CATALYST & TECHNOLOGY NEWS

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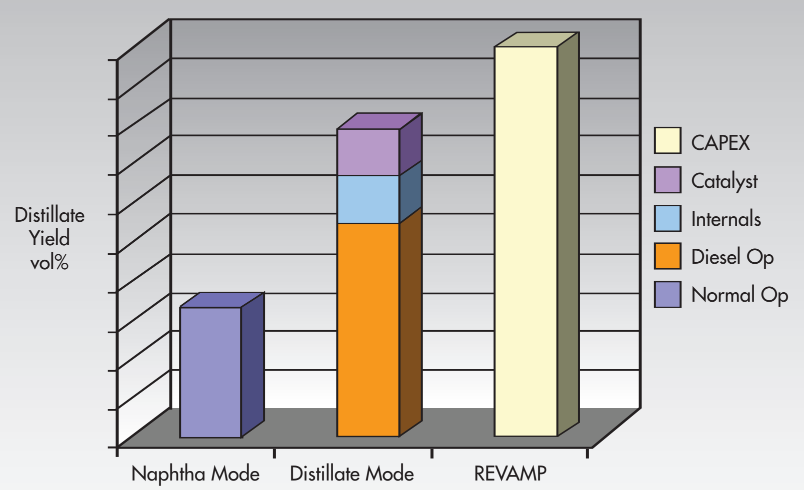
Maximizing Diesel in existing Hydrocrackers

Diesel has been getting lots of attention these past few years in both North American refining and worldwide. Hydrocrackers are a major source of high quality diesel, although most of the conversion capacity of the approximately 60 operating hydrocrackers in North America is geared to the gasoline market. Criterion and Shell Global Solutions (Shell GS) have experienced that many hydrocrackers can add product flexibility. This switch from gasoline to distillate mode can be achieved by adjusting process operating parameters such as cracking conversion, liquid recycle rate, and product cut points without requiring capital expenditures (CAPEX). Further maximizing of diesel production and quality from existing assets can be achieved through changes in catalyst and through CAPEX investment in small or large revamp projects.

Clearly, each hydrocracker is unique and requires a detailed analysis of feed diet, operating constraints, and desired yield to adjust and optimize operations. Maintaining flexibility to adjust to diesel market conditions and building in the capability to handle a variety of feeds will allow for maximum hydrocracker profitability.

Figure 1 illustrates the potential increase in distillate yield based on a single or two-stage hydrocracker for which the main fractionator bottoms are used in diesel pool blending. Feed quality, especially the final boiling point, needs close monitoring in these units to meet diesel specifications.

FIGURE 1

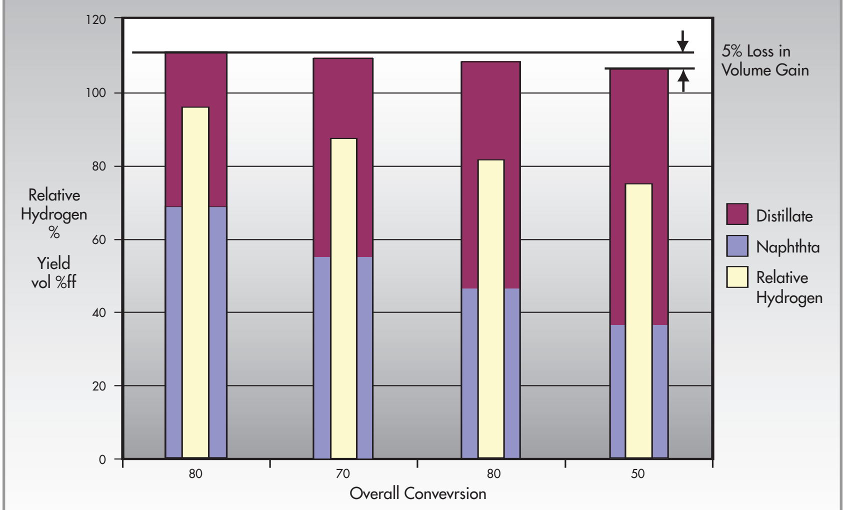


Example of Maximizing Hydrocracker Diesel Yield

The relative increase in distillate production when switching to a distillate mode of operation is based on fixed feed rate and quality while meeting diesel quality specifications. The feed is a mixture of light cycle oil (LCO), atmospheric gas oil (AGO), and light Coker gas oil (LCGO). These deltas are based on hydrocracking units for which the cut point between naphtha and distillate is 375°F. The distillate yield represented is the 375°F+ material.

