INNOVATION IN PETROLEUM PROCESS ANALYZERS TECHNOLOGY

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ABSTRACT

Petroleum process analyzers based on standard ASTM methods are not dependent on crude quality and other factors, but their response time is longer and maintenance is expensive. Near-infrared (NIR) spectroscopy requires close attention to the modeling efforts, but an innovative solution discussed in this paper enables automatic model correction. Nuclear magnetic resonance (NMR) technology does not have the continual model maintenance issue and the main advantage of this technology is the linear spectral response which enables models to be extrapolated accurately. Application of all three technologies are presented and discussed to reach the optimize performance, accuracy and availability in petroleum process analysis.

INTRODUCTION

The objective of a modern process plant is manufacturing the high value and on-specification products at optimal cost and minimal environmental burden. Therefore on-line qualitative and quantitative measurements of physical properties and chemical composition are indisputable requirements[1]. Successes that can be attributed to the use of process analyzers include reduced cost of production, decreased product giveaway, operating manpower and energy conservation.

DISCRETE PETROLEUM PROCESS ANALYZERS

It is essential that process stream composition, operating conditions and standard laboratory method used for process analyzer validation be properly defined at the earliest stage of system design[2]. Based on this information, the analytical method and system configuration approach

should be selected. Since the process analyzer results must be correlated finally against the standard laboratory methods of analysis, it is very important to distinguish between ASTM-based analyzers and correlative analysis technologies.

ASTM-based discrete analyzers do not dependent on crude quality and other factors, resulting in better correlation with the laboratory, but their response time is longer and maintenance is expensive. However, for many petroleum applications using these analyzers is an indisputable requirement, especially when there is a need for on-line product certification and quality assurance.

NIR PROCESS ANALYZER TECHNOLOGY

Much has been written on the subject of NIR and Mid-IR spectroscopy which requires close attention to the modeling efforts. Over the past 15 years repeated attempts have been made to validate these on-line systems. The conclusion is that the systems validate when close attention is paid to the modeling effort[3]. Continuous model updates are required after each crude slate change (the analyzer is not available until the new gasoline has been produced and placed in the model). The project will fail and the analyzer will never be validated if on-site expertise is not continuously available.

NIR analyzers are usually simple to install, very reliable and requires minimum maintenance. However, this technique is not linear and not all components in the sample are clearly resolved, so that any change in stream composition or process conditions requires model updating. The new innovation represents NIR Analyzer located in the control room and connected via telecommunication fiber optics to the field units installed as needed in the process or on blending collectors[3].

This technology enables the facility to connect of up to 15 process stream sensors which uses no electricity and contains no moving parts, to a single main analyzer situated in the control room[4]. The special software installed on the analyzer compares analyzer readings with the laboratory results and enables the automatic correction of models if systematic disagreement between results is determined. The use of standard telecommunication fiber optics has resulted in multiple analyzers installations in petroleum industries worldwide, which did not require any manual model updates during the last five years.

The main drawback of NIR is not related to the hardware but to finding the resources (time and money) to build the models and maintaining the model robustness. For the most economical incentive applications, such as CDU and blending, a successful implementation of NIR can last up to 12 months. The bottleneck is not the NIR spectrometer accuracy or the limits on laboratory resources, but the fact that the model has to be robust. The model has to cover all possible variations of the product composition, which is constantly changing over time. Therefore, although very powerful, current NIR systems are not “plug and play” devices. If changing crude influences the analyzer's behavior, the refinery operators will lose their confidence in the analyzer.

