Our World of Cats: Panthera pardus. All melanistic leopards, also known as black panthers, are born in the same litter as normally marked cats and also carry the rosette markings, although these are masked by the darkness of the fur. Panthers grow to a length of 1.5 meters with an additional tail length of 0.9 meters.
Any positive change in hydrocracking unit operation improves the overall refinery economic equation significantly. The proper selection of hydrocracking catalysts offers great potential for enhancing the performance of the hydrocracker unit with respect to yield structure, product properties, throughput and on-stream efficiency, resulting in a more positive refinery margin.

The Fundamental Knowledge and Experience of Topsøe applied to Hydrocracking Catalysts

Decades of research, development and production of high-quality catalysts have brought Topsøe to a top position as a supplier of catalysts and technology for the refining industry. Topsøe’s TK-series - a wide range of hydroprocessing catalysts - is well recognised by the refining industry and covers applications from deep desulphurisation and dearomatisation of diesel, hydrotreating of FCC and hydrocracker feedstocks through upgrading of resid.

Building upon our full spectrum of expertise and knowledge gained in making TK catalysts and upon the technological capabilities that have been developed over more than five decades, Topsøe decided to enter into the hydrocracking arena in 1996.

The solid foundation in high severity hydroprocessing provided a strong and natural basis for the expansion of Topsøe technology into the hydrocracking area. Topsøe implemented a Research & Development programme to independently develop superior middle distillate hydrocracking catalysts. Topsøe installed a number of state-of-the-art hydrocracking pilot plants, introduced new analytical methodologies and equipment, increased its research staffing and employed experts with extensive hydrocracking experience to assist in screening and developing proprietary catalyst formulations. Upon completion of the initial development phase, Topsøe introduced to the refining market a new generation of middle distillate hydrocracking catalysts that are technically very competitive.

The development of new hydrocracking catalysts is very dependent on new or modified materials. Topsøe has found unique methods of preparing hydroprocessing catalysts, and through an extensive understanding of the chemistry has demonstrated a high level of expertise in making catalyst carriers with a uniform distribution of acidic sites and hydrogenation metal sites.

Topsøe produces many of the raw materials used in the catalyst formulations, which gives the advantage and the capability to tailor and optimise the catalyst carriers and the metal impregnation process to produce balanced and consistently high quality hydrocracking catalysts.

Hydrocracking is a strategic technology area for Topsøe. Commercial experience has proven that Topsøe’s range of high-performance catalysts and knowledge of hydrocracking technology are enabling refiners to meet their objectives and to optimise their hydrocracking unit operations.

A hydrocracker is one of the most profitable units in a refinery as it converts heavy feedstocks to lighter and more valuable products such as naphtha, diesel, jet-fuel, kerosene and feedstocks to FCC, lube units and ethylene plants. As refiners are pushed to operate at higher efficiency levels, at lower costs and with more stringent fuel specifications, the performance of their hydrocracking units becomes more significant.

Hydrocracking Catalysts

Strong R&D Commitment
Maximum Middle Distillate Hydrocracking Catalysts
A complete Topsøe portfolio of middle distillate hydrocracking catalysts is offered for specific needs of hydrocracking reload patterns where the product quality, product slate and cycle length could be adjusted to improve refiners’ margins.

Topsøe hydrocracking catalysts have been developed in-house and are manufactured in two Topsøe Catalyst Manufacturing Plants in Houston, USA, and Frederikssund, Denmark. These catalysts can be delivered in several sizes and shapes depending on the requirements of the hydrocracking units.

TK-931 – Low Zeolite Hydrocracking Catalyst
Topsøe’s TK-931 is a nickel-tungsten low zeolite maximum middle distillate hydrocracking catalyst designed to produce very high yields of premium quality diesel, jet fuel or kerosene and high quality lube oil base stocks. Actual commercial performance shows excellent product quality resulting from the high degree of aromatic saturation, cracking of the heavy aromatic compounds and selective production of isoparaffins. Specifically, the product quality includes a high smoke point for the full range jet, excellent Cetane Number for the diesel fraction and high viscosity index (VI) upgrade for lube base oils.

TK-931, combined with the appropriate Topsøe pre-treatment catalysts has an first-rate nitrogen tolerance offering the significant advantage of lower start-of-run (SOR) temperatures and long catalyst run lengths.

