Axens hydrocracking



Excellence from innovation and experience

Processes, catalysts and services

Axens
IFP Group Technologies

Hydrocracking trends

World oil demand is primarily driven by the transportation fuels sector. Forecasts show significant growth in these fuels, while the share of heavy fuel oil will decrease in the refined products slate. Among fuels, on-road diesel and jet fuel will exhibit the highest growth rates, about 2.5% per year over the period 2010–2020. Along with this trend, fuel specifications continue to be tightened, pushing demand towards ultra-low-sulfur, low-polyaromatics-content, high-cetane diesel.

Hydrocracking technology can respond to the most demanding market constraints. This flexible process is capable of converting a wide variety of feedstocks into diesel and jet fuel products that meet the most challenging specifications. For cases where incomplete conversion is desired, the unconverted hydrocracked residue (also called unconverted oil, UCO) can, because of its excellent properties, be used as a high-viscosity-index (VI) lube oil base stock, as a superior steam cracker feedstock owing to its very low BMCI* value or as an FCC feed.

High price differentials between on-road diesel/jet fuel and hydrocracking feedstocks encourage investment in hydrocracking units owing to high profitability and short payback times.

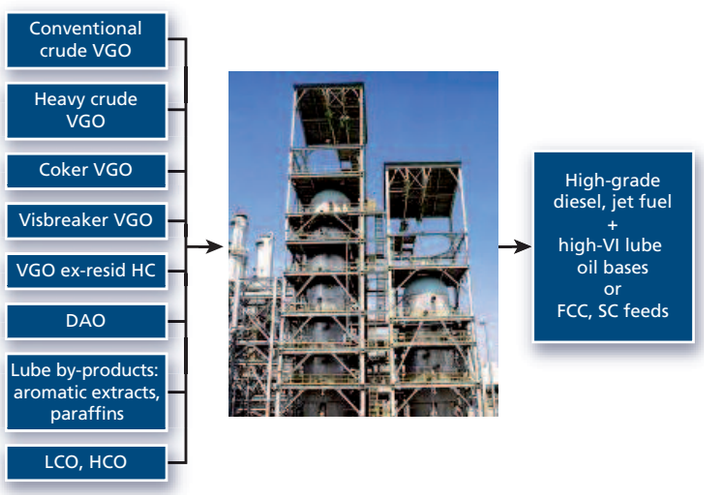
* BMCI: Bureau of Mines Correlation Index

Axens' hydrocracking experience

Axens is an established name in hydrocracking licensing with more than 40 years' experience in all types of hydrocracking processes.

We have a large portfolio of hydroconversion processes, including fixed- and ebullated-bed technologies. Our commercial units operate at low, medium and high conversion, and in once-through, single-stage recycle and two-stage modes.

As of 2011, Axens' hydrocracking technologies had been selected for more than 80 licensed units with a combined capacity of over 3.3 MMBPSD.



Service

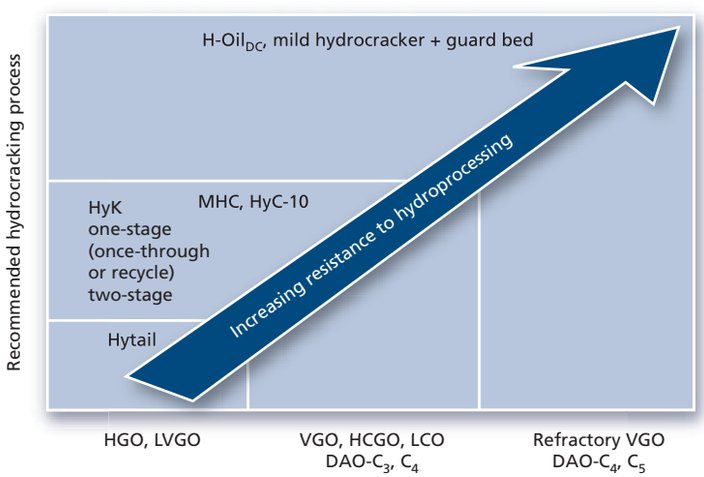
Axens has a global reputation for basic engineering design excellence. We provide both limited and extended basic engineering packages and can extend this capability upon request.

