

INCREASING EFFICIENCY, SAFETY, AND RELIABILITY IN REFINERIES WITH REAL-TIME CRUDE FEEDSTOCK ANALYSIS

Understanding the Hidden Loss: The Impact of Crude Oil Variability on Profit Margins



The refining process of crude oil, a complex and intricate operation, hinges significantly on the detailed understanding of the oil's properties and composition. Each refinery process unit's efficiency, output quality, energy usage, and safety are directly linked to the fundamental quality of the crude oil feeds including the distillation profile, cut points, API gravity, aromatic content, asphaltenes, Total Acid Number (TAN), sulfur content, etc., which define the operational parameters and constraints of the refinery units.

Despite the importance of these properties, refineries often operate on approximate estimations or outdated analyses, due to several challenging factors:

- 1. Time-Induced Variability:** Properties of crude oil, even from consistent sources, vary and fluctuate over time due to natural changes and also due to slow degradation.
- 2. Alteration During Transportation:** The process of transporting crude oil via pipelines, tankers, and storage tanks often leads to the mixing of various crude types, altering the original properties.
- 3. Uncertainty with Opportunity Crudes:** These economically attractive crude types often lack detailed and reliable assays to accurately determine their properties.

The prevalent method to counter these challenges is manual laboratory testing. However, this method falls short due to its infrequent nature (often only once daily), time delays in obtaining results (the time lag between the sample grabbing and its analysis completion), incomplete data, data reliability and cost.

This lack of real-time, comprehensive analysis significantly hampers the effectiveness of refinery planning, control, and optimization software, leading to underperformance in efficiency and on-spec product quality. This, in turn, results in substantial revenue and profit losses, and forces the refinery to operate far away from its operation constraint to still ensure acceptable safety and reliability levels within the refining process.

Adopting real-time analysis of crude oil revolutionizes refinery operations and economics by:

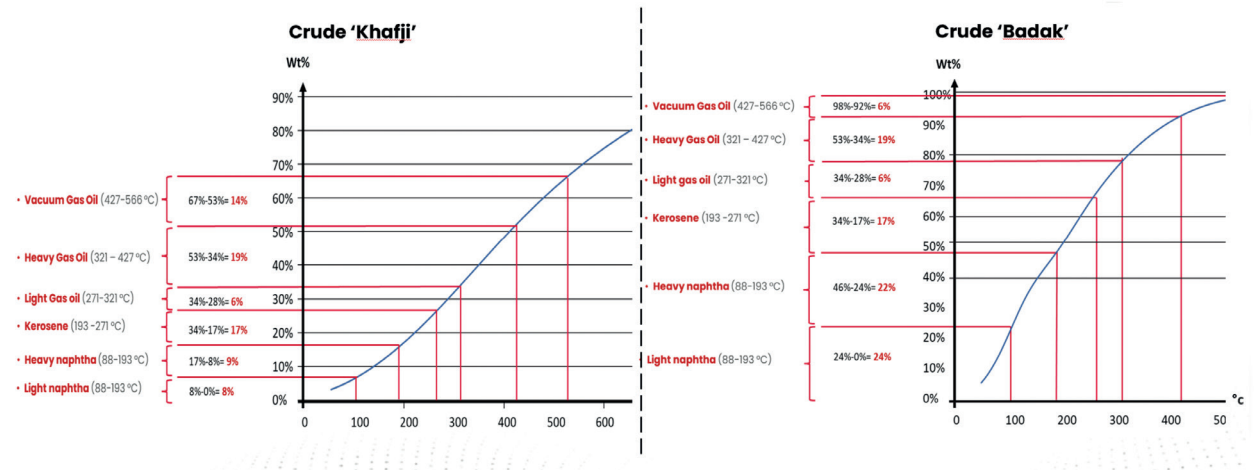


Figure 1: For custody transfer verification, detailed distillation profile is the core property to be measured by on-line analyzer

a. Crude Custody Transfer Verification: With real-time, on-line crude analysis, refineries can immediately confirm the quality and properties of incoming crude, ensuring compliance with purchase agreements and effective execution of production plans made months in advance. Continuously monitoring critical quality aspects like TAN, sulfur level trend, and water content, are enhances refinery unit reliability, and reduces operational costs. Continuous real-time incoming crude analysis enables the refinery to safely expand the range of usable crude sources, including Opportunity Crudes, without introducing operational risk, and thus leveraging the performance economic benefits. of such crudes.

