



Gasoline Blending

Industry: Oils and Gas
Product: NR800

New Refinery Applications

Gasoline and Diesel blending applications of on-line Near Infra-red (NIR) analysis and control are well documented in the literature¹, and the economic benefits of NIR control systems have been reviewed recently². In his *Hydrocarbon Processing* article, Ara Barsamian states, "Although there are other spectroscopic methods for process analysis like nuclear magnetic resonance (NMR), nothing comes close to NIR analyzers – which are proven, reliable, highly accurate and reasonable in terms of life cycle cost of ownership. For a mogas blender, \$200,000 to \$400,000 will buy a top-notch, expandable NIR easily measuring 10 to 20 properties with minimal maintenance problems compared with 5 to 10 conventional individual property analyzers (two knock engines plus a spare, RVP, distillation, density, oxygenates, etc.). With conventional analyzers and their fast sample loops, sample conditioning systems, spare parts and analyzer technician training, you are facing a \$-million investment before starting the life cycle support costs! The NIR is a critical component in obtaining the benefits of blending optimization. Its benefits range from \$4 to 8 million/yr., depending on the number and size of blenders."

Here we offer a few examples of gasoline blending measurements to demonstrate the capability of the Yokogawa NR800 FT-NIR system.

RON

Thirty samples of regular gasoline were scanned to produce the spectra in Fig. 1.

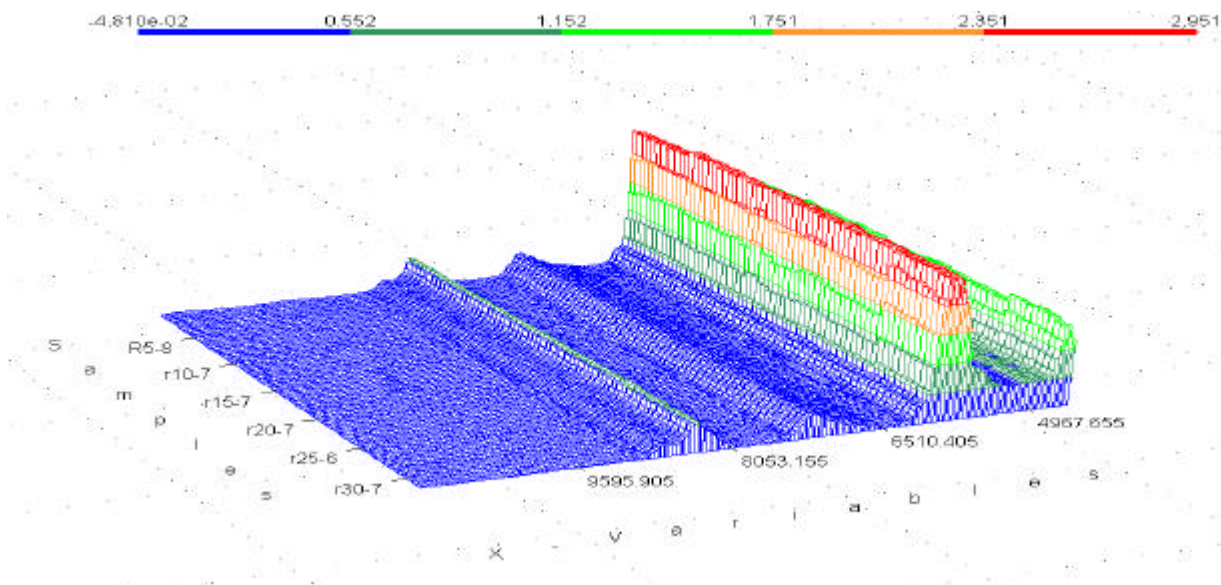


Figure 1: Spectra of Regular Gasoline Samples

The data was transformed by taking the first derivative and a PLS1 model made using the spectral region 6510 - 8980 cm^{-1} . The plot in Fig. 2 shows the RON predicted by FT-NIR vs. the RON measured in the laboratory.