Our technical services are second to none, and include the provision of training, catalyst loading, start-up assistance, performance monitoring, troubleshooting and process optimization.

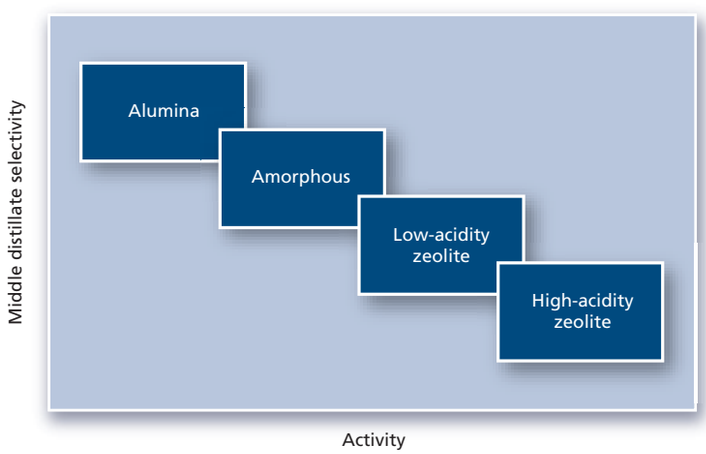
Technology configurations

Our commercial hydrocracker designs can cover a large variety of feedstocks varying from light HGO and LVGO feeds to the most difficult feeds, such as highly resinous and organic-nitrogen-containing VGO, processed VGO or DAO. In addition, our hydrocracker designs are exceptionally adapted for upgrading low-quality products such as LCO, which is used as a cutter stock for heavy fuel oil. With the continuing decrease in demand for heavy fuel oil, additional low-cost LCO will be available for upgrading.

The considerable flexibility available with these technologies is enhanced by a complete line of dedicated materials covering feed pretreatment and conversion steps. Applying the right combination of materials and process designs enables our technology to respond to a diverse set of economic and operational constraints with various feedstocks, desired conversion levels and product selectivities. Hydrocracking objectives are achieved while ensuring long catalyst cycle lengths and employing best practices relating to operational, environmental and safety concerns.



Axens' technologies cover every type of feed



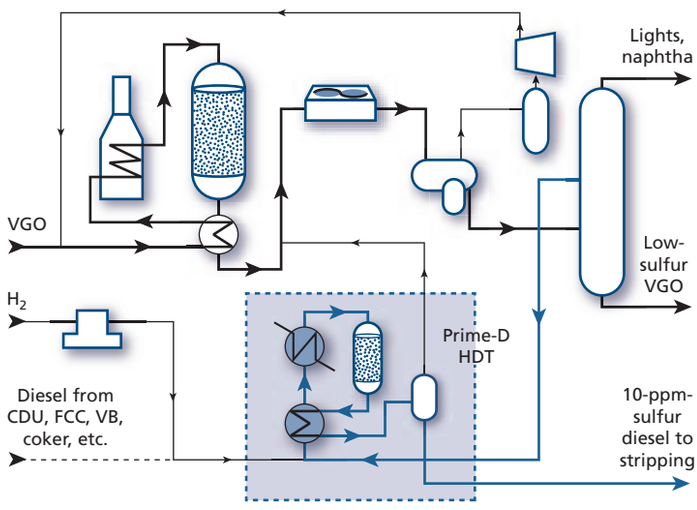
A wide range of catalysts is available to meet specific market objectives