b. Boosted Enhanced Safety and Utilization Through Proactive Upset Prevention: Continuous, real-time monitoring of crude feedstock allows for proactive prevention of operational disruptions in Crude Distillation Units (CDUs). By identifying composition deviations that could cause upsets such as tray flooding, refineries can proactively mitigate these

risks. Furthermore, real-time analysis allows for the fine-tuning of unit operational and Advance Process Control variables (heat, pressure, flow, mix ratios) according to true, real-time composition of the crude feed, leading to enhanced process efficiency and improved sustainability, resulting in reduced material waste, enhanced throughput, reduced re-runs from off-spec rundown streams, and, lower carbon emissions.

c. Enhanced Product Quality and Efficiency Through Real-time Feed Blend Alignment: Real-time monitoring at the discharge pumps of the crude feed tanks after the crude blending point enables refineries to optimize the actual feed to the first distillation unit. Real-time adjustment of the actual crude feed to more consistently align to LP targets stabilizes CDUs and upgrading units, and improves rundown and product blending quality.

d. Comprehensive Operational Stabilization: Consistent crude feed control at the beginning of the refining process leads to stabilization throughout the entire refinery operation.

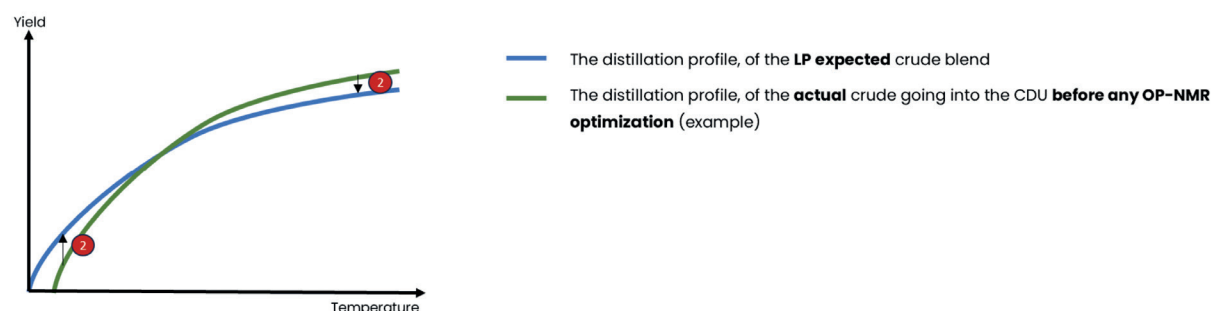


Figure 2: Continuous monitoring of the distillation profile of the blend crude enables real-time optimization

