Gasoline/Diesel Blending Analysis

Applied Analytics Application Note No. AN-029

Application Summary

Analytes: **physical properties of the fuel stream**

Detector: **OMA-300 Process Analyzer (SW-NIR spectrophotometer)**

Process Streams: **gasoline, diesel, various fuel streams**

Introduction

At the end of a gasoline production process, various streams are blended to produce distinct gasoline blends, e.g. to meet different octane specifications. This blending process is treated with extreme precision since producing off-specification gasoline incurs large costs, either in the form of 'octane giveaway' or fines/penalties from below-spec products.

In order to maintain efficiency in this final stage of refining crude oil, real-time analysis of the gasoline blends is required. When functioning properly, this analysis will serve to validate each blend against specification in real time, thus actively reducing operational cost. Conventional methods of blending analysis (e.g. knock test engines and FT-NIR systems) are increasingly being viewed as impractical due to high maintenance requirement and significant upfront costs.

The OMA-300 Process Analyzer presents a solid state solution which matches the accuracy of FT-NIR systems at a small fraction of the price — all without any moving parts or consumables. This system uses a dispersive shortwave near infrared (SW-NIR) absorbance spectrophotometer to produce a full, high-resolution 400-1100 nm spectrum of gasoline sample absorbance. Utilizing an industry-standard chemometrics package, the ECLIPSE software correlates the rich raw data to various physical properties in real time.

Measurements Performed by the OMA System

- RON (Research Octane Number)
- MON (Motor Octane Number)
- (R+M)/2
- RVP (Reid Vapor Pressure)
- TVP (Total Vapor Pressure)
- Total olefins
- Total aromatics
- BTX (benzene, toluene, xylene)
- Oxygenates
- %MTBE
- Density
- Distillation: D10, D50, D90, E70, E100, E180

Problems with Conventional Methods

Knock Test Engines

These engines are often used in conjunction with property analyzers to detect the anti-knocking capacity of the fuel. They are famously expensive to maintain, provide lower octane precision than optical methods, and sacrifice a significant amount of fuel product to the sample stream.

FT-NIR Instruments

The bulky FT-NIR systems provide good accuracy — at enormous cost. Beyond the staggering upfront cost, the moving parts require regular maintenance and operation requires an FT-NIR technician.

The Benefits of OMA

- Proven reliability in blend analysis at a fraction of the cost of FT-NIR
- Totally solid state build — modern design with no moving parts for low maintenance
- Designed for automation with readings normalized by Auto Zero function
- Compatible with various industry-standard chemometrics packages
- Simple graphical interface conveys needed information without extensive training required
- Easily multiplexed to monitor multiple blend streams with a single OMA unit

Using Chemometrics for Blending Analysis

The exact relationship between the gasoline absorbance structure and physical properties like octane is not well understood. Yet, since octane rating is linked to the proportion of straight-chain hydrocarbon molecules to branched hydrocarbons and aromatics, the absorbances overtones and combination bands of the CH stretch are highly involved in the strong correlation between he asorbance spectrum and the octane. These absorbance features occur in the near infrared (NIR) wavelength range and are best analyzed with a dispersive SW-NIR spectrophotometer.

Chemometrics is an empirical technique used in blending analysis to correlate and predict various physical properties from the raw NIR absorbance data. Partial Least Squares (PLS) regression is the method best suited for processing the raw data, since prediction is the ultimate goal and no practical considerations limit how many predicting factors are used together.

This technique has proven highly effective for accurate correlation of gasoline properties, and healthy competition in the field has produced several widely used chemometrics solutions. The OMA can be specified to run the customer's chemometrics package of choice.

Calibration Modularity

The ability to easily transfer calibrations between analyzer units and build calibration libraries is critical for automated analysis. The OMA addresses this need in the following ways:

The Need	OMA's Answer
Wavelength accuracy and reproducibility	The solid state diode array spectrophotometer has no moving parts and sustains accuracy much better than instruments with filters.
Software correction for small variations	The spectrophotometer firmware incorporates extremely precise wavelength-to-diode calibrations that do not drift due to solid state build.
Insensitivity to temperature fluctuation	The temperature-controlled spectrophotometer housing maintains the optimal opearational temperature range; CMOS circuitry reduces dark current.
Ease of transferring/storing calibrations	The OMA software runs on a Windows platform to provide familiarity and simple calibration transfers.

