Volver

Impact of Tight Oil Processing in refineries

Marcelo Carugo

Emerson Process Management

Marcelo.carugo@emerson.com

Summary

The nature of crude is changing and the refining industry must change with it. At one time, oil wells could be adequately characterized by a crude assay that would change only slowly with time. Thus, refineries could count on fairly stable feedstock.

That is no longer the case, with the arrival of shale oil and other opportunity crudes resulting in wider feedstock variations. Dealing with this situation requires three components: an ability to do accurate, on-the-fly, rapid analysis; the capability to adjust feedstock blending as needed; and smart process control to achieve the best processing possible.

This paper will describe the tight oil characteristics which require some modifications to the refineries production schemes that are underway or in engineering phase in US and Argentina.

INTRODUCTION

A Changing World

Consider the situation confronting refineries in the past. Feedstocks largely came from traditional oil wells, which were typically characterized by a crude assay that determined such important parameters as density, sulfur, salt content and volumetric yield. Usually the crude assay would change little over time, often taking years and only happening slowly as the well moved toward the end of its productive life. What's more, the crude assay of one well frequently could serve as a proxy for all other wells in a field.

As a result, refineries dealt with stable feedstocks. In many ways, this aided process optimization.

Refineries consists of many process units which are operating on fully integrated basis, which as a whole, pose challenges to quickly adapt to changing feedstocks."

Of course, yesterday's refineries still had to deal with variation, but the cycle of change often ran over years.

Now look at the world confronting refineries today, as illustrated by the accompanying chart of properties (see attachment No. 1) of various sources of United States and Canadian crude. Examine the last entry, that of Eagle Ford. Five years ago, this source accounted for 50,000 barrels a day of production.

(Attachment 3) A year ago, thanks to hydraulic fracturing and horizontal drilling, that figure had climbed to 1.1 million bbl a day, a more than 20-fold increase. Understandably, this feedstock source has become grown more important. Thanks in part to this surging production, the United States has vaulted into the position of being the world's leading fossil fuel provider.

Yet the crude produced from the Eagle Ford formation has the most variation of any of the 22 sources listed. The percentage of light crude to condensate lies between a low of about 20 and a high of 65 percent. Thus, it can require very different processing, depending upon where along the spectrum a particular batch of crude lies. However, other sources also exhibit large variations in important parameters.

Two more pieces of information complete the picture. The first is that one Eagle Ford cargo may differ radically in characteristics from another, even though both bear the same name. So, the type of crude assay that has been valuable in the past is no longer so useful because assays that were once good for many years, if not decades, may no longer hold from one well to another or from one well to itself a few months hence. Second, for those who want to dismiss this as mainly an Eagle Ford or U.S. problem, realize that other areas around the world are also considered strong hydraulic fracturing candidates. For example, Argentina's Vaca Muerta basin is thought to similar to the richest drilling areas in the U.S. and there are also plays in Australia, China and Poland. (see attachment no. 2) credit EIA.

In general, such opportunity crudes offer discounted pricing and are increasingly abundant as compared to traditional sources. However, they vary in properties and so may not match the design and configuration of a refinery.

Dealing with the situation involves three steps: developing the right analysis capabilities and then using the data thus generated to adjust the blend and the process to create the optimum solution.

METHODOLOGY

First, Analyze

Having a sufficiently advanced analysis capability is critical. Ideally, this analysis will be capable of rapidly discriminating between different types of crude, thereby providing information about distinguishing characteristics. Such data can then serve as the source for any plan to deal with incoming feedstock.

Importantly, the analysis must also capture data about crude properties in general. Often, the engineering and operations team at a refinery may not know exactly what will cause problems with heat exchangers, distillation columns and other components of a crude processing unit. Casting as wide an analysis net as practical can provide some protection against such unknowns. The analysis data can be used to produce a history of properties of past crude shipments that may be essential to diagnosing problems when they occur.

There are many different ways to do such an analysis. Of all the possible methods, techniques based upon light can come perhaps closest to the ideal of a fast, cost-effective, and highly discriminating analysis method. All matter interacts with electromagnetic radiation, but the nature of that interaction depends upon the material and the wavelength of the radiation. So, developing a light-based method involves finding the right spectral band to use to interrogate the incoming feedstock stream and then devising ways to interpret the data.

Researchers at large global oil companies have devoted years to investigating the feasibility of using light in the near infrared, a spectral region that runs from the edge of the visible at 700 nanometers out to about 2500 nm. This is well below the thermal IR, which is 5000 nm and on up and which is where objects can be detected by the heat they generate.

The reason why the near IR has attracted interest as an analysis tool is that chemical bonds absorb such light. This is particularly true for the varying hydrocarbon bonds found in crude, with the region running from 2000 to 2500 nm being among the best possible choices because it is far enough from the visible to be free of any absorption effects related to the light that can be seen with the naked eye.

The result of absorption in this near IR band is a spectral signature. Such a signature can identify specific hydrocarbons as clearly as fingerprints do people.

