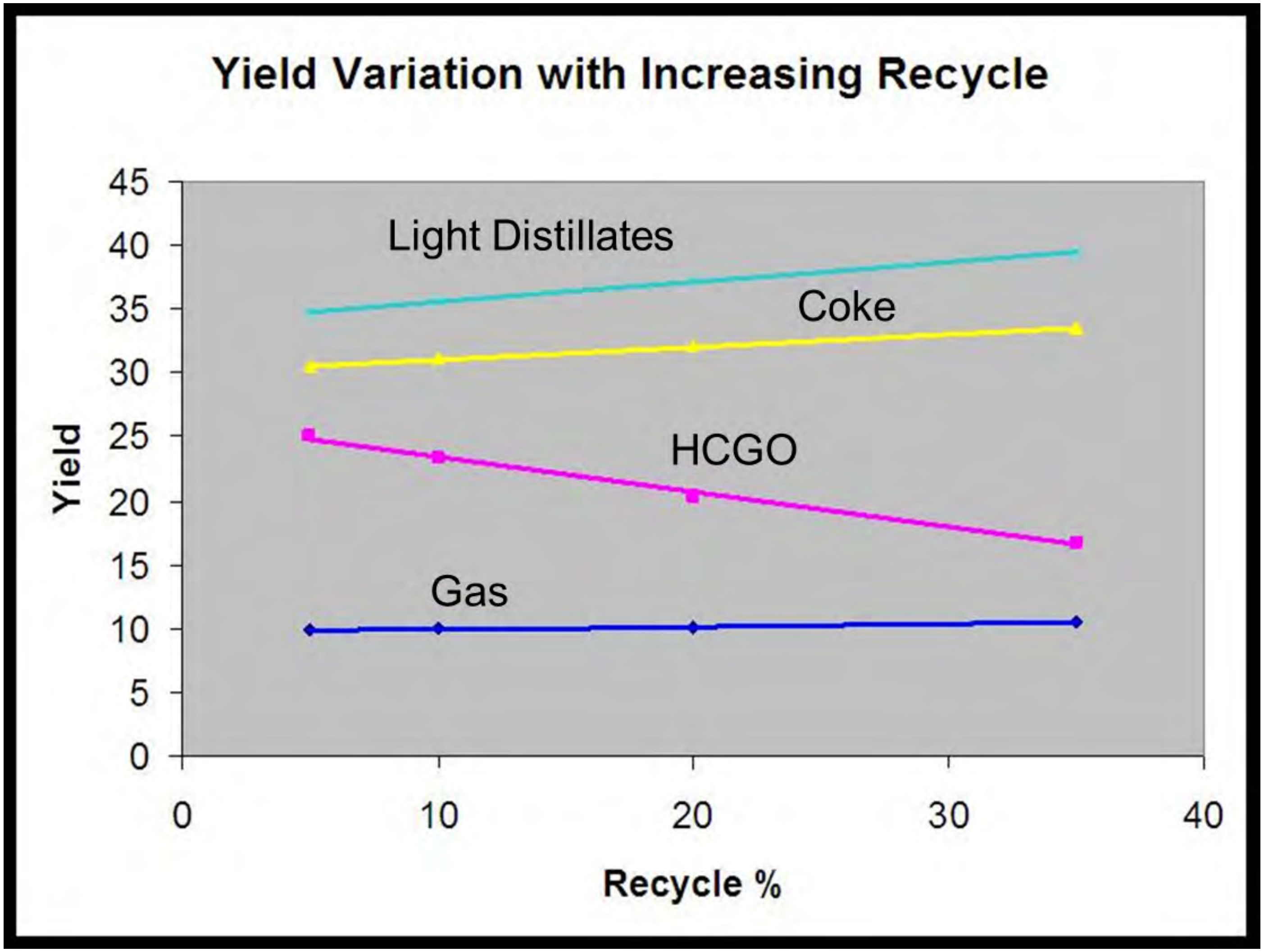
***Rules of Thumb***

- Process Variables
  - Temperature — Higher is better
  - Pressure — Lower is better
  - Recycle — Lower is better, but…

- Lower recycle increases HCGO
  - End point
  - CCR
  - Heptane insolubles (nC7 asphaltenes)
  - Metals (Ni + V)

# Delayed Coking Operational Optimization

## *Impact of Recycle on Yield Distribution*



# Delayed Coking Operational Optimization

## *Effect of Coking Cycle Time*
## *Rules of Thumb*

- Range: 12 – 24 hours for fuel grade cokers
- Typical: 18 hours for new, fuel grade cokers
- Usually set by refinery operational capabilities and requirements
- Can use shorter cycles, e.g. 12 hours, for revamp designs to allow for processing more feed capacity
  - Additional stress on Coke Drum
  - Tendency to reduce Coke Drum life

# Delayed Coking Operational Optimization

## *Optimization During Coking Cycle*

- Reaction rates need to be increased using increased temperature to account for limited reaction time; prevents hot spots
  - Ramp up COT by 2 – 3℃, 2 hours before switch
  - Bring COT back to normal, 1 hour after switch
- Coker Fractionator swings during Coke Drum switch and preheat
  - Increase total draw product pan levels
  - Increase HCGO PA temperature (PA steam generator duty varied)
  - Leave switch valve in midpoint position for 15 minutes to minimize heat loss
- Coke Drum Quench
  - Ramp schedule / adequate quench time
  - Water level above coke bed with 30 minute soak
  - Thermal monitoring

# Delayed Coking Operational Optimization

## *Optimization During Coking Cycle*

- Coke Drum Level Detectors
  - Continuous gamma ray – only detects fluid at a level
  - Nuclear point density detector (neutron backscatter / NBS) – can distinguish between coke, foam, and water
  - FW typical design:
    - One nuclear point (density) detector 0.6 m (2 ft) below TTL (cuts off quench water pump on high pressure)
    - One nuclear point (density) mid point between normal coke bed height and TTL (alarm for water fill during quench)
    - Continuous level to cover coke bed height 2 hrs before switch to mid point between normal coke bed height and TTL
    - Bottom nuclear point (density) detector at 25% fill (coke volume)

# Delayed Coking Operational Optimization

## *Coke Morphology*

- Shot
  - High asphaltene feedstock
  - Low pressure / low recycle
  - Max liquid / min coke yields
  - CCR / nC7 < 2
  - 30-50 HGI
  - Fuel grade
- Sponge
  - Low asphaltene feedstock
  - High pressure / moderate recycle
  - Lower liquid / higher coke yield
  - 40-70 (Hvy) / 70-100 (Lt) HGI
  - Fuel / anode grade

# Delayed Coking Operational Optimization

## *Coke Morphology*

- Needle
  - Low asphaltene feedstock / aromatic tar
  - Very high pressure / high recycle
  - 70-110 HGI
  - Coke production operation
  - Electric grade
- "Rules of Thumb" (Fuel Grade)
  - Raise COT 2.8 – 3.9℃ in final hours of coking or for 1% decrease in VCM
  - Raise COT 0.6 – 1.1℃ for one hour reduction in coking cycle time

# Delayed Coking Operational Optimization

## *Training*

- KnowledgeWeb Plus on line training program for Foster Wheeler Delayed Coking Technology is an efficient tool to improve on-boarding of new hires and up-skill existing workers in DCU safety and operations
  - 24/7 Real time access anywhere, anytime with the internet and a browser
  - Customized: Unit / Site Specific
  - Helps to maximize yields by applying the knowledge of the unit designers
  - Helps to improve reliability by incorporating the knowledge and maintenance procedures of the different process equipment.

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