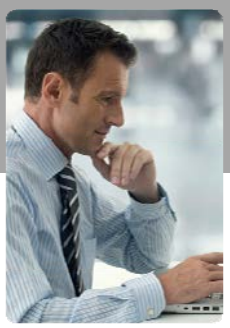
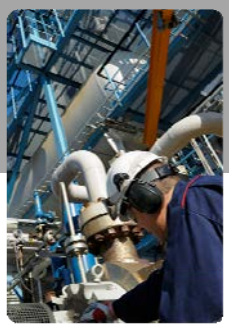




KBC NextGen Performance

Coking.com®

Thermal Kinetics-Dynamics in Delayed Cokers

3rd of May, 2012

Delayed Coker History

KBC NextGen Performance

- 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?

Delayed Coker Process (cont.)

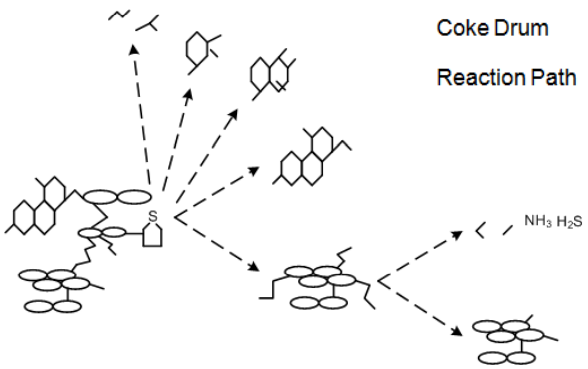
- Refinery's most dynamic process
- Batch process in the coke drums
- Multi-variable constrained process
- Non-linear relationships between variables
- Dynamic changes with time

Thermal Reaction Types

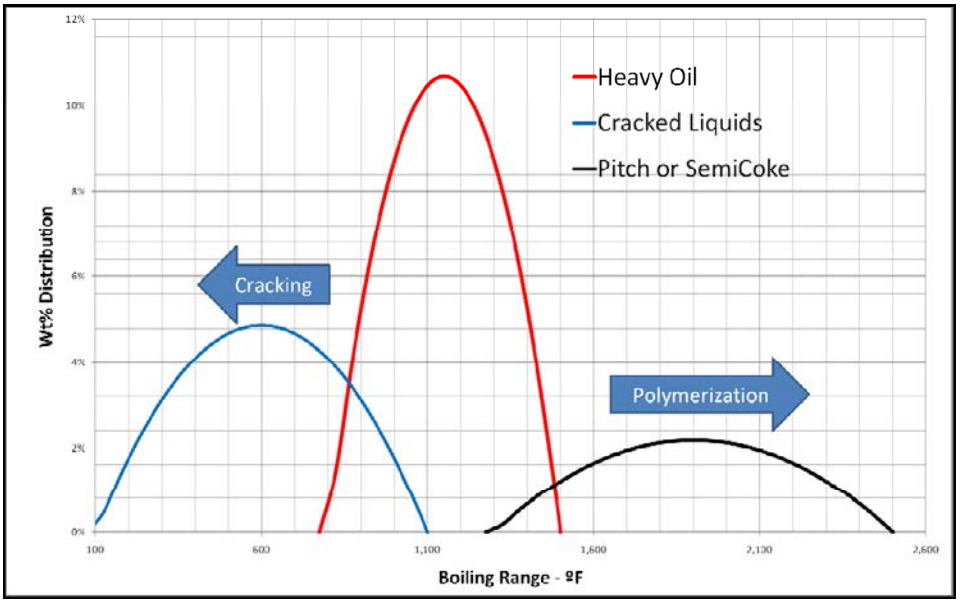
- Coker Drum Reactions
  - Thermal kinetic-dynamics
  - Semi-batch environment
    - Thermal cracking, polymerization/condensation reactions
  - Direct Impact
    - Unit yields
    - Coke properties
    - Drum reliability
    - Unit operation dynamic adjustments
- Coker Heater Reactions
  - Steady state thermal kinetic process
    - Except during the drum switches-dynamic reactions