Correctly classifying hydrocarbons is a multistep process. First, the instrument takes spectral data from a sample of unknown composition. This is then compared to the results from a library of samples with a known makeup. The product is something like a scatter plot, with one axis being the wavelength and the other being a relative reading. Visually, this would group various grades of crude into different clusters.

In the ideal world there would be plenty of data points to easily place an unknown into the proper classification. In the real world, refinery managers cannot wait too long for an analysis to be complete. At the same time, they cannot afford to have an analysis be wrong, since that may actually be worse than not knowing anything at all.

One way out of this bind that is being pursued by instrument makers is through a process called densification. This is based on interpolation between a sparse set of data points to create a much denser data cloud. Consequently, the accuracy of analysis can be significantly improved without having to sacrifice speed. Doing densification properly demands deep expertise in in the how and why of spectral blending.

Taking Action, Part A: Blending

Using analysis to determine crude characteristics is only part of the solution. The second and third steps involve acting on the information.

In the ideal world, such action would be easy. Distillation columns, heat exchangers, and the rest of a crude processing unit would be infinitely and rapidly adaptable to the incoming feedstock, thereby ensuring the best possible outcome. Unfortunately, refineries operate in the real world. Consequently, there are some constraints on how they can be configured.

However, the range of possible solutions can be expanded because there are two sides to this optimization puzzle. On one hand there is the refinery and its capabilities. On the other is the feedstock. It is the mismatch between the two that is the problem, and, as has been discussed earlier, today's feedstock has more variability than ever. So, by careful blending incoming feedstocks it may be possible to create an input stream to the refinery that is a better match than any crude source may be on its own.

What would an ideal blending solution look like? It would be responsive and react in real-time to input from analyzers characterizing incoming crude. It would have algorithms built in to it that would give the optimum ratio of different feedstocks for a given situation. Importantly, the best crude oil blend would vary depending upon refinery configuration and the desired fuel target to maximize during favorable market conditions. At one time it might be gasoline.. In another case it might be either ultra-low sulfur diesel or jet aviation fuel, Jet A1. Lubricants and asphalts are another class of products that might be part of the decision matrix.

Projects in Europe and Americas using an analyzer-driven blending system have shown that it is possible to determine such important properties of crude as its True Boiling Point in less than a minute. In turn, this enables blending adjustments that result in benefits that run into the millions of dollars.

Scheduling in such a blending scheme will be improved by having visibility into incoming crude characteristics as soon as possible. That implies that analysis should be done as soon as feasible in the supply chain.

Speaking of the supply chain, disturbances happen. A crude shipment may be delayed, for instance, and a refinery will then run with what is in the tank because it costs too much for a facility to shut down and sit idle while waiting for a shipment to show up. Even in this case, though, knowing the characteristics of what is on hand in can be used to minimize the disturbance of a crude switch. For instance, automatically making set point changes in a fractionator via advanced process control may help smooth out any supply hiccups.

Taking Action, Part B: Smart Refining

The last item brings up an important point: process control. Actual situations will necessarily have some unevenness in feedstock properties. Therefore, the third and final part of the ideal solution involves implementing intelligent refining solutions. For instance, it is not only changes in feedstock that can impact the distillation process that is at the core of refinery operations. Changes in the weather can also push distillation column operation out of optimum. One way to avoid going out-of-spec as a result of feedstock, weather or other changes is to over-purify, leading to wasted energy and lower product yield. A better solution is to use advanced process control technology to automatically adjust distillation column parameters to optimal targets without violating constraints.

Doing so will reduce product quality variation and off-spec production while minimizing energy consumption per unit of feed. It also will increase recovery of more valuable products and column throughput. In the context of a world where feedstocks are more variable, this will mean that blending operations will have more leeway. This is because the blended feedstock can have a wider range of characteristics yet the refinery will still be able to produce the required product blend.

This distillation process control also has to be dynamic. After all, it is not only the feedstocks that are changing over time. The output goal is also changing. The possible targets include reduced energy consumption or production at maximum capacity, just to name two. It may be necessary in the first case to minimize purification while in the second the requirement may be to continuously operate a distillation train at the most limiting overall constraint. Thus, refinery process control should be nimble so as to cope with changes in operational targets and feedstocks.

Conclusion

As has been shown, the world of crude is changing due to the appearance of significant supplies of shale oil and other highly variable feedstock. In addition to becoming increasingly abundant as compared to traditional feedstock, these opportunity crudes may be discounted and so cannot be ignored. Because their properties are so variable, an old-style crude assay does not make sense. Hence, the need is for real-time analysis to provide the data for ad-hoc blending of crude supplies and intelligent process control. Together these can make a solution.

Given the reality of the world refineries face today, it is important that such optimization solution be implemented. It is also important that when this is done, it must be backed by deep expertise, as this is the best way to successfully handle a complex and changing situation.

