PD-09-111  Optimal Gasoline Blending

Presented By:

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Agenda

- Why Optimize Gasoline Blending?
- Wood River Refinery’s (WRR) Gasoline Blending Operation & Work Process Overviews
- Keys to Optimal Gasoline Blending
  - Structured, Flexible & Well Developed Modeling Plan
  - Inferred RBOB Properties from Neat NIR Spectra
  - Adding Ethanol Boost Equations to Off-Line Blend Recipe Generation Tool for better recipes
  - On-Line NIR Analyzer Diagnostics Feedback
- Summary & Questions
Why Optimize Gasoline Blending?

• Gasoline blending is the “cash register” of the refinery – “if we give it away at blending, it is gone for good…”

• At a typical refinery, optimized gasoline blending could represent more than 50% of the total APC savings in the refinery and exceed $15-20 million/year in bottom-line savings

• Small reductions in give-away yield huge results through scale – i.e. WRR makes roughly 2 billion gallons of gasoline/year
Blending Operation Overview

- **3** Gasoline Blenders all of which are **in-line**
  - Straight to pipeline – not tanks **so no room for errors**
- Honeywell TPS (TDC-3000®) LCN-based DCS using Honeywell’s BRC/BPC (on-line) & BLEND (off-line) blending applications
- **9** gasoline blending components – **the more components, the more opportunities (degrees of freedom) for optimization**
- “Fly-switch” capability – change to a new blend without stopping the blender/pipeline

TDC 3000® registered trademark of Honeywell, Inc
Blending Operation Overview

• “Segment Control” – each blend is optimized in 5,000 Barrel segments within a given blend
• Nearly 1000 Gasoline Blends/yr ranging from 20,000 to over 200,000 Barrels per Blend
• Produce roughly 50% conventional blends (premium, regular, and sub-grade) & 50% RBOB blends (premium & regular)
• Produce ~50 different recipe types with capability of unique property estimation for each different type
Blending Operation Overview

• Majority of key Gasoline Properties are **On-Line Certified**
  • Allows direct property specification control for maximum optimization (**minimum give-away**)  
• Use redundant **Near InfraRed (NIR)** on-line analyzers to provide key gasoline properties to the Honeywell control system  
  • Additional Motor Lab NIR for 3 NIR’s total  
• Sophisticated Quality Control system to keep our on-line system statistically similar to our off-line Motor Lab analysis
Blending Simplified Schematic

Off-Line
Honeywell
BLEND
Non-Linear
Blend Equations

Good Starting Recipes for BPC

Alkylate
Reformate
Butane
Etc...

Blend Component Tanks

Motor Lab Testing of Properties

Gasoline Blender Header

NIR Analyzers

BRC/BPC
Closed-Loop Control

ON-LINE BLENDER

Good Blend Values (S-S Gains) For BPC
Gasoline Blending Work Process

Notes:
- Main Sequence
- Monthly O.C. Review Meetings between APC NIR Modeler, Blending Engineer, Lab Chemist to review On-Line vs. Off-Line Statistics to determine if there are analyzer issues, lab issues, or NIR modeling issues that need to be addressed

Blending Software: 1 = Honeywell OFF-LINE BLEND Recipe Generation Software; 2 = Honeywell's ON-LINE BRC/BPC (Blend Ratio Control / Blend Property Control)
Keys to Optimal Blending

• Three Major Pillars to Optimal Gasoline Blending
  • Good Working Blending & Analytical Equipment
  • Good Starting Blend Recipes
  • Good Blending Control & Optimization

Let’s look at these in detail....
Keys to Optimal Blending

- Good Starting Recipes
  - Accurate Regression Models in BLEN
  - Component Lab Validation Program & Ethanol Boost Calculations
  - Good BPC Blend Values
- Good Coordination w/Planning Group
- Good Lab Data on Blend Components
- Good NIR Models
- Well Defined Blend Recipe Ranges
- Blend Recipe Monitoring Graphics
- Good Off-Line Motor Lab Data
- Structured & Well Developed NIR Modeling Plan
- NIR Model Catalog & Modeling Database