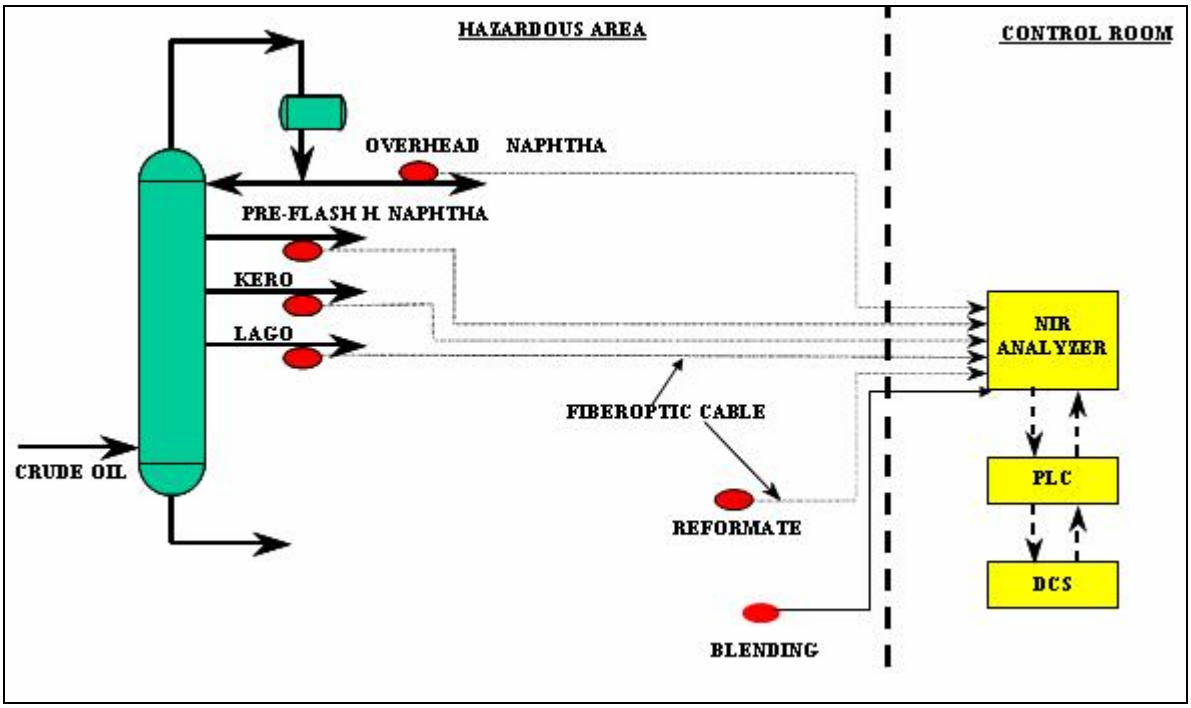

FIG. 1 – NIR PROCESS ANALYZER USED FOR ATMOSPHERIC CDU ANALYSIS

The solution offered for this problem is Freetune™ software, which is composed of two sequential blocks. First, partial least squares (PLS) regression is used to build a localized sensitive model (LSM), based on just a small number of samples. One of the characteristics of this model is its sensitivity to short term (hours) process variations. Since it is localized, the model can be quickly built and validated. This procedure takes up to one week and can be performed prior to startup. Second, a proprietary software program processes the model, together with the specified plant data, to accurately quantify the properties. This second part deals with predicting the long-term product variability.

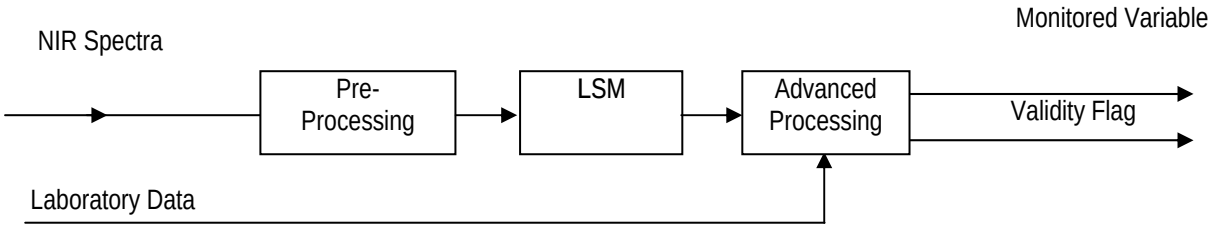

FIG. 2 – TWO SEQUENTIAL BLOCKS OF MODEL BUILDING

The graph below shows how this software enables an analyzer to predict results after a crude switch, when usually manual model update is required to accommodate the new sample composition.

