Allocation of Non-Conventional Feedstocks in Petroleum Refineries: An Overview

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More and more, conventional crude oil is being augmented by synthetic crudes from oil sands, oil shale, GTL processes, biomass, and coal. What is the best way to convert these non-conventional feedstocks into useful products? To what extent can existing facilities be used? How will non-conventional feeds affect product yields and properties?

Steel on the Ground Already

Petroleum is a tough act to follow. It is found on or beside every continent. It is stable enough to be stored either by leaving it in the ground or by pumping it out and loading it into tanks or caverns. With relative ease, it is converted into fuels, and (along with its close cousin, natural gas) is transformed into thousands of chemicals used to make plastics, fibers, dyes, waxes, building materials, etc.

Petroleum-based fuels are clean, stable fluids under ambient conditions. With little or no degradation, they can be stowed for weeks or months and pumped through pipelines for hundreds of miles. They are relatively safe; every day, billions of people use them with confidence.

Replacing a "typical" modern refinery could cost about $4 billion. Older refineries were cheaper, but it is safe to conclude that, in today's money, the world's 700 petroleum refineries [1] represent an investment of nearly a trillion dollars. Many times more money than that has been invested in product distribution – pipelines, terminals, barges, and retail outlets.

Refining companies are not the only stakeholders with vested interests in existing infrastructure. Their customers own and operate engines, vehicles and petrochemical plants. This equipment was designed to use particular substances. Changing those substances would require these customers to replace or retrofit their equipment – at considerable cost.

Cost is not the only factor. Change takes time. Time is expensive. So are people. These days it is hard to find qualified engineers and operators to design and run new plants. High demand, driven in part by rapid economic growth in Asia, has increased the cost of raw materials. And as we have seen in recent months, even if the rate of economic growth decreases, it may hard to find capital.

Without doubt, and to the greatest possible extent, energy companies will continue to use their "steel on the ground already."

Which Feed Where?

At present, several petroleum refiners are processing blends of non-conventional feeds with conventional crudes. In many places process modifications were required, but most of these have been minor, such as protecting hydrotreating catalysts with arsenic-trapping material and accepting shorter catalyst cycles.

Dollar-wise, planning is a bigger problem. In the past, traders bought conventional crudes based on density, sulfur, and distillation. These guidelines do not necessarily represent the value of non-conventional crudes. Planners have learned the pitfalls of using conventional-crude LP vectors to allocate streams within refineries.

Non-conventional feedstocks have un-conventional value because they contain different molecules, which behave differently in existing process units. Examples include:

- Synthetic crudes from oil sands and oil shale often contain arsenic and other unusual trace metals. At sub-ppm levels, arsenic can cause rapid catalyst deactivation.
- Pre-hydroprocessed feeds tend to have low density, low sulfur content, and low nitrogen content. But they also contain large amounts of polynaphthenes and naphtheno-aromatics. In hydrocrackers and hydrotreaters, these compounds can induce rapid catalyst fouling.
- Liquids derived from biomass contain higher-than-usual levels of olefins and organic oxygen, which can quickly release a lot of heat during processing. This limits the amount that can be blended safely into conventional feedstocks.

Conclusion

To properly allocate non-conventional feeds within existing petroleum refineries, we must understand their composition and reaction chemistry. We must understand what can and can't be done by changing catalysts and process conditions. We must learn how the new feedstocks affect yields and product properties. We must update the models we use for control, operations, and planning.

We may end up with some new steel on the ground, but for now it's challenging enough to learn how to use the steel we already have.

[1] International Petroleum Encyclopedia 2004, PennWell Corporation, Tulsa, OK: p. 286.