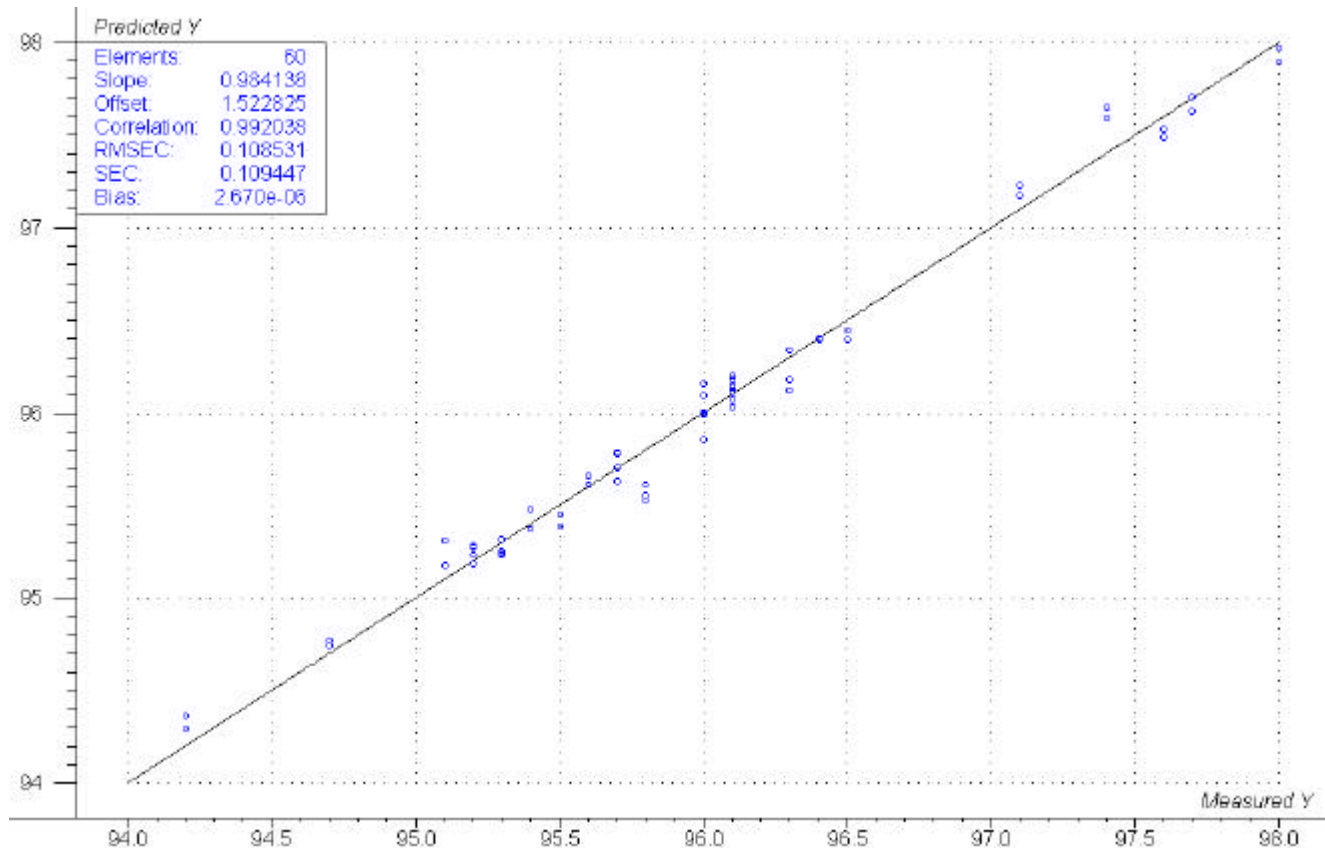


Figure 2: Predicted vs. Measured RON on premium gasoline

RMSEC (Root Mean Square Error of the Calibration) is used to evaluate the accuracy of the calibration. RMSEC is similar to standard deviation in that 95% of the measured RON values lie within $\pm 2 \times \text{RMSEC}$ from the predicted values. Thus at the 95% confidence level the accuracy can be said to be ± 0.22 RON. It is important to understand that the accuracy of NIR systems is limited by the accuracy and precision of the lab data used to calibrate NIR analyzers. An on-line NIR system measures only the spectrum of the sample. The variations in the spectrum at several wavelengths are correlated to laboratory measurements made on the same sample. Therefore, any error in the lab data ultimately affects the accuracy of the NIR calibration. Therefore, NIR calibrations routinely are only about as good (in terms of ASTM Reproducibility) as the lab methods.