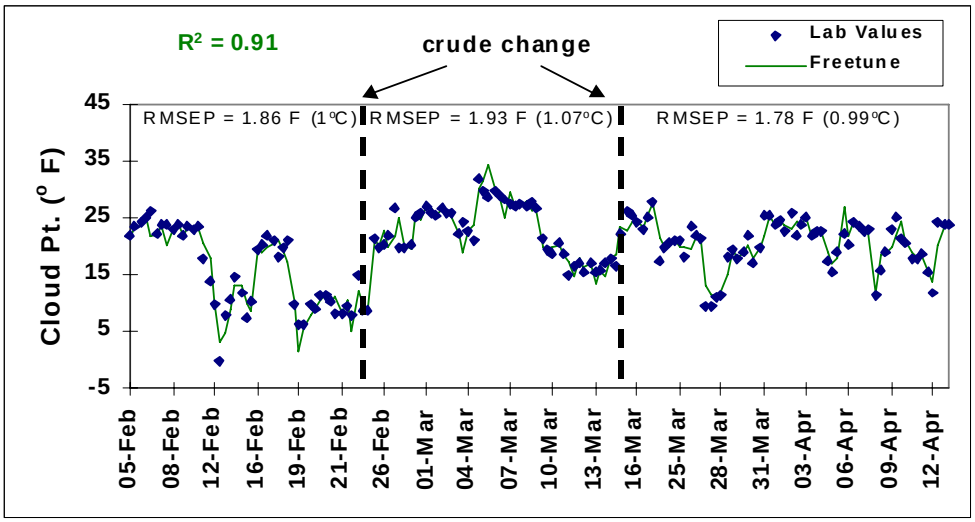

FIG. 3 – RESULTS OF MODEL UPDATING DURING THE CRUDE SWITCHING

The guaranteed utilization factor with this technology is at least 98%. The utilization factor is application dependent with conventional calibration methods[5]. In complicated applications, such as CDU and blending applications, utilization factor cannot exceed 90%, and for the remaining part of the 10% samples there is no red flag alerting the process operator that the readings are outside the required performance for process control. Utilization factor of 98% is feasible for traditional analyzers, but only under strict conditions and at extra cost. For example, typical gasoline blending application requires 5 traditional analyzers and the combined utilization factor is approximately 90%.

NMR PROCESS ANALYZER TECHNOLOGY

The NMR analyzer is quite different to the NIR for the modeling side of an analyzer project. It does not have the continual model maintenance issue caused by spectral changes seen with crude composition changes[3]. An NMR analyzer provides a continuous flow-through, accurate chemical and physical analysis of multiple components in dense and opaque materials. It allows various process industries such as chemicals, biotechnology and food to explore new ways of increasing profits by controlling and optimizing the production process.

The main advantage of this innovative process technology is linear spectral response across a broad range, which enables models to be extrapolated accurately. The process NMR spectrometer is ATEX-certified and mainly designed for the petrochemical and refinery markets.