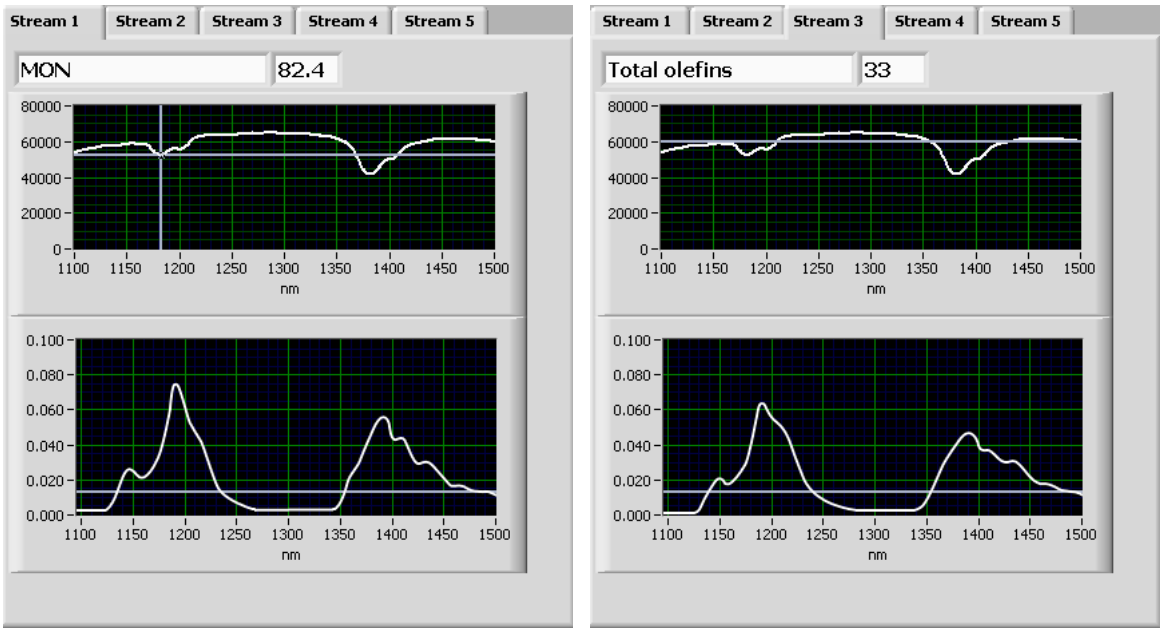
Economic Viability

On average, installing the OMA-300 allows blending 0.3 octane units closer to specification than knock engine data; using valuation per octane unit in 2010, the OMA saves a 17,000 b/d refinery up to $120,000 per month.

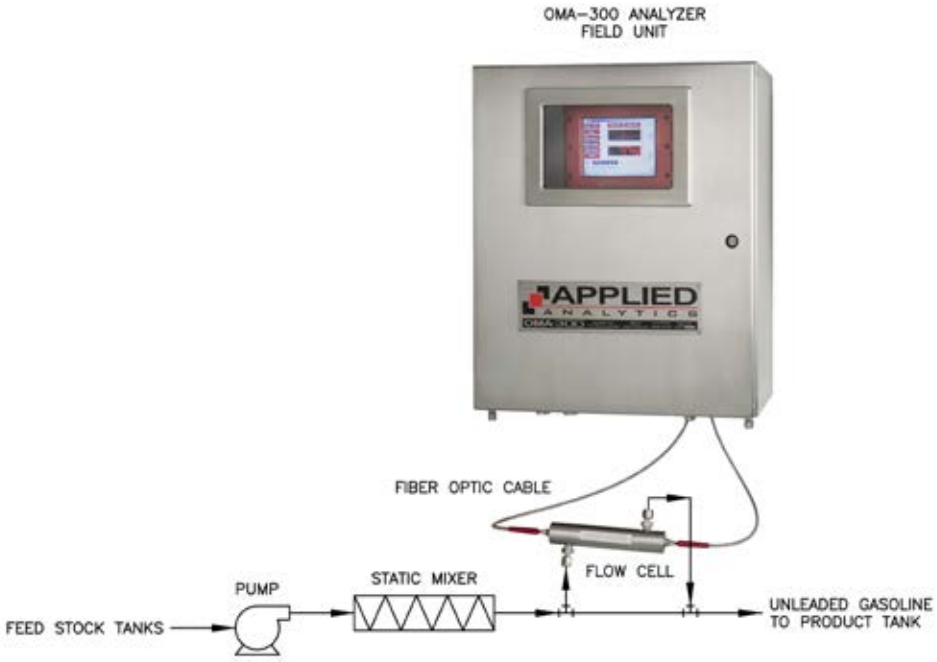
At the above estimate, an OMA will easily cover its own cost within one month.

Multiplexing the OMA

Using the OMA to analyze multiple blend streams simultaneously is an excellent way to compound the value of the system. The tabbed stream browser is demonstrated below; the user can cycle through streams as well as correlated physical parameters while viewing the raw absorbance data.



OMA Integration Schematic



Further Reading

Subject	Location
OMA-300 Process Analyzer Data sheet	http://aai.solutions/documents/AA_DS001A_OMA300.pdf

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