Originally appeared in:
September 2015, pgs 87-89.
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HYDROCARBON PROCESSING®

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Improve refinery flexibility and responsiveness

The hydrocarbon processing industry (HPI) has changed significantly with an abundance of available discounted crude oils, a rise in markets served beyond the traditional local or regional demands, and a renewed focus on being both competitive and profitable while complying with ever-changing regulations. With continuous media scrutiny waiting to pounce on any negative incidents, refiners are also more vigilant about mitigating the risk of safety or environmental incidents. With numerous influences on refiners' businesses, the key to survival is to be flexible and responsive as opportunities emerge.

Crude oil availability and selection. Opportunity crudes have been around for years, but only until recently has the abundance of these discounted crudes shifted the mindset of refiners. For example, the US has dramatically increased its production of tight oil over the past few years, especially from the Bakken and Eagle Ford basins. In 2014, these two shale basins accounted for nearly two-thirds of all North American (NA) tight oil production (FIG. 1). The ban on US exports means that US refiners are processing a higher percentage of this light tight oil. However, a specific refinery is designed to process crude oil of a particular composition and produce products with specified properties, with some flexibility based on the capabilities of equipment such as pumps, compressors, heat exchangers and the catalyst selection within the reactors.

Although the refinery configuration and design are fixed, most refineries process many different crude oils. Coastal refineries often process 50 or more different crude oils over the course of a year. Additionally, many refineries on the US Gulf Coast have made major investments that enable them to process heavier sour crude oils from sources such as Venezuela and Canada. These changes were made before the technological advancements that triggered the tight oil and shale gas boom in recent years. Because tight oil is both light and sweet, there is now a mismatch between the crude oil properties that these upgraded refineries require. Refiners try to match the crude oil composition to their refinery's configuration, usually by blending two or more crude oils. This is where challenges come into play.

Blending two or more crude oils to achieve the right balance of feed qualities can introduce unknown issues with crude incompatibilities. When crudes are incompatible, accelerated fouling occurs in the crude unit heat exchanger train due to a rapid increase in asphaltene precipitation. Accelerated fouling can lead to additional energy costs with the crude unit fired heater, limiting throughput when the fired heater becomes duty-limited, or causing an earlier shutdown for exchanger cleaning. These factors will negatively impact the profitability of the refinery. The traditional approach of monitoring heat exchanger fouling through Excel spreadsheets with manual entry of temperatures that are not historical and trended makes it difficult to identify the crude blends that are incompatible, so the same condition for accelerated fouling may likely be repeated in the future.

In addition to crude blend incompatibilities, some opportunity crudes can have a high total acid number (TAN), indicating the potential for corrosion and forthcoming asset integrity issues. Refiners are investing in additional measurement devices to sense the onset of fouling and corrosion, thus taking steps to identify and mitigate the associated risks. With the addition of online monitoring and analysis software, refiners are able to detect accelerated fouling; this information can be used to avoid blending incompatible crude mixtures that lead to accelerated fouling. For aqueous corrosion in the crude unit overhead system, refiners are installing pH transmitters to monitor the circulating wash water and corrosion transmitters that are in contact with the process fluids. For naphthenic acid corrosion in the hot sections—in particular, the transfer piping from the crude and vacuum heaters to the crude and vacuum columns, respectively—refiners are installing corrosion detection solutions that do not penetrate the process piping. Also, improved emulsion level detection in the desalter helps refiners avoid carrying over brine into the downstream units, reducing the associated fouling and corrosion.

Some refiners that have dependable access to tight oils are avoiding the crude blending issues altogether by adding a separate crude unit that operates on 100% tight oil. After

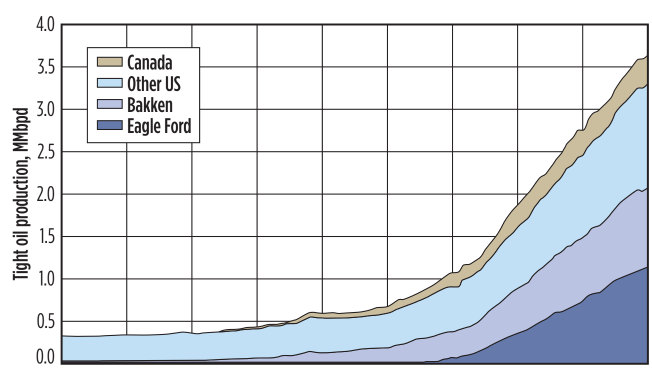

FIG. 1. NA tight oil production, January 2005–February 2014. Source: EIA.

washing, heating and separating in a dedicated fractionator specifically designed for top loading (tight oils can have double the naphtha content vs. traditional crudes like Light Louisiana Sweet), the separated cut points are added to the existing crude unit piping for further processing from downstream units. New units have much more automation on the process, in particular to monitor asset health, resulting in safer, more reliable operation while meeting operational objectives. Older refineries were typically built with the minimal amount of instrumentation required to operate the plant safely.