Compared to other hydrocracking catalysts of this type, Topsøe TK-931 has demonstrated:
- Superior product properties
- Higher middle distillate selectivity
- Excellent activity and stability

TK-925 – Amorphous Hydrocracking Catalyst
Topsøe’s TK-925 is a nickel-tungsten amorphous maximum middle distillate hydrocracking catalyst that is highly selective towards middle distillates and has shown higher activity and selectivity when compared to other amorphous hydrocracking catalysts. In addition, better liquid yields and superior product properties, such as lower aromatic content, higher Cetane index and higher smoke point are also achieved.

TK-925 commercial experience shows a remarkable nitrogen tolerance offering a significant advantage in that the feed to this catalyst does not need pre-treatment. TK-925 offers lower SOR temperatures, high catalyst stability, and long catalyst cycle lengths. TK-925 is a prime catalyst for single stage hydrocrackers where the main objectives are to maximise the middle distillate yields and cycle length.

TK-926 – Amorphous Hydrocracking Catalyst
TK-926 is able to outperform traditional competitive amorphous catalysts in both activity and mid-distillate yield, and it is a nice complement of TK-925, depending on specific customers’ needs of product quality.

Specially developed raw materials were used to manufacture TK-926 with the additional purpose to improve the acid sites functions, enhance isomerisation reactions and improve cold flow properties of diesel. The acidity, population, and nature of the acid sites are important features, which vary from structure to structure and are responsible for the enhanced isomerisation and cracking activity of TK-926.

TK-941 and TK-951 – Zeolitic Hydrocracking Middle Distillate Catalysts
It is commonly known that for hydrocracking catalysts there is a trade-off between high activity and high middle distillate selectivity. The task of properly balancing metal activity with acidity in hydrocracking catalysts, and particularly more activity with more middle distillate selectivity, was a priority task for Topsøe.

As a result Topsøe developed and commercialised TK-941 and TK-951. These hydrocracking catalysts were developed as catalysts with higher activity than TK-931 and still with very good jet + diesel selectivity and high nitrogen tolerance. TK-951 is around 7˚C more active compared to TK-941, and both provide excellent mid-distillate yields with efficient hydrogen utilisation.
Commercial Experience

Topsøe is in the unique position among hydroprocessing catalyst manufacturers to be able to provide a complete hydrocracking technology package including hydro-treating, pretreating and post treating catalysts, hydrocracking catalysts, grading packages, reactor distributors and quench internals, as well as engineering design and technical service.

Topsøe has been serving the needs of refiners to meet the second millennium’s challenging goals of the mid-distillate market. Topsøe has been one of the world’s leading suppliers of middle distillate hydrocracking catalysts in the current decade. In these last five years Topsøe was awarded to very successfully supply 10 full hydrocracking catalyst loads to different high pressure hydrocrackers. Three of the 10 worldwide largest hydrocrackers have chosen Topsøe hydrocracking catalysts.

Successful Operations of Topsøe Hydrocracking Catalysts

Early 2001, TK-931 was sold and installed in the existing hydrocracking unit of a European refinery. Based on the superior performance of Topsøe catalysts, this client awarded Topsøe a second full reload of hydrocracking catalysts in 2003. In 2003, one of the largest and most technically complex Korean hydrocrackers, with a capacity of 45,000 BPD, gained advantage of the high performance new generation Topsøe hydrocracking catalysts. This hydrocracker has been obtaining high yields of jet, diesel and unconverted oil for lubes with high smoke point, cetane number and VI, respectively. Commercial experience confirmed capabilities of Topsøe catalysts that are meeting the new stringent objectives.

In 2003, a client in Italy also installed Topsøe hydrocracking catalysts in its 55,000 BPSD hydrocracking unit. For the first time this hydrocracker has obtained very low sulphur diesel (< 10 wt ppm) and high quality products. In 2004, two other clients decided to load Topsøe catalysts in their hydrocrackers, one in the Far-East, and another in the USA. In 2005, Topsøe was awarded a full catalyst reload for a 60,000 BPD high pressure hydrocracker, located in Venezuela. The hydrocracker was initially started up in October 2004 and the client has now changed to Topsøe high performance hydrocracking catalysts to improve throughput and performance.

Partial Conversion Hydrocracking Experiences

At the beginning of 2002, Topsøe catalysts were installed in two partial conversion hydrocracking units, and a CFI unit was revamped to a Topsøe licensed partial conversion hydrocracker to increase the yield of less than 10 wt ppm ultra low sulphur diesel. This unit has successfully started-up in 2003.

