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HP Viewpoint

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The opportunity for greater growth and value—Considerations for crude-to-chemicals projects

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Industry players are focused on upgrading to higher-growth, higher-value chemical products. One approach to achieve this on a large scale is crude-to-chemicals facilities. These configurations create a step-change increase in conversion, resulting in the share of final products being as much as 50% chemicals. Energy usage, hydrogen balances and resid upgrading options at the site are critical when developing crude-to-chemicals projects.

In the article "The need for change—Why the industry is looking at crude-to-chemicals," published in the August issue of *Hydrocarbon Processing*, it was shown that growth in the middle class is the key driver behind the global demand for chemicals outpacing the growth of global GDP.

As the industry looks to capture value from these trends, there has also been a shift toward more sustainable growth, with producers looking to reduce energy consumption and emissions.

A step-change transition in product mix. A traditional refinery's product mix will typically generate around 20% resid (**FIG. 1**), with fuels consisting of most of the finished products. The lighter material will be converted to chemicals—approximately 5%–20% of the total—depending on the level of aromatics and olefins recovery.

When transitioning to a product slate favoring chemicals, a refiner would implement the first round of changes to increase paraxylene (PX) production that would result in the product mix shown in the middle bar in **FIG. 1.** As coke production and handling become less desirable, producers minimize the bottom of the barrel and upgrade the resid.

Recently, producers have been trying to push that balance even further, driving the fuel production down to as low as 50% of the total product mix—the right bar in **FIG. 1.** They further maximize aromatics production and upgrade molecules into other derivatives, such as polyethylene and lubricants.

A chemicals-focused run plan will require a step-change increase in the conversion of gasoils and resid to light liquids by adding processing units. For example, **FIG. 2** shows a high-conversion, maximum-chemicals configuration, which added a proprietary coking technology[a] unit to convert vacuum resid to coker naphtha and gasoils. The coker liquids are fed to the hydrocracker, while light gases from the proprietary coker unit would be combined into the fluid catalytic cracking (FCC) gas plant.

To maximize chemicals production, light paraffins are processed in a dehydrogenation plant to produce propylene and butylene. An aromatics plant produces benzene, toluene, and mixed xylene or PX. Naphtha and light gasoils are fed to a steam cracker to produce ethylene and higher olefins.

Because of the additional processing facilities, chemicals production can be increased to approximately 40%–50% of the product slate.

Resid conversion. Several technology alternatives exist for each of these processing steps. However, the vacuum resid conversion technology is critical to managing a range of important parameters affecting the configuration. Several factors must be considered, which include:

1. Energy balance: Is the site a net importer of energy? If so, what types are available?
2. Hydrogen balance: What is the source and economics of the site's hydrogen?
3. Environmental considerations: Are there permitting limits on sulfur oxide (SO_x), nitrogen oxide (NO_x) particles, solid coke handling or other emissions that must be met?

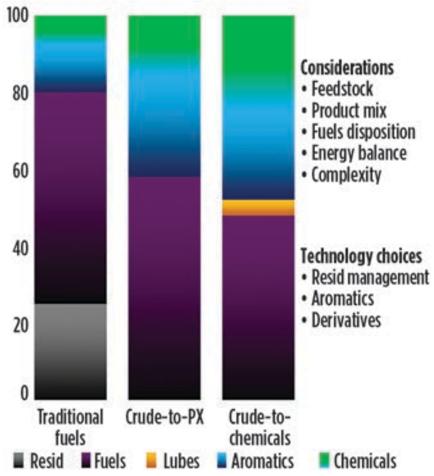

FIG. 1. Transitioning the product mix from traditional fuels to chemicals.

Other factors include investment costs, feed flexibility, cost and disposition of unconverted pitch and tar, as well as the cost of fresh catalysts and disposition of spent catalysts.

In their initial form, resid (or residuum materials) are hydrocarbons with high boiling points and are unsuitable for transportation fuels or lubricants. However, they can be converted to lighter, more hydrogen-rich hydrocarbon types.