Axens' hydrocracking processes

Mild hydrocracking and HyC-10™

For refineries equipped with a VGO FCC unit, mild hydrocracking (MHC) enables increased diesel production through VGO hydroconversion. This process simultaneously improves the quality of the treated VGO, which, once converted in the FCC unit, offers higher gasoline yields, higher octane retention, lower SOx emissions and lower-sulfur products. Under conventional MHC operating conditions (low-to-medium pressure range, 50–100 bar [730–1500 psi] and 20–40% conversion levels) direct production of 10-ppm-sulfur diesel is not easily attained. Axens' commercially proven HyC-10 technology achieves both objectives, thereby enabling diesel cut quality to be controlled independently from the VGO conversion. This has the added advantage of not putting excess hydrogen into the treated VGO and reducing the investment costs.

In addition, HyC-10 systems can be designed to co-process other difficult feedstocks present in the refinery such as LCO, light cracked GO, and visbroken GO. Streams like these can exhibit high metal or CCR values, which shorten run cycles. Axens' permutable guard reactors can be installed to counteract this problem.



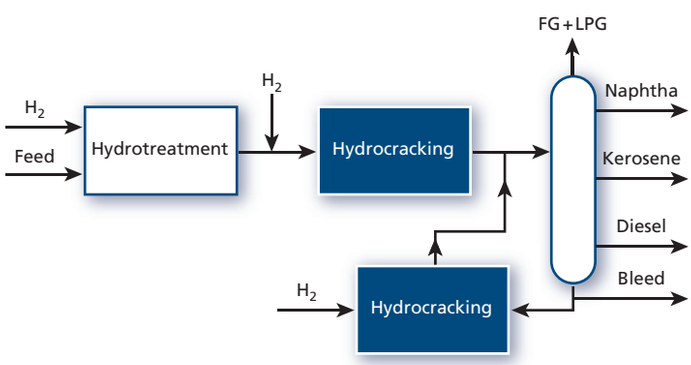
HyC-10 mild hydrocracking scheme

High-conversion hydrocracking (HyK™)

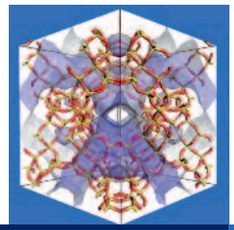
To achieve conversion levels higher than 50% and to maximize middle distillate production from VGO and light DAO, Axens offers three configurations of HyK processes: single-stage once-through, single-stage with liquid recycle, and two-stage. All the hydrocracked products, including unconverted oil (UCO), present excellent characteristics.

The configuration selected will depend on the desired product slate and the investment criteria. For instance, when the hydrocracking project is driven by a high diesel incentive, a two-stage full-conversion scheme provides maximum production of exceptional-quality diesel.

Single-stage once-through hydrocracker

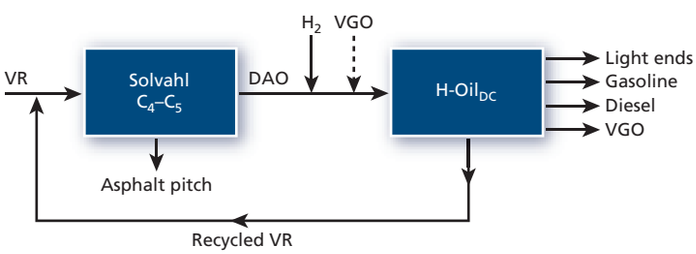


Two-stage hydrocracking scheme



H-Oil®$_{DC}$

For the most refractory feeds, including heavy VGO and DAO-containing feeds, the H-Oil$_{DC}$ ebullated-bed technology is suitable for deep-conversion objectives. Conversion levels of over 80% are achievable by adjusting operating temperature, residence time and catalyst replacement rate. Recycling of unconverted VR to a solvent deasphalting unit enables nearly full conversion of the DAO. The addition of an integrated hydrotreater on the H-Oil$_{DC}$ distillate fraction ensures ultra-low-sulfur-diesel quality.



