Thermal Kinetics-Dynamics in Delayed Cokers

Delayed Coker History

• Invented by Vladimir Shukhov

• Patented in 1891

• First Delayed Coker-1929 Standard Oil of Indiana at Whiting

• Innovations in equipment design and metallurgy

• Improvements in safety
Delayed Coker Process

Black art?

• Refinery’s most dynamic process
• Batch process in the coke drums
• Multi-variable constrained process
• Non-linear relationships between variables
• Dynamic changes with time
Thermal Reaction Types

• Coker Drum Reactions
  ▪ Thermal kinetic-dynamics
  ▪ Semi-batch environment
    - Thermal cracking, polymerization/condensation reactions
  ▪ Direct Impact
    - Unit yields
    - Coke properties
    - Drum reliability
    - Unit operation dynamic adjustments

• Coker Heater Reactions
  ▪ Steady state thermal kinetic process
    - Except during the drum switches-dynamic reactions

Coke Drum Reaction Path

• Thermal Cracking & Polymerization
  ▪ Two competing parallel irreversible reactions
  ▪ Heavy oil cracks to lighter oils
  ▪ Heavy oil polymerize to semi-coke or pitch
    - Semi-coke or pitch polymerizes
    - Smaller aliphatic side chains attached to the semi-coke crack off as lighter gas products
Statistical Distribution of Reaction Products

- Heavy Oil
- Cracked Liquids
- Pitch or SemiCoke

Boiling Range - °F

Cracking

Polymerization

Theoretical Batch Kinetic Model

- Light Gas
- Liquids
- Pitch - Intermediate Coke
- Finished Coke
- Oil Feed

Time hrs
Coke Drum Thermal Dynamics

- Drum at beginning of filling
  - Heat sink
  - Vapors Condense
  - Cool material collected in the drum
  - Low amount of product leaving the drums
  - First coke in drum-longer residence time

- Drum at end of filling
  - Heater temperature ramping philosophy
  - Coke quality and liquid yields

- Coke drum kinetics strongly time dependant

Foaming Kinetics

- Foamover Occuring
  - Drum filling
    - Drum switch
    - Initial steam stripping (post-switch foaming)
Foam Potential on Different Crude Mixtures

- 10% M100/ 90% Maya
- 100% M100
- 30% M100/ 70% Maya

Drum Overhead Temperature, °F

Shot Coke

- Feed impact
- Hot Spots
- Challenges for operations
- Mitigation options
Drum Cooling Dynamics

- Effects on overall thermal kinetics
- Temperature rate of change
- Impact on drum lifetime

DC-SIM KBC Technology

- Kinetic model calibration
  - No calibration required for design studies
  - May be calibrated to match plant data from existing units
- Predict mode calculates unit behavior with changes in operation
  - Key parameters can be modified
    - Yield predictions
    - Product qualities
    - Drum fill time
    - Quench and wash oil rates
    - Furnace fouling, etc.

- Great advances in our understanding of the complexities of heavy oil thermal dynamics
• We are continuously developing technology, improving our skills and evolving our tools. Therefore KBC is also dynamic!

• “Science and technology multiply around us. To an increasing extent they dictate the languages in which we speak and think. Either we use those languages, or we remain mute.”

J.G. BALLARD
QUESTIONS?