Weekly Probe Cleaning PM Program
Good NIR Maintenance
NIR Quality Control Diagnostics Monitoring Tool
Well Maintained Field Instrumentation & Analyzers
Well Maintained DCS / UPS

Optimal Recipes
NO Off-Spec Blends

Good Working Equipment

Good Blending Control & Optimization
- Accurate On-Line Property Analysis
- Properly Trained Blend Operators

Good BPC Tuning & Unclamped Limits to Optimize Blends
Keys to Optimal Blending

• Flexible NIR Modelling for Various Blend Recipes
  • Utilize a Model Catalog to allow targeted property modelling to minimize give-away for each recipe type
  • Targeted Models minimize give-away in various blending seasons
    • i.e. Winter blending requires different components and mixes from Summer blending, therefore the NIR models should be unique (targeted) to capture recipe type specificities and minimize give-away
Keys to Optimal Blending

• Inferred RBOB Properties
  • Significant give-away surrounds RBOB Blending
    • Oxygenates like ethanol (most common) are \textbf{not} allowed in pipeline due to corrosion affinity
    • \textbf{Refineries blend neat RBOB} – meaning minus the ethanol, which is added at the terminals
  • Ethanol boost is highly composition (recipe) dependent & \textbf{non-linear}

<table>
<thead>
<tr>
<th>Recipe</th>
<th>Neat Octane</th>
<th>Blended Octane</th>
<th>EtOH Octane Boost</th>
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<td>93.2</td>
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<tr>
<td>Low Toluene Concentrate; High Alkylate Blend</td>
<td>91.6</td>
<td>94.9</td>
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• \textbf{Use NIR to infer Blended RBOB Properties}
Keys to Optimal Blending

• Adding Ethanol Boost Equations into Off-Line Recipe Tool

In order for the Honeywell BLEND Recipe Generation Program to properly develop optimal initial recipes, the composition-dependent boost effect of Ethanol addition for RBOB Blends must be accurately predicted.

These calculations do not normally come standard with the Recipe Planning Tool (i.e. BLEND), but instead must be added by the customer.
Keys to Optimal Blending

• On-Line NIR Analyzer Diagnostics
  • Online Near InfraRed (NIR) analyzers predict 13 key gasoline properties
    • RON, MON, D86 properties, %Aromatics, etc..
  • Online certify gasoline from these properties so it is important they are both accurate & precise
  • Diagnostic information from the NIR’s are transferred to the DCS via OPC
    • For each property, the NIR produces 2 important diagnostics, Residual Ratio (RR), and Mahalanobis Distance (M-Dist) as it is analyzing the sample
Keys to Optimal Blending

- On-Line NIR Analyzer Diagnostics

- **Residual Ratio (RR)**: compares the unknown’s residual variance to the average residual variance for the calibration set.

- **Total M-Distance (M-Dist)**: compares unknown spectrum to calibration set spectra.
Summary

- Gasoline blending is the “cash register” of the refinery so optimization can mean “big bucks”
- Set up a good Gasoline Blending Work Process
- Utilize Advanced Technologies like NIRs, Honeywell’s BLEND, BRC, & BPC
- Create a structured, flexible & well-developed NIR Modeling Plan for recipe targeted optimization
  - All NIR results should be within the reproducibility limits of the primary method (i.e. 0.7 for RON; 0.9 for MON…)
  - Routine comparison to primary methods are crucial, and model adjustments or on-line property target changes required if not meeting minimum criteria
Summary

- Integrate NIR Diagnostics as crucial feedback to avoid off-spec blends and proactive analyzer maintenance.
- Add Ethanol Boost Equations to Off-Line Blend Recipe Planning Tools (i.e. Honeywell BLEND) for better initial blend recipes & better blend values for on-line blend optimization system (i.e. Honeywell BPC).