Ethylene Unit Pyrolysis Furnace
Opportunity
& Strategic Improvements

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Pyrolysis Furnace Opportunity & Strategic Improvements

- Furnace layout
- Radiant Coil Elongation
- Convection tube bowing
- Shadow box hot-spots
- U-bend erosion
- Radiant Coil Thermal shock
- Conclusion
Unit 2 Furnace Layout

- 6 furnaces (12 Zones)
- 10 Naphtha Zones & 2 Recycle Zones
- Common Convection Heat Recovery Bank for two zones with Induced draft fan
- Radiant products cooled by quench coolers producing SHP (105 bar) steam
- Effluent sent to Quench Section
1st Opportunity:

Coil Elongation - scenario

- Creep rate is between 60 - 78 mm per year in one zone example
- Coil needs shortening approx. every 5 years
- Recycle zones are fired harder to achieve optimum yield causing higher Tube Metal Temperature (TMT)
Coil Elongation - theory

- Flame impingement
  - burner tip blockage
- Heat maldistribution
  - uneven firing
  - mixture of old & new burner tips
- ASWT
  - average sound wall thickness
  - thicker walls more prone to creep
Coil Elongation -a glance

Creep amount

Tube no.

Maximum limit when shortening

Creep amount

Creep, mm

0
50
100
150
200
250
300
350
400
450

Creep amt
Coil Elongation - current & future mitigation

- Burner tip cleaning and maintenance
- Coil elongation monitoring
- Future:
  - Kubota MERT tubes - lowers TMT’s by increasing heat transfer
  - Auto Excess O2 control - lowers firing needs
2nd Opportunity: Convection Coil Bowing - scenario

- Bottom section of convection bank bowed approx. 30cm
- Cracks at weldment from mixing header to inlet manifold
Convection Coil Bowing - theory

- Zone mainly recycle feed
- Recycle cracking requires higher Coil Outlet Temperature for conversion
- Excess heat recovered in convection
Convection Coil Bowing - theory

- Too much excess heat raises XOT temperature which initiates premature cracking
- Metallurgy limits promotes creep and expansion
Convection Coil Bowing - a glance
Convection Coil Bowing -current & future mitigation

Current

• Stress analysis required on piping and full understanding of metallurgy limits
• Spring hanger adjusted to relief piping stress
• Bowed convection coils replaced
• Secondary steam injection optimized
Future

• Upgrading of crossover and convection material
• Protect convection coils by insulative material
3rd Opportunity
- Shadow Box Hotspots- scenario

- Insulation around radiant outlet replaced and shadow box plates upgraded to SS304 after turnaround
- Hotspots detected on shadow box during thermograph survey
- Shadow Box Hotspots- scenario

- Plates deteriorated and warped
- Some insulation cladding melted
- Insulation material noticed on firebox floor
Shadow Box Hotspots
- theory

- Heat escaping shadow box due to improperly installed insulation
- Gaps existed which allowed heat to escape the radiant box
Shadow Box Hotspots
- a glance

The Past
Shadow Box Hotspots - a glance

The Present
Shadow Box Hotspots
- current & future mitigation

- Insulation stuffed from outside and inside
- Reengineer installation procedure and shadow box plate
Shadow Box Hotspots
- current & future mitigation

- Final assessment of insulation integrity must be carried out each time furnace insulation replaced
SLE U-Bend Erosion - scenario

- Thinning 1mm per year at the inlet sweep bend
- Change U-bend if thickness drops below 3.5 mm from initial of 8.8mm
- Replacement every 3 years
**SLE U-Bend Erosion - theory**

- Erosion main contributing factors include solid presence, material specification and flow path geometry
- Initially, gradual transition in flow section and shallow-angle intersections was enough to mitigate erosion
SLE U-Bend Erosion - theory

Area badly eroded
SLE U-Bend Erosion - theory
SLE U-Bend Erosion - a glance
SLE U-Bend Erosion - current & future mitigation

- Inlet and outlet sweeps alternated to even out erosion effect
- Ultrasonic Thickness Scanning (UTS) to detect thinning and make replacements
- Modify U-bend to increase integrity of pipe inline with increasing flow turbulence
Coke formation is an undesirable feature of the cracking process.
The carbon coats the inside surface of the tubes, increasing in thickness.
The coke layer can reach > 10 mm thickness depending on the type of feedstock and severity.
Radiant Coil Thermal Shock -theory

- The thickness of the coke is a function of the TMT
Radiant Coil Thermal Shock - theory

• Coke layer is hard, relatively brittle, and has a lower coefficient of thermal expansion than the tube metal
• With coke presence during sudden shutdown two things can happen:
  ~ coke falls off - spalling that leads to tube blockage
  ~ coke remains - coil splitting due to it’s faster rate of contraction
Radiant Coil Thermal Shock

- scenario

- 1st Dec 01 power supply interruption due to national power grid
- Steam from utilities lost during power outage
- Furnace damper goes to minimum opening to avoid heat loss
- Bottom air register dampers manually closed
- Radiant Coil Thermal Shock scenario

- Coil temperature drops 100 ~ 200 °C in 1st hour after trip
- Allowable temp. drop is <80 °C
Radiant Coil Thermal Shock

-scenario

• Difference in cooling rate depends on amount of coke and insulation condition
• Coils inspected after temperature almost ambient: ~ 70 coils needed replacement
Radiant Coil Thermal Shock -scenario
Radiant Coil Thermal Shock -scenario
Radiant Coil Thermal Shock Mitigation

- Decoke End Of Run tubes as soon as possible before shutting down furnaces
- Avoid unnecessarily furnace emergency shutdowns
- Ensure reliability of Uninterrupted Power Supply (UPS)
Pyrolysis Furnace Opportunity & Strategic Improvements

Conclusion

- Reviewed Furnace layout
- Reviewed Furnace opportunities
- Reviewed current and future improvement strategies
Pyrolysis Furnace Opportunity & Strategic Improvements

Conclusion

- Implemented improvements to reduce Equipment Opportunity Losses
- Prolonged life and operability of equipment, thus reducing downtime and maintenance cost
- Further opportunities to improve are being evaluated
Thank You