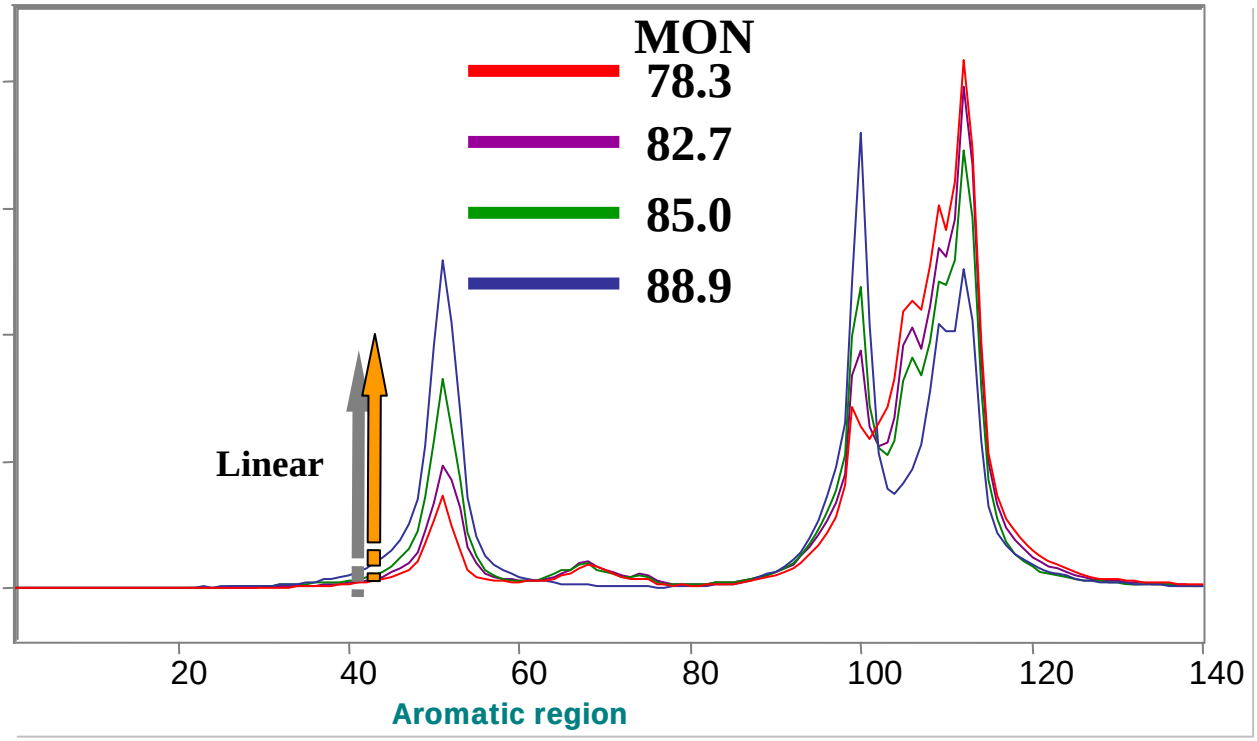

FIG. 4 – LINEARITY AND EXTRAPOLATION WITH NMR TECHNOLOGY

This technology could be applied in many refinery applications and enable multi-stream operation for high utilization and process efficiency.