BIOGRAPHY

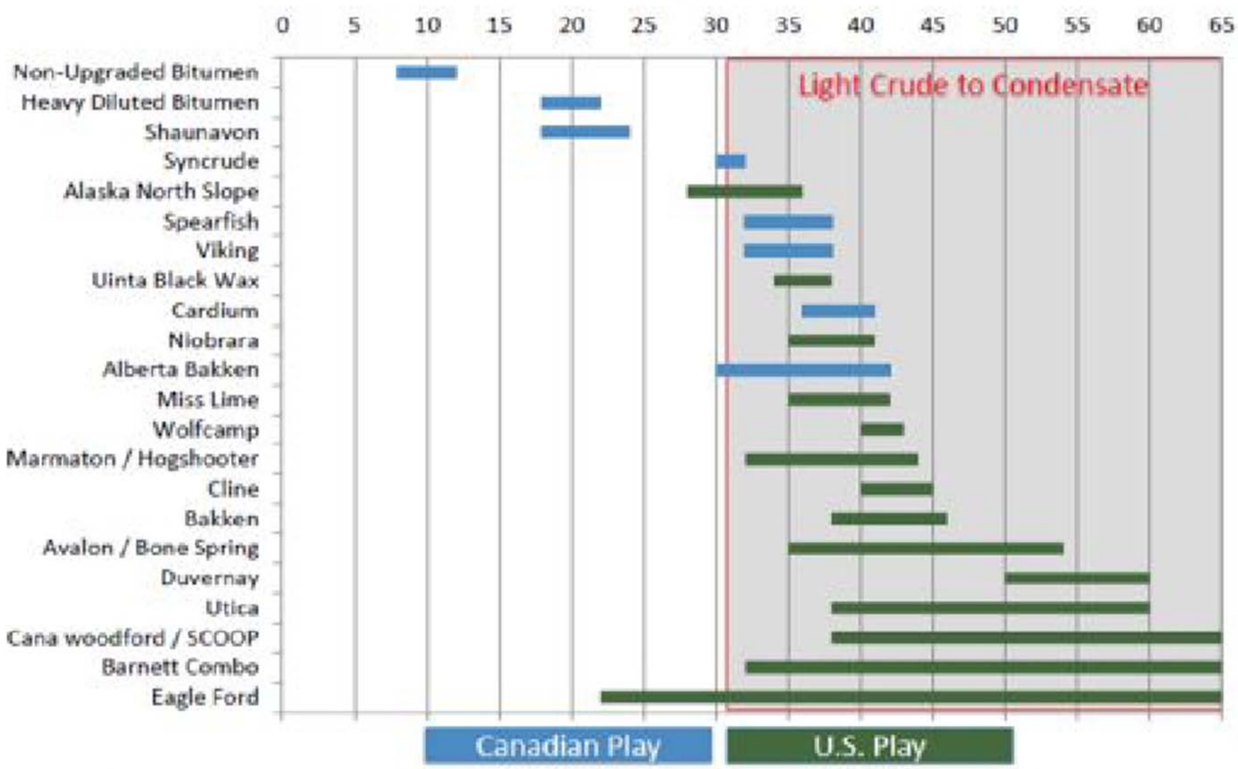
Marcelo Carugo

Emerson Process Management

Refining Global Director

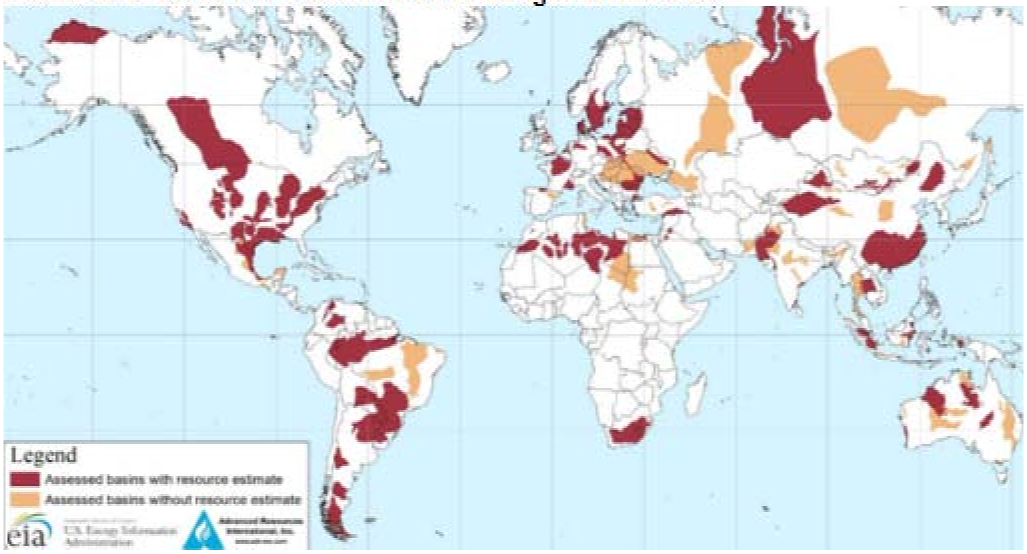
ATTACHMENTS

Attachment No. 1 (credit to Platts)



Source: Platts

Basins with assessed shale oil and shale gas formations



Attachment 3