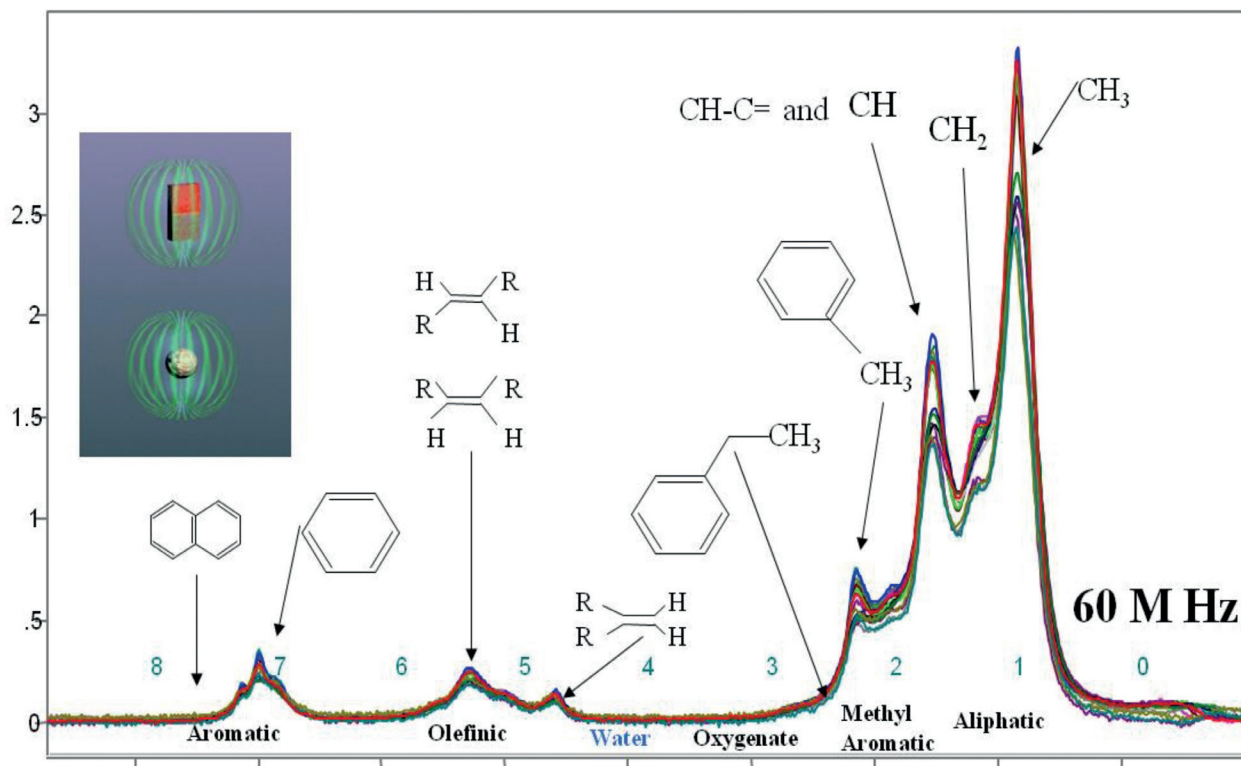


Figure 3: Typical OP-NMR Spectra of Crude Oil

enhancing overall efficiency and product consistency.

e. Dynamic, Plant-Wide Optimization: Continuous, real-time, feed forward crude feed analyses empowers refineries to adjust their production slate almost instantly in response to market opportunities, thus leveraging economic benefits and staying competitive.

Conservatively, real-time crude feed forward analyses will achieve 3-5% gains in operational efficiency and throughput with minimal off-spec product quality and re-work.

OP-NMR: The Optimal Technology for In-Depth Crude Oil Analysis

Given crude oil's opacity, traditional optical analysis technologies (like NIR, FT-IR) face significant limitations. In contrast, Nuclear Magnetic Resonance (NMR) technology, based on magnetic excitation of atomic nuclei, effectively bypasses these issues. On-line Process NMR (OP-NMR), a specialized variant of NMR, is tailor-made for continuous, on-line fluid analysis and stands out as a superior solution for comprehensive crude oil characterization.

The benefit of OP-NMR spectrometry lies in its linear correlation between hydrogen atoms of the molecules present in the crude oil, and the distinguished chemical shifts representing the chemical nature of its components. Chemometrics transforms the spectrometric measurements into the critical crude oil and crude oil blend property measurements required for real-time control and optimization of a refinery.

Pros and cons of OP-NMR Spectroscopy:

Advantages:

- Non-optical spectroscopy
- No dependency on transparency
- Linear and quantitative spectral response to the hydrogen content and molecular bonding environment of the sample.
- Robust Chemometric performance
- No spectral temperature dependency
- Water content does not interfere with spectral quality and is measurable and quantifiable
- Simplified sample preparation and handling

Disadvantages:

- Solids can't be observed
- Low sensitivity to impurities
- Sensitive to ferro-magnetic substances
- Non-Hydrogen containing molecules are not observed

In summary, the implementation of real-time crude analysis, especially through advanced technologies like OP-NMR, marks a significant leap in refining operations. By addressing the challenges posed by the variability of crude oil, refineries can achieve optimal efficiency, heightened safety, and increased profitability, ensuring high-quality products and a strong market position.

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