Hydrocracker distillate mode operation is typically achieved by switching from a recycle operation to once through operation while lowering conversion, which increases diesel (bottoms) production, as depicted in Figure 2.

FIGURE 2



Reducing conversion in HCU to Maximize Diesel

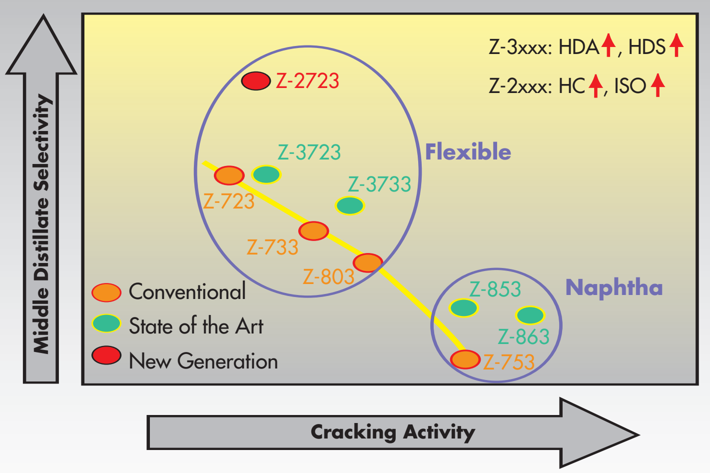
Hydrogen consumption is shown as a percentage of the high-conversion-naphtha-mode operation hydrogen consumption. Yield is shown as a percentage of fresh feed.

As discussed below, lower conversion may result in lower distillate quality due to an increase in aromatics and resultant drop in API gravity. A drop in product quality can be overcome through the use of a more distillate selective catalyst that will improve distillate quality via higher hydrogenation activity while improving distillate yields.

Hydrocracking Catalysts

The cracking catalyst portfolio of Criterion/Zeolyst, is well established in providing a wide range of solutions to meet product selectivity and product quality targets. As an illustration, Figure 3 shows the middle distillate selectivity and cracking activity of Flexible and Naphtha selective catalysts.

FIGURE 3



Reducing Conversion in HCU to Maximize Diesel

This is a limited view of the entire Criterion/Zeolyst cracking catalyst portfolio focusing on Naphtha and Flexible catalysts only. Flexible catalysts directionally have more hydrogenation activity than the Naphtha catalysts. HDA aromatics saturation activity, HDS desulfurization activity, HC hydrocracking activity, ISO isomerization activity.

Shell GS and Criterion/Zeolyst have utilized these catalysts to meet a range of liquid product goals in many refineries in North America and throughout the world. As summarized in a 2006 NPRA paper (1), Shell GS has applied state-of-the-art cracking catalysts, such as Z-3723 with superior hydrodesufurization (HDS) activity via enhanced aromatic saturation performance (HDA) to remove the difficult sulfur species from hydrocracker distillate fractions while improving distillate yield. As described in the referenced 2006 NPRA paper, the North American refiner was able to meet ultra low sulfur diesel targets while reducing bleed sulfur significantly throughout the cycle. This resulted in improving diesel production at the refinery with significant economic benefits for this refiner.

In many refineries, an improvement in distillate yield and quality has been realized by switching catalysts from a Naphtha catalyst to a Conventional Flexible catalyst. Table 1 illustrates the advantages of this change in catalysts as experienced at a North American refinery.