Product quality and requirements. There has been a rise in markets served beyond the traditional local or regional demands, especially for the US. In 2011, the US exported more petroleum products than it imported for the first time since 1949. Although government regulations banned the export of raw crude oil from the US with the Energy Policy and Conservation Act of 1975 (EPCA), there is no ban on exporting oil once it has been refined into gasoline or diesel fuel. In fact, US refineries are now shipping record amounts of gasoline and diesel abroad (**FIG. 2**). The increase in foreign purchases of distillate fuel has contributed the most to the US becoming a net exporter of petroleum products. While this is good news for capturing new fuel markets, it also adds complexity and challenges related to product quality and many regional specifications. Ever-changing regulations have also constrained the ability to make products that meet all the required specifications.

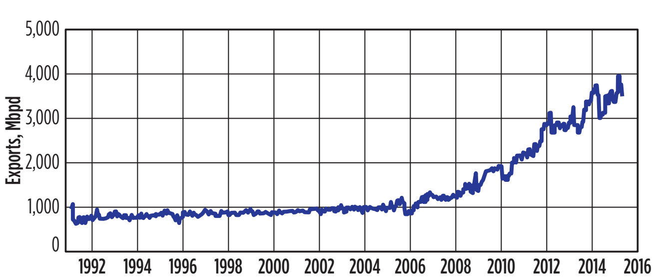

FIG. 2. US exports of total petroleum products, 1992–2014. Source: EIA.

FIG. 3. Modern automated systems can provide significant improvements in plant performance.

With additional markets served, this not only requires knowledge and ability to blend fuel products to specifications, but also the capability to effectively utilize storage tanks and timing, along with the effective use of all fuel component streams. Add inline blending and just-in-time delivery, and the reliability of the blending system becomes a major factor in a refiner's adeptness to serve the various markets. Having an individual processing unit shut down unexpectedly can result in a missing component required to meet both quality specifications and required regulations. Refiners may consider intermediate storage to temporarily sustain product blending during abnormal operation or shutdown of a unit.

The crude oil feedstock can also vary, resulting in a shortage of one fuel component and an excess in another. This adds to the complexity of product blending with component quality and quantity fluctuations.

A preferred crude oil blending system would be responsive and react in real time from online analyzers to identify incoming crude oil properties. Analysis of the properties of crude oils, considering product qualities and quantities, would provide optimum blend ratios of feedstocks (when more than two crude oils are blended). Refiners need to be nimble to take advantage of favorable market conditions to maximize one fuel over another—so both crude blending and product blending need to be considered, depending on the refinery configuration and current catalyst capabilities loaded in the reactors.

Refiners using an analyzer-driven blending system have shown that it is possible to determine important properties of each crude oil. This enables blending adjustments on the front end that impact desired product qualities and quantities on the back end. Using such a blending scheme, scheduling is improved by having visibility into incoming crude characteristics before purchase, as well as additional onsite analysis before being charged to the crude unit.

To add even more complexity, the supply chain can be disrupted as well. A crude shipment may be delayed due to weather in the Gulf of Mexico, for example, and a refinery will run with what crude is available onsite. Even in this circumstance, having online knowledge of the crude oil properties can be used to minimize the disturbance of a crude switch. Automatically making setpoint changes in a fractionator via advanced process control will result in minimal disturbance impact and duration.

Advances in automation technology. Modern automation systems include features not found in legacy systems, such as embedded advanced process control algorithms, statistical monitoring, smart device monitoring, asset health monitoring, the implementation of wireless sensing, and more. They bring process and asset condition data to both operations and maintenance, enabling new and better ways to integrate work processes and improve the timeliness and accuracy of decisions. Significant improvements in plant performance are possible when the right expertise is applied at the right time, and when personnel have the information and access to the specialized supplemental expertise they need to make quality decisions quickly. Most processing facilities are balancing the needs for safety, quality, profit, environmental compliance and reliability against the challenge of applying the right knowledge across organizational and geographic boundaries, while simultaneously reducing costs. Therefore, many manufacturers are taking advantage of technologies and efficiencies (**FIG. 3**) such as virtualization, remote monitoring, enhanced key performance indicators (KPIs) and dashboards, co-location of personnel, control room consolidation, etc.

Determining how to benefit from these technologies and processes can be complex. It requires industry and technology expertise, as well as a deep understanding of the company's strategic goals and the status of its facilities. It also requires an understanding of the business workflow, the operations and maintenance philosophies of the facilities, and the existing roles within the organization and the needs for collaboration between those roles.

The control room operator can and should be presented with not just more information, but with effective information that allows the right decisions to be made in a timely manner. If the console operator continues to use the modern automation system in the same way as the older replaced system, the benefits of additional functionality and information are lost. This is analogous to using a modern smart phone for the phone call capability only. As process units become larger and larger, the financial impact of unplanned slowdowns and shutdowns has become greater and greater, thus driving the new unit designs to have a greater emphasis on incorporating more measurements for asset health monitoring and for improving safety.

The automation technology and behavior to utilize the new information is advancing to meet the new challenges with crude oil supply variations and fuel product flexibility. Opportunity crudes can be discounted and too tempting not to buy. Because properties can vary, a traditional crude assay does not completely represent the crude oil delivered to the refinery. Hence, the need is for real-time analysis to provide the data for crude blending. This also contributes to the component qualities and quantities needed for product blending; new served markets, with different quality specifications and regulations, increase the complexity. A refiner needs to be flexible and responsive to stay competitive and profitable moving forward. HP

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