Coke Drum Reaction Path

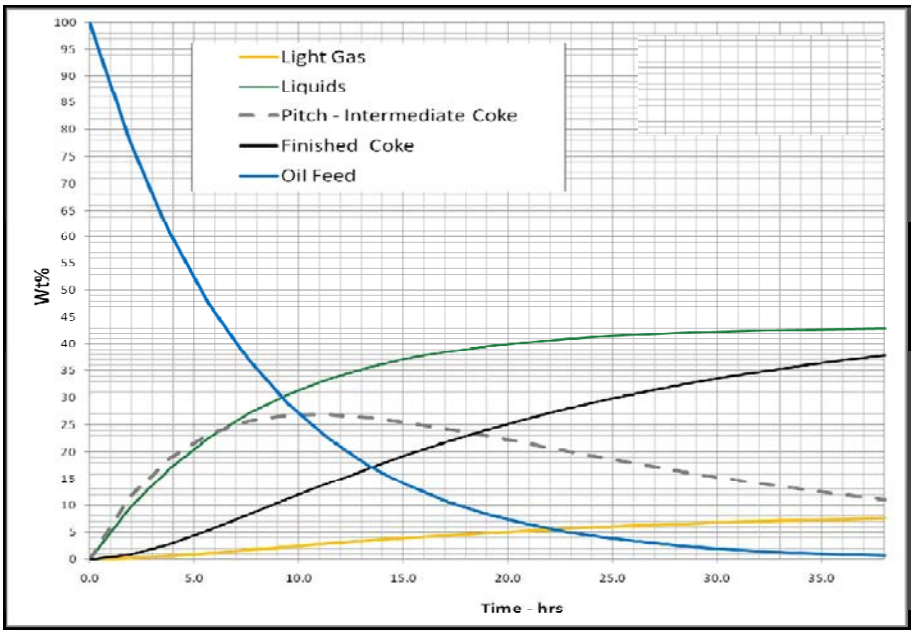
- Thermal Cracking & Polymerization
  - Two competing parallel irreversible reactions
  - Heavy oil cracks to lighter oils
  - Heavy oil polymerize to semi-coke or pitch
    - Semi-coke or pitch polymerizes
    - Smaller aliphatic side chains attached to the semi-coke crack off as lighter gas products