TABLE 1

		FLEXIBLE
Gas Make	scfb	-15%
Naphtha	vol %ff	-1.4
Distillate	vol %ff	+1.8
Unconverted (UCO)	vol %ff	BASE
Feed Rate	bpd	+15%
Distillate	bpd	+20%
H_2 Consumption	MMSCFD	BASE

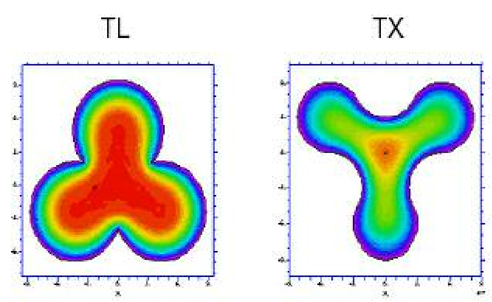
Commercial Results for Catalyst Change to Increase Distillate Production

The values for the Flexible catalyst case are relative to the base Naphtha catalyst. The volume percentages are presented on fresh feed basis as denoted by the "ff". In this case, the distillate produced was from a side draw.

At this refinery, the hydrocracker was constrained by the gas make from the hydrocracker. Since the gas make and hydrogen consumption were lower for the Flexible catalyst, the feed rate to the unit could be increased to match the refinery's capacity to: a) handle the gas generated from the hydrocracker and b) supply hydrogen to the hydrocracker. The increase in the feed rate, combined with the increased selectivity of the catalyst, equaled increased barrels of produced distillate. The lower activity of the Flexible catalyst compared to the Naphtha catalyst did not limit the hydrocracker overall catalyst cycle, since the cracking catalyst temperature window still fit within the pretreat catalyst operating temperature window.

Though reactor loop pressure drop was not an issue in the above example, lowering reactor pressure drop is always beneficial to hydrocracker operation, particularly if it is a limiting factor for hydrocracker feed rate and/or cycle life. As presented in a 2007 NPRA paper (2), the catalyst shape TX has been designed to reduce pressure drop across the reactor high-pressure loop.

FIGURE 4



Cross Section of TL Trilobe Shape Compared to the TX Trilobe Shape.

The TX Trilobe shape further reduces the diffusion path and simultaneously decreases pressure drop through a higher void fraction.

Implementing Flexible Solutions

The right solution for "dieselization in North America" will be highly dependent on the individual refinery's configuration and marketing position. The best solutions should be developed out of deliberate evaluation of "unit know-how" with "best available technologies". Attention should be given to refinery-wide integration to improve return on investment.

Flexible solutions within an overall refinery approach can increase capability to respond to market variation, particularly when pursuing a targeted gasoline-to-diesel ratio.

For more information on how Criterion/Zeolyst and Shell Global Solutions can contribute to your hydrocracking operations, contact your Criterion sales representative or visit www.criterioncatalysts.com.

For detailed information on options for increasing diesel in existing hydrocracking units and the development of grassroots units for current and future crude sources, refer to the 2009 NPRA paper (3)

1. M. Hu, R. Anderson, R. Adarme, C. Ouwehand, J. Smegal, „The Era of ULSD – New Challenges and Opportunities for Hydrocracking Processes", NPRA 2006 Annual Meeting, AM-06-46.

2. A. Sharpe, B. Jones, V. Hruska, G. Baumgartner, R. Anderson, R. Adarme, M. Hu, C. Ouwehand, M. Boer "A Success Story: Significant improvement in hydrocracker profitability with ULSD production through customized catalyst systems, state of the art reactor internals and outstanding technical cooperation", NPRA 2007 Annual Meeting, AM-07-67.

3. R. Karlin, A. Macris, R. Adarme "Dieselization in North America: Flexible Solutions for Diesel Production", NPRA 2009 Annual Meeting, AM-09 101.

If there questions you would like to pose to the hydroprocessing experts at Criterion, contact us today to learn more at CriterionPublicAffairs@cri-criterion.com.

Important:

All information contained in this document is considered accurate at the time of the testing, based on the equipment, and specific conditions and other limitations during the testing process. It is being furnished upon the express condition that the user will make its own assessment to determine the accuracy and applicability for the user's particular purpose.

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