EQUIP FOR OPPORTUNITY CRUDES

Marcelo Carugo and Tim Olsen, Emerson Process Management, USA, discuss the rise of opportunity crudes, and explain how to implement them successfully in a facility.

The refining industry has changed noticeably over the past several years, with an ample supply of opportunity crude oils available. Opportunity crudes have been around for years, but only until recently has the abundance of these discounted crudes shifted the mindset of refiners.

With the use of opportunity crude oils comes new processing challenges; automation technology is advancing to meet these challenges to ensure refiners are successfully alleviating these issues. In addition, automation today is smart, having built-in diagnostics to alert if the instrument itself is not working properly; the key is to ensure these valuable diagnostics are not stranded out in the field.

Even though a refiner's process unit design and configuration are fixed, the refiner does have flexibility in selecting catalyst and which crude oils to process. Although the catalyst loaded will be fixed until the next turnaround, there are options to change it depending on expected crude oil feedstocks, product quality and yield. As for crude oil selection, most refineries process a number of different crudes depending on availability, price, and being acceptable to process for the refiner's configuration. For example, a refiner that is not designed to process heavy sour crude oil will tend to use little or no crude oil with these properties. Refiners on the coast will typically have more access to opportunity crudes and can process 50 or more different crude oils in a year. Because crude oils can be very different in properties (Figure 1), refiners try to match the required crude oil composition for their refinery configuration, usually by blending two or more crude oils. To make matters more

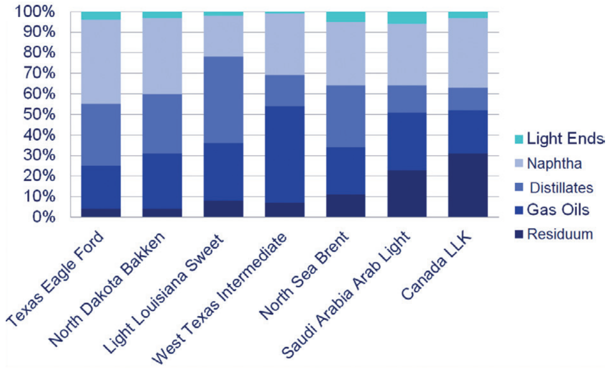

Figure 1. Distillation cuts displaying differences in properties.

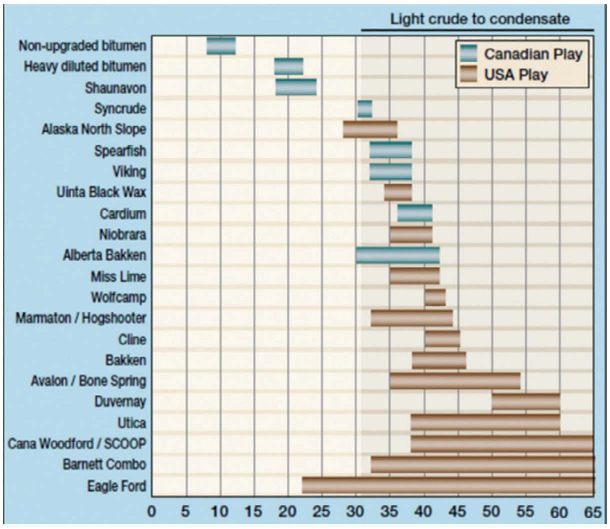

Figure 2. Crude oil API gravity variability. Source: Platts.

challenging, sometimes crude oils purchased to process are crudes that the refiner has no experience processing.

The main challenges with processing opportunity crudes include, but are not limited to: crude blending to match a refiner's configuration and processing capabilities, crude switch disturbances, fouling and accelerated fouling from incompatible crude blends, corrosion, energy balancing across the crude unit preheat exchangers, tight oils which have additional challenges related to H_2S (treated with amine-based H_2S scavengers), paraffin waxes, filterable solids, API gravity variability, and catalyst performance related to higher levels of calcium and iron.

Crude blending and API gravity variability

With numerous crude oil feedstocks to select and varying API gravity, a refiner needs to ensure the crude tanks have modern level measurement capabilities that can accurately measure tank level with a wide variety of crude oil gravity. In addition, as per API 2350, a second level measurement is required to avoid overfilling the tank.

With crude oil blending, a more consistent option is to have coriolis mass meters to measure and control the crude blend ratio. A volume basis may not provide the desired blend unless lab samples are taken in a timely manner to compensate for varying crude oil gravity (Figure 2).

Safety in the tank farm

Tight oil, sometimes referred to as light tight oil, is a crude oil from shales or other low permeability formations. Permeability is the ability for fluid, such as oil and gas, to move through a rock formation. Although tight oil is considered sweet (little sulfur content in the crude oil itself), there is H_2S that needs to be addressed at the drill site, during transportation and offloading. Even though amine-based H_2S scavengers are added to mitigate the safety risk, crude from North Dakota Bakken can be loaded in the cold of winter and have safe conditions, which is then transported via railcar to a warmer climate. The mixing of the railcar during movement along with a change in temperature can result in higher vapour pressure and the release of entrained H_2S, making the offloading a potential safety hazard. Hydrogen sulfide monitoring should be standard for loading and offloading if the refiner currently uses or has future plans to process tight oil.

Fouling and accelerated fouling

For a refiner, the original design and configuration of the processing units had a specific type of crude oil or range of crude oils in mind. As years went by, that particular crude oil may no longer be available or be priced competitively versus other opportunity crudes. For most refiners, the solution is to blend two or more crude oils to get the desired properties to match the capabilities of the refinery. Unfortunately, crude oil incompatibilities may happen if the refiner has no experience with the crude oil blend.