Statistical Distribution of Reaction Products



Theoretical Batch Kinetic Model

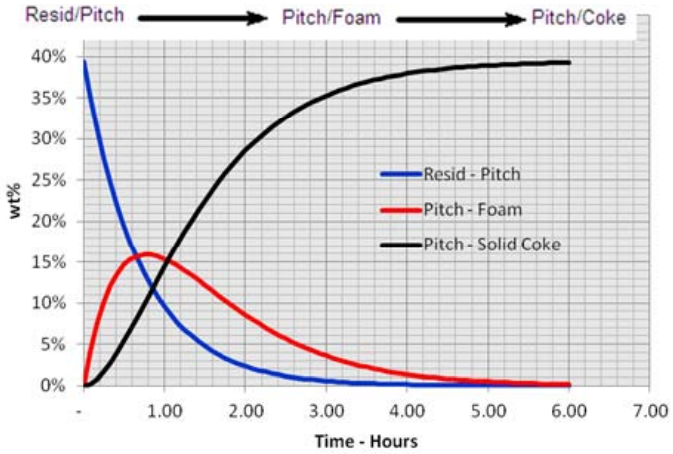


Coke Drum Thermal Dynamics

- 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

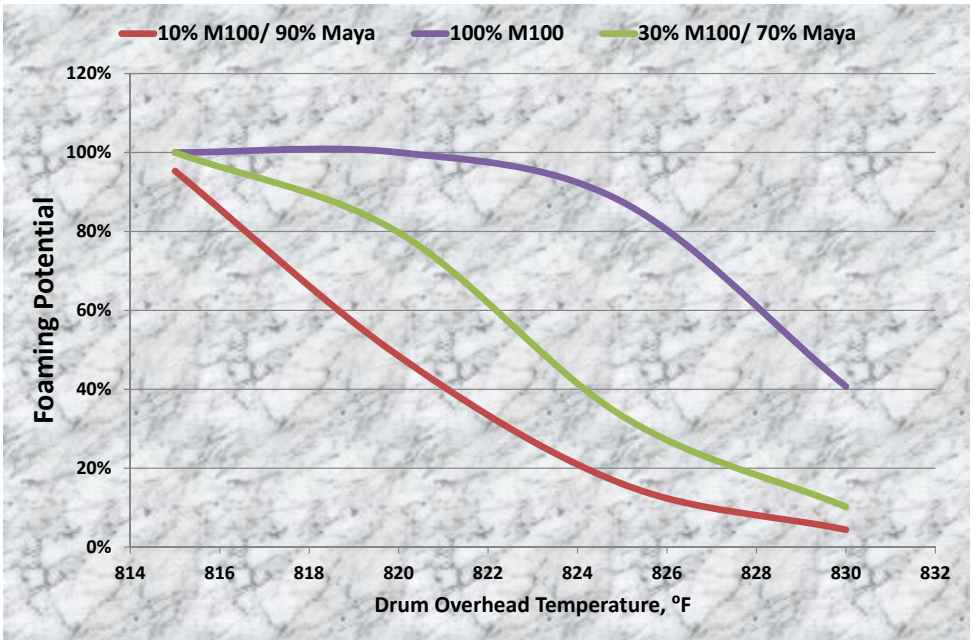
Foaming Kinetics

- Foamover Occuring
  - Drum filling



  - Drum switch
  - Initial steam stripping (post-switch foaming)

Foam Potential on Different Crude Mixtures

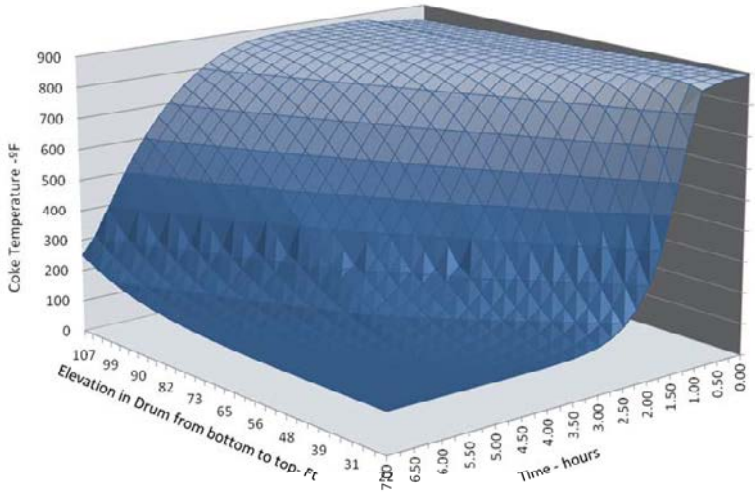


Shot Coke

- 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

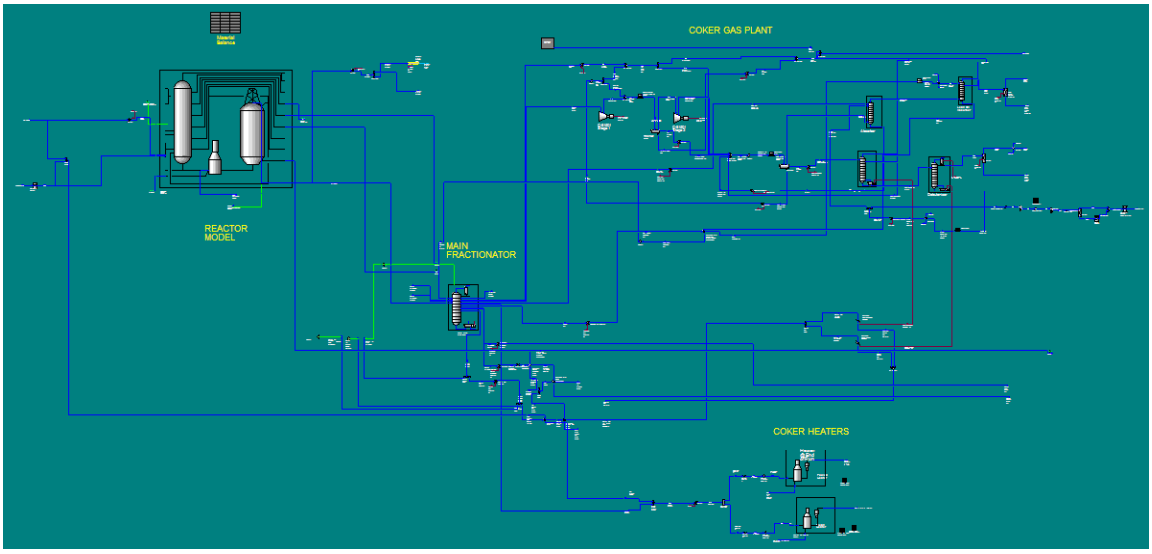


DC-SIM KBC Technology

- 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

Petro-SIM Delayed Coker and Gas Plant



- 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?