The precision of NIR measurements, that is the repeatability of these measurements, is typically much better than the standard ASTM methods. This is because once the NIR is calibrated, the measured parameter (RON, MON, RVP, density, Benzene, MTBE, etc.) is calculated directly from the absorbance at the wavelengths used. NIR analyzers in general are amazingly accurate at producing the same spectrum for the same sample. In this case, the standard deviation of replicate scans of the samples is 0.044 RON. Using the 95% confidence level ($\pm 2 \sigma$) the repeatability of measurements is ± 0.088 RON.



Gasoline Blending

Many other components can be measured the same way:

- RON
- MON
- RVP
- Distillation Points
(IBP, FBP, 10, 30 50, 90% Off, etc.)
- Paraffins
- Olefins

- Naphthenes
- Aromatics
- Benzene
- Oxygenates
- MTBE
- Density
- Cetane
- Pour Point
- Flash Point
- Freeze Point
- Cloud Point
- CFPP
- PIONA
- Viscosity

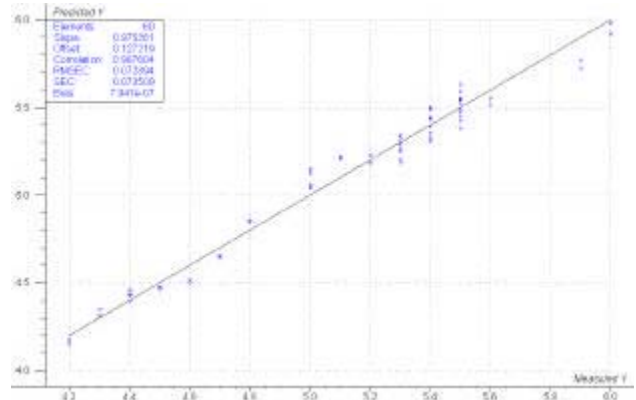


Figure 3: Benzene in gasoline calibration

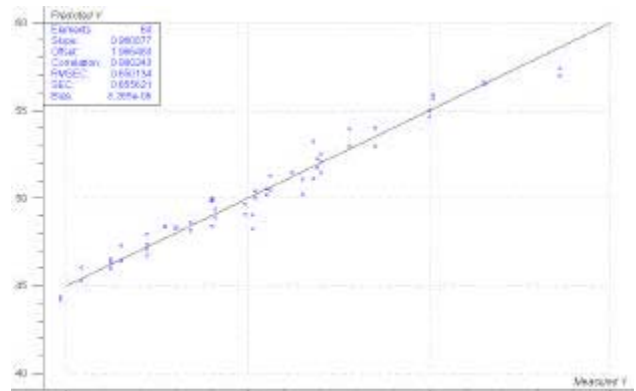


Figure 4: RVP of gasoline calibration

Economic Benefits

Typically, blending systems controlled by NIR analyzers can be operated at set points 0.3 Octane units closer to the specification than systems based on knock engines. The value per octane unit was estimated to be \$5/m³ (\$0.79/bbl) in 1994. For 100,000 m³/month (21,000 b/d) the cost savings amounts to about \$150,000/month. The entire cost of an FTNIR system, including sample conditioning and analyzer shelter, can be paid out in 3 – 4 months.

i Espinosa, M.S. et al, "On-line NIR Analysis and Advanced Control Improve Gasoline Blending," *Oil and Gas Journal*, Oct. 17, 1994

ii Barsamian, A. "Get the Most Out of Your NIR Analyzers," *Hydrocarbon Processing*, January, 2001, pages 69-72.