When crudes are incompatible, accelerated fouling occurs in the hot preheat crude unit exchanger train due to asphaltene precipitation. Accelerated fouling can lead to additional energy costs with the crude unit fired heater, limited throughput when the fired heater becomes duty limited, or earlier shutdown for cleaning. All these negatively impact the profitability of the refinery. Traditional manual heat exchanger fouling monitoring with limited data and Excel spreadsheets do not always catch which crude blends are incompatible, thus the same condition for accelerated fouling (incompatible crude blends) can be repeated in the future. Refiners processing many crude oils have recognised that additional temperature and pressure measurements across all preheat exchanger bundles along with predictive analytic software can detect accelerated fouling and also determine when a heat exchanger bundle should be cleaned. WirelessHART has enabled an economic and easy to implement solution to add sensors for more comprehensive monitoring and analysis.

If accelerated fouling is detected, a refiner can observe the current crude oil blend and make efforts to avoid that crude blend ratio in the future. It should be noted that the percentage of crude blends will have an impact on crude incompatibilities. For example, an 80 - 20 blend with 20% tight oil may not be enough to see accelerated fouling, whereas a 70 - 30 blend may be unstable and have unwanted accelerated fouling.

Corrosion monitoring and desalter level

Lately refiners have invested more in corrosion monitoring as they utilise more opportunity crude oils, some considered a high TAN crude, but with the intent to blend and keep the overall TAN within limits for the processing unit design metallurgy. The typical monitoring technique in the past was corrosion coupons or probes (intrusive) along with inspections during turnarounds. The disadvantage of a coupon is that the processing unit needs to be shutdown during installation and inspection. Automation advances have allowed online monitoring capabilities (non-intrusive) along with corrosion coupons and inspections during turnarounds.

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.

If a refiner is using tight oils, unwanted paraffin waxes and filterable solids, as much as 200 lbs/1000 bbls, are also part of the crude oil and are typically treated with chemicals and removed in the desalter. With the desalter expected to do more, these additional chemicals and solids make it more difficult to detect the emulsion separating the water and oil in the desalter. Guided wave radar level measurement is a solution that has helped avoid carrying over brine into the downstream units.

Fired heater optimisation and safety

The crude unit fired heater is a main user of fuel gas/natural gas to heat the crude oil prior to entering the fractionator. As mentioned earlier, heat exchanger fouling can increase the duty requirements for the fired heater. However, so can operating the heater with too much air. All refiners understand the importance of operating with optimal air, but many tend to operate conservatively with too much air to ensure safe operations. The primary reason for this behaviour is a lack of confidence in the CO and O_2 flue gas analyser measurements. As stated earlier in this article, smart instruments have diagnostics to ensure the instrument itself is working properly. With online diagnostics available, console operators can have the confidence to operate the heater less conservatively yet maintain safe operations.

In April 2011, API released an updated RP 556 related to fired heaters. The new recommended practices included advances in safety automation and design procedures and implementation practices since the first edition in 1997 (this former document no longer reflected cumulative best practices). The revision by committee comprised of instrumentation, control and heater experts. Although refiners may be aware that this document has been released, they may not yet have studied the content or may not yet understand what their particular situation is with respect to the fired heaters within their facilities.

One example from the updated recommended practice is how refiners are controlling the fuel gas flow by controlling the burner header pressure or controlling the flow, as measured by the differential pressure across an orifice plate, then changing composition of the refinery fuel gas will change the amount of heat released in the heater, if at constant header pressure or at constant orifice dP. Hence this disturbance of varying fuel gas composition will not be corrected by the process controls until the heater outlet temperature changes. However, since the heating value of light hydrocarbon gas mixtures more closely correlates to mass flow rather than volume flow, it is recommended to control the mass flow of fuel gas to the heater to minimise the impact to the process when changes in fuel gas composition occur; a coriolis meter is recommended to directly measure the mass flow without the need for compensation.

Finally, advanced process control (APC) on heaters ensures consistent and safe operation across all shifts no matter the console operator. Most refineries have APC implemented on the fired heater and downstream fractionator.

Atmospheric fractionator

Although refiners try to mitigate crude switch disturbances by keeping similar crude properties, crude blending mostly, conditions outside their control may occur. For example, a crude oil shipment may be delayed, resulting in a refiner to quickly switch to a crude oil that is currently onsite (no second crude oil to blend for example). Refiners with APC have the ability to mitigate the disturbances caused by the switch, thus downstream units are less impacted. For those without APC, console operators may struggle throughout their entire shift trying to line out new operating conditions for the different crude properties; time spent changing setpoints manually impacts downstream units for a longer period.

The other advantage of APC on the fractionator is the ability to maximise certain sidecut draws when favourable market conditions occur, while keeping all sidecut draws on specification. Today's modern automation systems include features not found in legacy systems, such as embedded advanced process control, statistical monitoring, smart device monitoring, asset health monitoring and more. The console operator can, and should, be presented with more than just measurements but rather current information that allows them to make the right decisions in a timely manner.

Training

Finally, with new automation and timely information from predictive analytics, the console operators need to be trained to act on this new insight. New alerts should not create confusion, but rather decisive action to mitigate abnormal operation or imminent failure. For those refiners investing in the technology, they should not forget to ensure the staff knows how to use it.

Conclusion

Opportunity crudes can be discounted and too tempting not to buy. As their properties can vary, a traditional crude assay does not always represent the crude oil delivered to the refinery. Hence, there is a need for additional measurements, predictive analytics and advanced process control to effectively handle these varying feedstocks. Automation technology and behaviour to utilise the new information is advancing to meet the new challenges with opportunity crude oil supply.