Topsøe’s hydroprocessing catalysts have significantly improved the overall performance in the existing units. One of these units, previously operated with only hydro-treating catalysts, was limited in cycle length by both pressure drop build-up and an excessive catalyst deactivation rate. Subsequent to reloading the reactors with Topsøe’s partial conversion hydrocracking catalysts and an optimised Topsøe bed grading, the unit activity increased significantly, which has allowed for a higher flexibility of operation. With the previous catalyst system, it was necessary for the refiner to operate the unit at maximum temperatures to meet the desulphurisation and denitrification specifications. The sulphur and nitrogen specifications have been met at lower temperatures since operating with the Topsøe partial conversion hydrocracking catalysts, resulting in a doubling of the cycle length compared to the previous cycle length.

Importance of Grading and Distribution

For more than 20 years, Topsøe has provided specially developed bed grading catalyst systems to minimise the pressure drop build-up in hydroprocessing units. Topsøe offers a unique grading approach consisting of high-void materials to handle pressure drop problems. The Topsøe solution grades the catalyst bed not only by particle size, shape and void, but also by catalytic activity. Topsøe has solved more than 300 cases of pressure drop problems and has a family of more than 20 high-void catalyst products available. More information about Topsøe’s pressure drop control systems can be found in a separate brochure.

Topsøe recognised the importance of having uniform flow distribution in hydroprocessing reactors early on and has conducted substantial research to develop new and more efficient liquid distribution trays and quench mixing assemblies. This includes unique designs for the challenging operating condition prevailing in hydrocrackers. Topsøe reactor internals technology is today perceived to be state-of-the art in terms of performance and reliability and has been supplied to more than 130 hydroprocessing units world-wide.
**Topsøe Technical Service Programme**

A reliable and well-qualified technical service support is an important element in the optimum utilisation of critical refinery products such as hydrocracking catalysts. Since 1996, Topsøe has achieved hydrocracking expertise through personnel additions and in-house development. Topsøe provides unique and comprehensive technical support to the refiner from project award, through the start-up and to the end of cycle.

Among the potential Topsøe support activities are:

- Interaction between the Topsøe hydrocracking experts and the refiners to exchange technical information about the current and future hydrocracking unit conditions and objectives.
- Preparation of pilot plant hydrocracking performance data based on the refiner’s feed and operating conditions. Topsøe has several hydrocracking pilot plant units in operation in Lyngby - Denmark - that are used to simulate customers operations. These pilot plant units can simulate both once-through and full recycle hydrocracking operations.
- Review and recommendation of the existing hydrocracker catalyst loading and catalyst activation procedures.
- Start-up assistance during the unit catalyst activation phase.
- Plant visits, on-site periodic reviews of unit operations, analysis of the operating data, feed analysis, catalyst analysis and ad-hoc troubleshooting.
- Spent catalyst analysis and estimate of catalyst regenerability.
- Assistance in the optimum operation of the hydrocracking unit.

**Pilot Plant Testing**

During the last 10 years, Topsøe has devoted a great deal of R&D effort to hydrocracking catalyst testing. This testing evaluates both the optimisation of current Topsøe hydrocracking catalysts and new catalyst formulations. In addition, considerable pilot plant time is spent conducting tests for existing hydrocracking units. It is of paramount importance to Topsøe to ensure that the pilot plant test results can be translated into the refiner’s actual operation. Therefore, Topsøe performs pilot plant tests with the actual customer feed, at the refiner’s operating conditions and with the Topsøe catalyst system configuration.

Meet Your Objectives
Refinery Services

Topsøe’s worldwide services to the refining industry are based on a fundamental understanding of heterogeneous catalysis, including catalysts, process technologies and engineering services.

Topsøe’s unique integrated approach has resulted in profitable solutions in the areas of:

- FCC Pretreatment
- Hydrocracker Pretreatment
- Hydrocracking
- Deep HDS of Diesel
- Diesel Dearomatisation
- Resid Hydroprocessing
- Kero/Naphtha Hydroprocessing
- Pressure Drop Control
- Reactor Design
- Reactor Flow Distribution
- Hydrogen Production
- Sulphur Management
- Spent Acid Regeneration
- Flue/Waste Gas Treatment

Visit www.topsoe.com for more information.