H-Oil$_{DC}$ and Solvahl (solvent deasphalting) combine for nearly 100% conversion of heavy DAO

Inside the hydrocracker

Grading materials and reactor internals

For fixed-bed hydrocracking processes, ultimate performance of the technology begins with feed pretreatment and a design that provides near-perfect liquid–gas distribution throughout the process.

Axens' EquiFlow reactor internals are designed and commercially proven to provide the industry's best fluid distribution. This ensures that the entire catalyst inventory is used uniformly and that the longest catalyst cycles are attained.

Once the hydrodynamic design is established, the next step is to ensure that undesirable feed materials, such as scale, polymer, other entrained solids, and highly reactive molecules do not prematurely end the operation cycle through pressure drop build-up, catalyst plugging or deactivation. To reduce the effect of this type of frequent problem, the top bed of the unit is loaded with ACT series grading materials that vary from non-porous to porous, large to small and low to high activity. Depending on the metals content (V + Ni) in the feed, the addition of Axens HF & HMC Series demetallization catalysts may be required before contact with the pretreatment catalyst to ensure long cycle lengths.

The cleaned, uniformly distributed feedstock and hydrogen are now in the optimum condition to be catalytically hydrotreated to remove sulfur and nitrogen and then hydrocracked into lighter products.

Hydrocracking catalysts

Our new-generation commercial hydrocracking catalysts treat a wide range of feeds to produce a diverse slate of products that respond to specific quality targets.

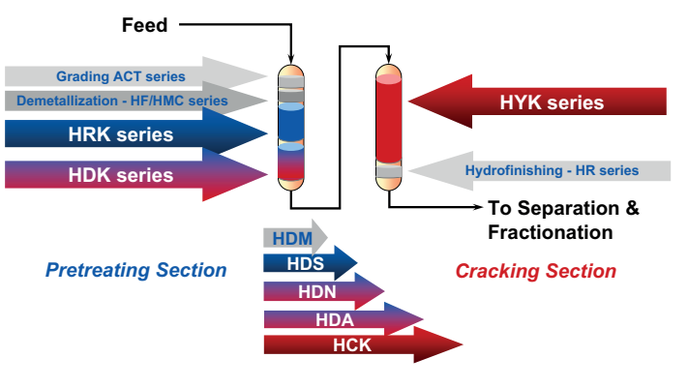
For high conversion hydrocracking applications, the combination of HRK, HDK and HYK series is definitely the best solution to squeeze more middle distillates from heavy ends while reaching high conversion levels.

A once-through HyK hydrocracker operating with straight-run VGO at 80% conversion (see figure right) would typically be loaded with:

- several sets of EquiFlow reactor internals;
- different ACT materials;
- HF / HMC Series demetallization catalyst;
- the winning combination of **HRK Series + HDK Series + HYK Series** and;
- HR Series catalyst to ensure optimal product quality.

High-conversion hydrocracking application

- The HRK Series hydrotreating catalyst features very high denitrogenation activity while affording deep sulfur and aromatics removal.
- HDK Series fills the gap between the HRK and HYK Series for both middle distillate selectivity and conversion activity. The combination of HRK Series and HDK Series is the most effective way to maximize HDN activity in pretreating section. The formulation strongly orients overall selectivity toward middle distillates and affords better UCO characteristics, particularly for high-VI lube-oil base stocks.
- HYK Series, the zeolite-based hydrocracking catalysts, displays high activity coupled to exceptional selectivity. HYK Series catalysts are well suited for the processing of heavier and more refractory feedstocks, and their high activity enables them to be extremely tolerant to nitrogen.