Two basic approaches exist to process these feedstocks into more valuable lighter products: hydrogen addition and carbon rejection.

Hydrogen addition. This approach usually operates at a high pressure and depends upon catalysis and hydrogen gas to achieve the desired reactions, which simultaneously crack and hydrogenate the large residuum molecules.

These heavy feedstocks generally cause catalyst deactivation at a significant rate due to coking and the presence of hetero atoms and metals, requiring high fresh catalyst makeup rates.

Hydrogenation is indiscriminate, and the resultant high hydrogen demand can be expensive at locations where hydrogen is costly. These processes also produce a very low-quality bottom stream that is difficult to dispose of in a cost-effective manner.

Carbon rejection. This approach generally refers to thermal coking processes that operate at low pressure and utilize thermal cracking reactions to achieve the desired conversion of the high boiling molecules.

This chemistry results in a redistribution of hydrogen in the feed to yield lighter liquid products with higher hydrogen-carbon ratios and a byproduct of solid coke with low hydrogen-carbon ratio.

Typical commercial coking processes include delayed coking, fluid coking and the previously mentioned proprietary coking process. Solvent deasphalting is an alternative carbon rejection process that separates carbon-rich asphaltenes by solvent extraction from a more hydrogen-rich deasphalted oil that can be processed in conventional FCCUs or hydrocrackers. The asphaltene pitch or "rock" is typically disposed of in fuel oil blending or in a coking process.

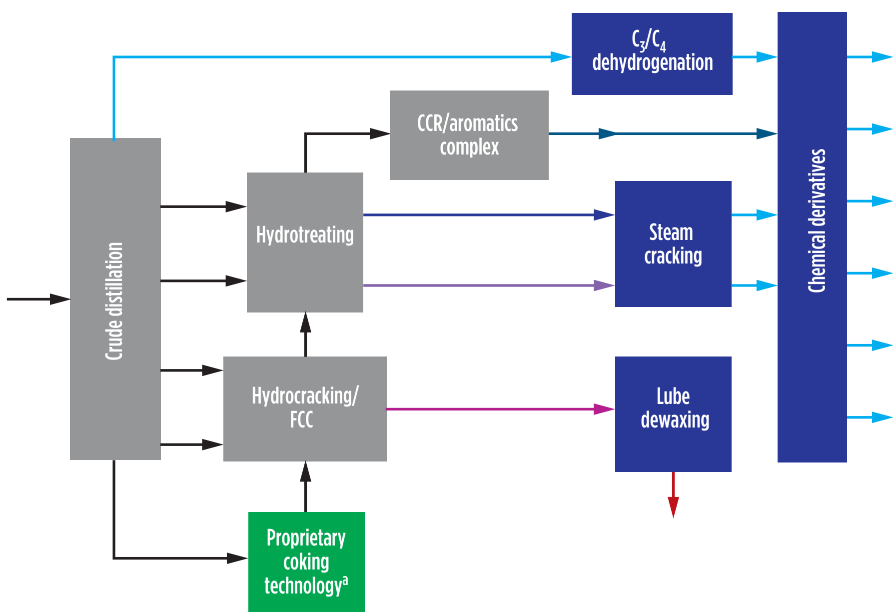

FIG. 2. Crude-to-chemicals run plan.

FIG. 3. View of ExxonMobil's chemical plant in Singapore. The facility is ExxonMobil's largest integrated manufacturing site in the world. Photo courtesy of ExxonMobil.

Takeaways. The demand for higher-value, higher-growth chemical products has created a unique opportunity for producers to improve their profitability, while supplying raw materials that will help billions of people improve their basic standard of living (**FIG. 3**).

Crude-to-chemicals projects represent one way that the industry is pursuing this opportunity, and resid conversion is a key element in the project configuration that impacts how much value can be extracted across the integrated facility.

Extracting the maximum value from all of these choices can be a significant challenge, but, by collaborating early with your technology provider, you can ensure that your configuration results in the best overall solution for your project. HP

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[a] Refers to ExxonMobil's FLEXICOKING technology