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“Finding The Data In The Noise”

A Data Mining Tool for Quantifying Improved Delayed Coker Performance
Agenda

- Introduction to Dorf Ketal
- Challenges in Today’s Cokers
- Dorf Ketal Innovation for Improved Liquid Yield
- Data Mining Approach
- Case Histories
Challenges in Today’s Cokers

- Significant Gap between current Coke Yield and CCR (theoretical min.)
  - COKERMAX™ helps close this gap
- Feed Quality is Poor
  - More Metals
  - More CCR
  - Higher Asphaltene content
  - High Sulphur Content
- More prone to fouling
- Coke Morphology is changing
  - Shot Coke formation
  - Less Profitable
  - Operational Challenges
- More foaming

Source: Solomon Associates 2008 Fuels Refinery Performance Analysis
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Economic Drivers for Improved Liquid Yield

Diesel vs. Coke pricing. Pricing varies by geography. 1% increase of liquid over coke valued at $1 to $1.20 per bbl of Coker Feed in 2014 for USA
Joint Industry Project on Delayed Coking
Research effort to address these challenges

• Project began in 1999 and is on-going. Members include major refining companies.
• Dorf Ketal is a member of this project.
• Improving liquid yield is one of the goals of the project.
• Dorf Ketal invested heavily in finding a solution to challenge of improving liquid yield.
COKERMAX™ Offering

• **COKERMAX™** is a chemical additive that increases liquid yield 1% to 3%.

• **Easy to feed**
  – Inject Additive into Suction of Main Fractionator Bottoms Pumps

• **Demonstrated success at one refinery in China**
  – Liquid yield improvement of 1.4% to 1.5%

• **Lab design and protocol to test your feed for liquid yield improvement**
  – Product selection, dosage range, liquid yield improvement
  – Predictive tool for full scale results

• **Data Mining Services to quantify impact of COKERMAX™ on liquid yield**
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Need for Data Mining

• **Variables affecting liquid yield**
  – feed composition, operating conditions, equipment configuration, processing goals, and nature of the coke.
  – Impractical to hold all these variables constant to isolate impact of additive.

• **Net Value of Converting Coke to Liquid**
  – $100 to $120 per barrel in USA, varies based on diesel & coke pricing
  – 1% improvement in liquid as % of Coker Feed = $1 to $1.2/bbl of feed.
  – 1.5% improvement for 30,000 bbl/day Coker is about $14MM/year.

• **$14MM/year is large number nominally, but:**
  – Benefit of CokerMax™ Additive may appear masked by normal yield variation.
Dorf Ketal Approach to Data Mining

A multivariate statistical approach towards optimized yield comprising of,

✓ Data Preparation, eliminating outliers
✓ Principle Components Analysis, A detailed study of key process variables impacting yield.
✓ Development of correlations between principle components and actual liquid yield.
✓ Definition of baseline for benchmarking impact of change.
✓ Detailed root cause analysis for all the batches with yields below potential.
✓ Pre-trial protocol to evaluate the impact of change, in this case additive performance.
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A histogram Representation of Yield

- The Low-Low limit (LL) is the absolute (engineering) minimum value that a model variable may have. A typical use of the Low-Low limit is to set the data quality of all values that are less than the Low-Low limit to "bad quality". All "bad quality" data will not be used in model construction.
- The Low limit (L) is a secondary limit that indicates the "operational" lower limit of a variable. By default, the low limit is set to 1 standard deviation from the mean.
- The High-Low limit (HH) is the absolute (engineering) maximum value that a model variable may have. A typical use of the this limit is to set the data quality of all values that are more than the High-Low limit to "bad quality". All "bad quality" data will not be used in model construction.
- The High limit (H) is a secondary limit that indicates the "operational" higher limit of a variable. By default, the high limit is set to 1 standard deviation from the mean.

+/- 1 standard deviation is almost 4%
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Scatter plot for one of the variables with respect to yield.

The green lines represent 1 standard deviation on the mean for Sulfur & yield respectively.
**Principle Components Identification Matrix**

*• SPE calculation for any variable is done for Principle Component Analysis.*
*• Depends upon:*
  a. The degree of variation of that particular component.
  b. Correlation of this variation to the target parameter/yield.
*• A high variation and a low correlation w.r.t yield will not have a high SPE.*
*• High variation and high correlation will definitely have a high SPE.*
*• SPE is a factor relative to yield.*
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A snapshot of the model output screen
Using the Model to Isolate Impact of COKERMAX™ Additive

Baseline: 65.77%
COKERMAX Impact: 1.43%
Total Yield: 67.20%
Actual Yield is 67.14%, Model Output is 67.96%.
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Model 67.2% vs. 67.14% adj. for principle components

Dosage: 155ppm
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Taking Chemical Out, Modeled Baseline is 65.77%, 1.43% due to COKERMAX™
Modeled baseline of 65.77% in close agreement with agreed actual baseline of 65.63%
Using the tool to evaluate how to improve yield with better control of principle components.
Actual yield is 64.38%, model predicts 65.841%
Adjusting for principal components, Model is close to actual.
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Summarizing Data Mining Process

- Outliers are removed from data set.
- Multivariate analysis rank orders principle components effecting liquid yield in baseline, used to create model.
- The model gives operator real time information on how variation in principle components is impacting liquid yield.
- The Model allows for every batch to have an adjusted baseline calculation, thereby isolating impact of COKERMAX™ Additive on batch by batch basis
- Ability to confirm additive effectiveness over time
- Model gives operator “What if” capability