Mild hydrocracking application and HyC-10™ units

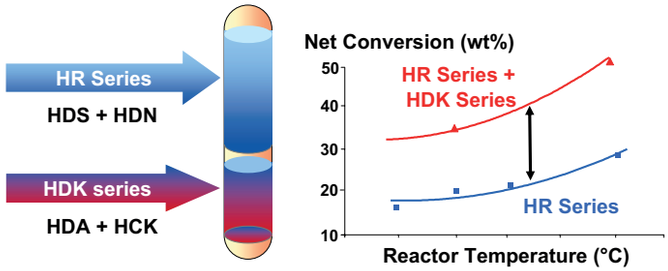
The proposed catalyst arrangement, combined the following high performance products:

- HR 500 series hydrotreating catalyst: a catalyst with exceptional HDS activity as well as high HDN and HDA performance.
- HDK series hydrocracking catalyst specially designed to maximize diesel production while providing higher activity.

When the FCC VGO feed is already pretreated in a catalytic feed hydrotreater (CFHT), this unit can be revamped into a MHC in order to increase the conversion of VGO to diesel. In this case, the HR 500 series catalyst (CFHT service) is replaced by the catalyst combination: **HR 500 Series + HDK Series**.

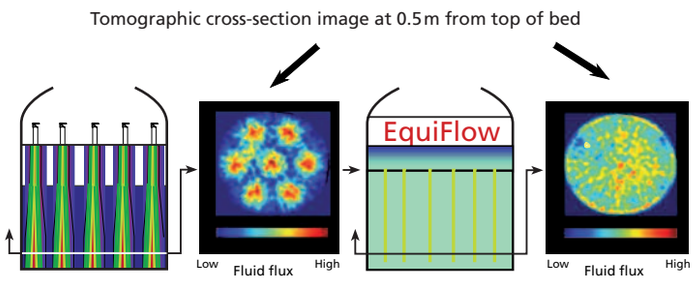
H-Oil$_{DC}$

For conversion applications with the most refractory feeds, the H-Oil$_{DC}$ technology associated with HTS Series catalysts provides substantial benefits owing to its continuous and uniform operation.



EquiFlow

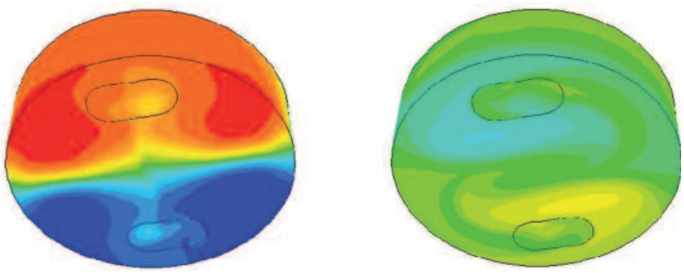
Hydrocracking reactor performance is determined by both the catalysts and the reactor internals. For fixed-bed reactors, EquiFlow internals ensure uniform liquid–gas flow distribution in the catalyst beds. This facilitates effective utilization of the entire catalyst inventory and minimizes radial temperature gradients, which can result from non-ideal flow. The images below show the efficiency of EquiFlow distributor trays. The yellow, light blue and green areas indicate the desired fluid flux, whereas dark blue indicates fluid flux that is too low and red too high.



Conventional chimney tray

EquiFlow, the latest generation of commercial distributors

EquiFlow quench boxes provide optimal remixing of the effluents between beds. These devices are particularly useful when hot product from the previous bed is mixed with fresh, cooler hydrogen. They provide the mixture with a uniform temperature before it makes contact with the subsequent bed. For hydrocracking applications in which highly exothermic reactions occur, compact EquiFlow quench boxes provide near-perfect flow performance and higher catalyst loading, which lead to substantial activity gains and margins improvements. The figure below shows the improvement in the temperature profile of the mixture as it exits the quench box: red and blue indicate high and low temperatures, green and yellow show temperatures close to the ideal mix temperature.



a. Conventional design

b. EquiFlow design

Quench-box outlet (viewed from below)

The winning catalyst combination for your hydrocracker

HRK, HDK, HYK series: the expert trio to maximize cycle length, activity and middle distillates selectivity

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