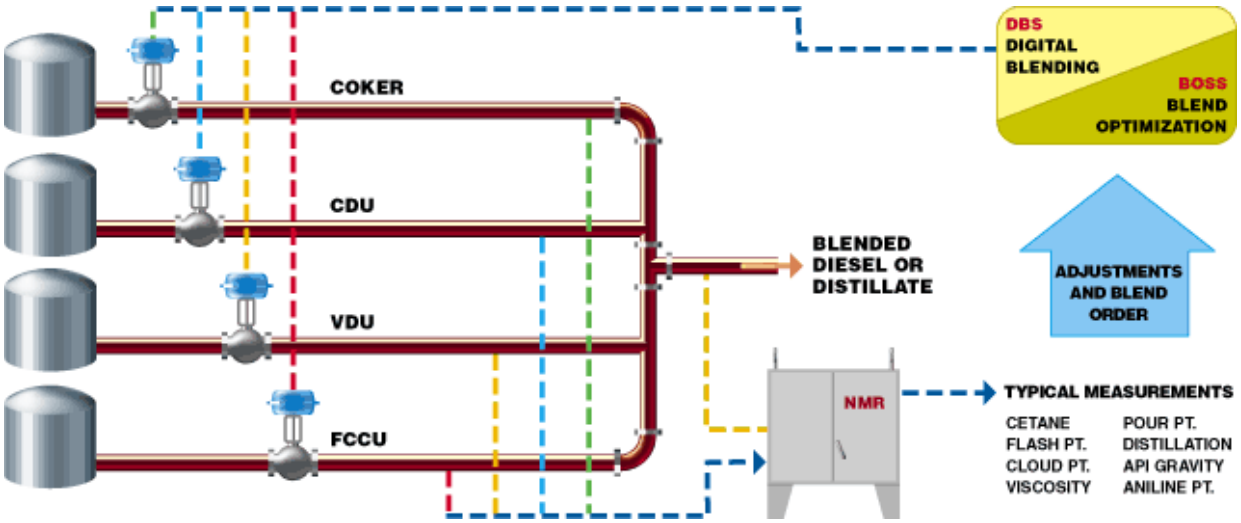

FIG. 5 – MUTI-STREAM CDU ANALYSIS BY NMR ANALYZER

COMBINATION OF DIFFERENT TECHNOLOGIES IN ONE SOLUTION

The combination of Discrete Analyzers with NIR and NMR Analyzers enables the user to reach performance, accuracy and availability which is difficult to reach using only one technology. The trend over the past years is toward prefabricated analyzer houses which are pre-piped and pre-wired with all analyzers, sample systems and utilities, complete assembly tested at the factory and shipped to site as a single package. Site installation work is kept to a minimum, thanks to turn-key responsibility when one team of specialists manages the project from start to finish.

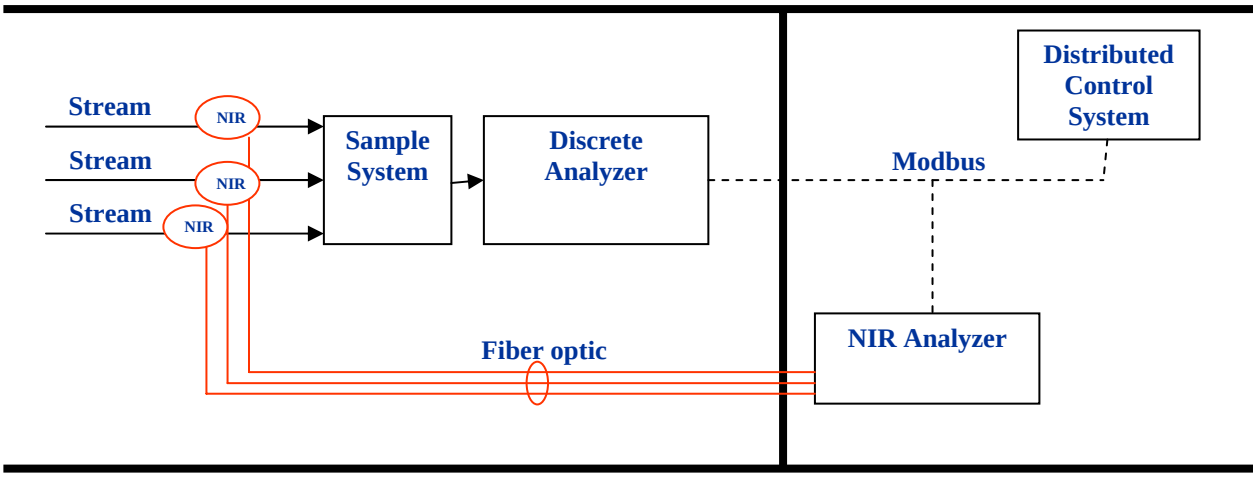

FIG. 6 – EXAMPLE OF COMBINATION - NIR AND DISCRETE ANALYZERS

PROCESS ANALYZERS VALIDATION

The methods of validation/calibration rely on effective coordination between analyzer maintenance forces and the laboratory. ASTM 3764 practice serves as a guide for the validation of process stream analyzers used in determining the physical or chemical characteristics of petroleum and petrochemical products[6].

There must be efficient and effective communication and mutual agreement between the process analyzer department and plant laboratory at all times. The trend today is towards increased use of analyzers for process control and decreased use of routine testing in the laboratory – with the laboratory deeply involved in analyzer validation/calibration. There are standard procedures developed by ASTM for validating process analyzers so that all problems could be solved "under one roof" and an agreed position taken for the benefit of process operations.

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