Unlock Product Flexibility for Maximum Profit with Hydrocracking Capability Innovations

The world market for transportation fuels continues to be driven by an increased long-term demand for high quality diesel. However, the path to higher diesel demand will not necessarily be straightforward, and will contain periods of significant swings between naphtha and diesel demand and profitability. With this forecasted diesel demand growth there is expected pressure for increased price differential between diesel and gasoline. As a result, refiners are asking, “How can I shift hydrocracker operations to flexibly produce either naphtha or diesel?” Therefore, refiners are searching for cost-effective solutions to successfully increase diesel yields from existing refinery assets but doing so with a flexible solution that will allow maximum production of diesel or naphtha as their local market dictates.

Evaluating project cost and product requirements requires in-depth knowledge and application of refinery-wide technologies, evaluating both catalyst and process designs, to meet these new challenges. UOP is uniquely suited to this task, deriving knowledge from over 100 refinery catalysts and over 70 process technologies installed worldwide for almost 100 years.

Among the key process units impacting the refinery diesel production rate, naphtha hydrocrackers can play an important role.

Naphtha hydrocracker landscape
Based on UOP’s experience and presence in the hydrocracking unit marketplace, a unit landscape was developed which classified the North American hydrocrackers by configuration, feed type and gross conversion to naphtha. (Figure 1)

This hydrocracker landscape provided UOP a fuller understanding of the market in the context of increased diesel production opportunities.

Naphtha hydrocracker commercial and pilot plant data base
UOP assembled commercial operating and existing pilot plant data maps to compare against the Naphtha Hydrocracker Landscape. Units where UOP has collected commercial operating data are shown in green. (Figure 2)

UOP’s pilot plant data map corresponding to the naphtha hydrocracker landscape (Figure 1) is shown in Figure 3. These commercial and pilot plant data maps demonstrate the variety and depth of existing experience already available to UOP. From them UOP identified specific data needs to be addressed in an additional capability project pilot plant program, as highlighted at the bottom of Figure 3.

Naphtha to Diesel Capability Project
UOP, as the leading hydrocracking process licensor and catalyst supplier, has completed an exhaustive hydrocracking unit capability project to specifically address a refiner’s need to shift hydrocracking unit operations to flexibly produce either naphtha or diesel. The project was built upon UOP’s extensive commercial and pilot plant database and revamp engineering capabilities.

Key Elements:
- Market landscape assessment
- Existing data assessment
- Market need driven pilot plant program
- Project specific customer studies
- Capability project output generation

Key Features:
- Pre-positioned flexible solutions with well defined catalyst selection criteria.
- Fast execution of scoping studies and subsequent revamp engineering.
- Commercial solutions backed by customer data and studies, and pilot plant testing.
Customer studies

From the naphtha hydrocracker landscape (Figure 1), UOP chose three units to evaluate via additional pilot plant testing and customer studies. These units were among the customer inquiries received by UOP for increased diesel production from existing hydrocracking assets. Basic unit information from these studies is summarized in Table 1. The basic approach for each Customer Study was:

- Evaluate target diesel flexibility range
- Optimize catalyst selection and operating conditions
- Determine revamp and capital cost requirements
- Perform economic evaluation with sensitivity analysis to key drivers
- Summarize key learnings with respect to catalyst selection, common equipment bottlenecks and key economic drivers

The customer studies covered a broad range of unit configurations enabling generation of key learnings and development of pre-positioned solutions applicable to the overall market landscape.

Capability project output generation

Translating the knowledge gained from the hydrocracking unit capability project into tools for application to future customer inquiries was the final key step of the project. The key outputs were focused into three areas: performance estimating, revamp engineering and economic evaluation.

Performance Estimating – expanded pilot plant database enables performance estimates to be executed faster, from a focused starting point, with optimized matching of catalyst features to match customer needs.
**Revamp Engineering** – pre-positioned revamp engineering solutions cover the market landscape and identify typical revamp investment costs.

**Economic Evaluation** – An economic screening tool to allow for cost benefit analysis of potential catalytic and revamp solution options.

**Catalyst selection**
UOP’s catalyst portfolio offers a wide range of options to enable the refiner to meet their specific objectives. UOP’s catalyst recommendation with respect to naphtha and diesel production depends primarily on the refiner’s product slate requirements: max naphtha production, max diesel production, or the ability to flexibly switch between naphtha and diesel production. Hydrocracking catalysts can be most simply classified by activity and selectivity to distillate yield. UOP continues to develop Unicracking catalysts across the entire range of product objectives. (Figure 4)

**The Hydroprocessing Alliance**
In 2006, Albemarle and UOP created the Hydroprocessing Alliance to deliver the most comprehensive portfolio of processes, catalysts, equipment and services. This unique collaboration of resources enables UOP to offer hydrocracking unit revamps featuring catalyst improvements and reactor internals based on the strengths of both Albemarle and UOP.

**Reactor internals**
UOP’s reactor internal designs (see Figure 5) have been commercially proven to help refiners achieve maximum benefit by obtaining full catalyst cycle length and maximum operating severity. The D-Plex vapor/liquid distribution tray offered through the UOP and Albemarle Hydroprocessing Alliance is the latest improvement to UOP hydroprocessing internals. The alliance reactor internals are key technology enablers for flexible hydrocracker operation as they ensure optimum performance across a wide range of operating conditions and vapor to liquid regimes and are applicable to revamp or retrofit of existing internals.

### Table 1
**Summary of the Customer Studies**

<table>
<thead>
<tr>
<th>Customer Study</th>
<th>Configuration</th>
<th>Feed type</th>
<th>Change in diesel production, vol% FF</th>
<th>Unconverted oil product routing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single-stage recycle</td>
<td>LCO, LCGO, AGO</td>
<td>2% ↔ 50%</td>
<td>Diesel product blending</td>
</tr>
<tr>
<td>2</td>
<td>Once through</td>
<td>LVGO, HVGO, DAO</td>
<td>34% → 39%</td>
<td>FCC feed</td>
</tr>
<tr>
<td>3</td>
<td>Two-stage</td>
<td>LCO, SRGO</td>
<td>2% ↔ 50%</td>
<td>Diesel product blending</td>
</tr>
</tbody>
</table>

**Figure 4**
UOP Unicracking™ Catalyst Portfolio

**Figure 5**
Reactor Internals
UOP revamp engineering experience

UOP has worked with hundreds of refiners through the last 50 years to develop hydrocracking revamp projects of all magnitudes. This experience has resulted in the development of a variety of revamp engineering services that are tailored to meet refiners' needs. Figure 6 shows figuratively the different scopes in progression from the least towards more increasing levels of detail, time and cost of engineering deliverables.

Figure 6
Increasing Level of Detail, Time, Cost

UOP has extensive experience conducting process revamps on our own units as well as on our competitor's units. In the past 10 years alone, UOP has issued over 50 revamp Schedule A packages and conducted over 170 process and equipment studies in the hydroprocessing area.

UOP commercial experience

Hydrocracking technology has been offered by UOP since 1959, and since that time we have continued our development efforts to improve the process and catalyst systems. More than 195 units have been awarded to UOP.

Summary

Today's market has shifted to one with local and seasonal fluctuations in diesel demand and pricing advantage. Naphtha hydrocrackers offer potential for shifting between gasoline and diesel production to capture maximum profit. UOP's recent investment in hydrocracking unit capability development allows for a rapid response with pre-positioned solutions to address this situation. UOP offers refiners a proven partner in the quest for naphtha/diesel flexibility or maximizing diesel production from existing hydrocracker assets.

Find out more

For more information, please contact your UOP representative or visit us online at www.uop.com