Refiners have always been on a quest to increase profitability. However, in recent years, rapidly changing conditions have complicated that mission, increasing the need to act and react more quickly and flexibly. Achieving profitability improvements can depend on the refinery type and configuration, the crudes processed and the markets served.

There is no ‘one solution fits all’, as each refinery is unique, with individual constraints and opportunities. Honeywell UOP provides a wide variety of solutions, from optimisation studies and supply of hydroprocessing catalyst systems, to refinery reconfiguration studies that involve new process unit design and licensing, including catalyst and equipment supply.

In the current environment, quick and simple, low cost options are the most compelling; a good example is the installation of a hydroprocessing catalyst system in the hydrocracker, which is designed to capitalise on a range of opportunities and constraints. The company launched its new Unity™ hydrotreating catalyst portfolio, which includes hydrotreating and hydrocracking catalysts, specifically to meet these challenges. These provide a unified approach to hydroprocessing by bringing hydrotreating and hydrocracking catalysts into one portfolio, and ensuring the catalyst technology is consistent with the process technology.

The hydrotreating catalysts cover a range of applications (Table 1), from demetallisation catalysts that trap poisons for the protection of the main catalysts downstream, to the production of clean fuels such as fluid catalytic cracker (FCC) gasoline, naphtha and distillate, to the pretreatment of vacuum gas oil (VGO) feeds for FCC or hydrocracking units.

This allows refiners to target their objectives and specific demands in the following areas of application:

- Targeting high quality diesel output from the hydrocrackers, both single and two stage units.
- Production of high quality diesel and lubricants.
- Enhanced distillate production.
- Flexible operation to enable quality distillate and naphtha.
- Production of high quality naphtha for fuel or aromatics production.

A catalyst system consisting of one or more Unity hydrocracking and pretreat products can help refiners deliver the desired product slate and performance in hydrocracker units (Table 2).

UOP followed a rigorous and proven research and development work process to meet the stringent requirements of high performing hydrocracking pretreat catalysts. This resulted in two new catalysts: HYT-6119, a robust high performance hydrotreating catalyst, and HYT-6219, a hydrocracking pretreat catalyst that offers high stability and activity for application in very deep nitrogen, sulfur and aromatic removal. These were designed to deliver the required hydrenitrogenation (HDN), hydrodearomatisation (HDA) and hydrodesulfurisation (HDS) performance in a wide range of hydrocracking pretreat processing and operating conditions. As a result, they handle a wide range of severities and different types of feedstocks, including light cycle oil, heavy coker gasoil, deasphalted oil and atmospheric and vacuum gasoil.

A well balanced combination of hydrocracking pretreat and hydrocracking catalysts can help a refinery target better or more desired products, providing the flexibility to adapt to changing conditions for better profitability. A number of facilities have already benefited from this approach.

**Case study: naphtha for aromatics production**

One refiner’s objective was to achieve a targeted cycle length and increase the quality and yield of its naphtha for petrochemical production. Its non-UOP licensed two stage hydrocracker targets a gross conversion of 90%, processing a feed composition of VGO, light cycle gas oil (LCGO) and heavy coker gas oil (HCGO).

UOP proposed a method of upgrading petrochemical feedstocks to deliver an improvement on the targeted performance, using HYT-6119 as pretreat, with a hydrocracking catalyst from the naphtha hydrocracking family.

Nitrogen slip out of the hydrotreating reactor and normalised hydrocracking pretreat bed temperature were used to evaluate performance of the hydrocracking pretreat. They provide a measure for HDN activity and catalyst stability – both features for enabling profitability.

After almost a year in operation, the nitrogen slip continues to be below the desired target (Figure 1), indicating that HYT-6119 HDN activity is as good, or better, than expected.

The trend in the normalised temperature line (red) indicates catalyst deactivation in the commercial unit. The actual deactivation rate is also as expected, or lower than expected, for the processed feedstock and operating conditions. This shows good stability, considering some of the high severity conditions that this catalyst has been exposed to, as well as the...
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additional demand on the catalyst due to the lower nitrogen slip achieved. The obtained nitrogen slip, in combination with the required temperatures, illustrates the reliably high HDN activity and stability of HYT-6119 in a commercial unit.

For the hydrocracking catalyst, the trend in the normalised temperature is much lower than the expected deactivation for these conditions (Figure 2).

The features of the hydrocracking and hydrocracking pretreat catalysts helped the operator to meet the objectives set for the hydrocracker. Furthermore, when used in combination, the catalysts provide the potential for profitability improvement.

Assuming operating conditions, and feed properties and targets, remain as observed earlier, based on the observed activity and stability, the catalyst system for this specific case is expected to exceed the original cycle target by 15%.

Another option for the refiner could be processing cheaper, higher severity feedstocks, or to use the extra activity and stability to operate for a longer period within the operating window, which would allow increased yield for the most favourable products.

As mentioned above, the objective of this hydrocracker is to produce high yields of high quality naphtha for aromatics production. The heavy naphtha is used as feed into the continuous catalyst regeneration (CCR) reformer and is subsequently processed in the UOP Parex™ unit, also loaded with catalysts and adsorbent products. The higher the quality of the heavy naphtha, the more profitable the complex. In this case, the better than expected heavy naphtha product properties can enable up to an extra US$9 million/y of aromatics production.

**Case study: middle distillate yields**

This refiner’s objective was to maximise middle distillate yields, while producing less than 10 wtppm sulfur and achieving cycle. This single stage recycle hydrocracker targets a gross conversion of 95%, processing a feed composition of VGO, automotive gas oil (AGO) and coker gas oil (CGO). In this case, the UOP solution included HYT-6219 as the hydrocracking pretreat catalyst, and a combination of flexible family hydrocracking catalysts.

As in the earlier case, the nitrogen slip out of the hydrotreating reactor and the hydrocracking pretreat bed temperature provided an indication of HDN activity and catalyst stability. When these features are well balanced with the downstream hydrocracking catalyst, they allow profitability improvements in the unit.

The data showed that the nitrogen slip is below the maximum target (Figure 3), allowing deep dehydronitrogenation. The fact that the hydrocracking pretreat catalyst is able to deliver such deep HDN activity...
the most profitable way, considering the specific opportunities and constraints of the refinery. During the cycle, the refiner now has the choice of extending to a longer cycle, increasing throughput, or enabling the processing of cheaper feedstocks. The high activity of HYT-6219 also enables the refiner to further increase diesel yields for the next cycle by selecting more diesel selective hydrocracking catalyst from the distillate family (Table 2), which would enable improvements in diesel yields for the next cycle.

In this case, the refiner chose to use the flexibility enabled by activity and stability to extend the cycle. Assuming operating conditions, and feed properties and targets remain as observed earlier, based on the available data, this catalyst system is expected to exceed the original cycle target by 25%.

Since the diesel product properties are better than the target (Figure 5), the refinery now has increased flexibility in the overall diesel blending pool. This allows options for further profitability improvements. As a result, the refiner will experience better results with regard to cycle and product quality than originally expected.

**Conclusion**

As each hydrocracker is unique, refiners require a comprehensive choice of hydroprocessing catalysts to tailor their hydrocrackers’ performance to extract the most profitability from their facilities. Furthermore, flexibility in the selection of catalysts or catalyst combinations to target specific processing objectives allows operators to consistently adapt to changing conditions.