



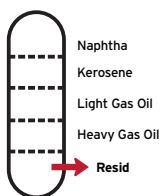
Our World of Cats: *Panthera tigris*. With the exception of the lion the tiger is probably the most recognised of all wild cats. With a body length up to 3 meters and a weight from 190 to 300 kg, the tiger is by far the largest and most powerful member of the cat family.

Topsøe Refinery Catalysts



Resid Hydroprocessing II





Topsøe has developed new additions to the TK-series of fixed bed resid hydroprocessing catalysts showing outstanding performance, which offer refiners a larger degree of operating flexibility and the opportunity to maximise profitability.

Resid Hydroprocessing

Traditionally, the primary objective in resid hydroprocessing was production of low sulphur fuel oil; i.e. desulphurisation was the main objective.

Over the past years the market for residual fuel oil has declined, whereas the demand for middle distillates has increased significantly. This market trend towards lighter products has made it attractive to convert the resid fraction to lighter, more valuable products through conversion in e.g. a resid fluid catalyst cracking (RFCC) unit.

In some cases, in order to meet the demand for lighter products, it can be advantageous to operate the resid hydrotreater to give maximum conversion. Obviously, the demands on the catalyst system vary according to the processing objectives, and will affect the ultimate choice of catalysts to be installed in the unit.

The Catalyst System

Resid catalysts deactivate by coke and metals deposited in the pore system. A combination of restricted access to and coverage of the active sites cause the activity loss.

Depending upon feedstock properties, operating conditions and the location of the catalyst in the reactor or

reactor train, each catalyst will be subjected to different levels of metals and coke. To accommodate the demands on versatility of the catalyst systems, Topsøe has developed “new members” of the TK-series of fixed bed resid hydroprocessing catalysts. These new catalysts have superior characteristics with respect to metals storage capacity and coke stability, together with the necessary activities for desulphurisation (HDS) and demetallisation (HDM).

These improved TK resid hydroprocessing catalysts can be divided into three categories:

- * HDM catalysts
- * Transition catalysts
- * Tail-end catalysts

The HDM catalysts are especially designed for operating in guard reactors and/or in the first part of the reactor train, where the concentration of metals in the oil is high. HDM catalysts ensure that metals (nickel and vanadium) accumulate deep within the pores giving a high HDM activity and superior tolerance for metals deposition. HDM catalysts thus protect the downstream cata-

Resid I Series	Resid II Series	Category	HDS Activity	HDM Activity	Metals Tolerance
TK-709	TK-719	HDM	Low	Very High	Very high
TK-711	TK-733	HDM	Moderate	High	High
TK-831	TK-743	HDM	Medium	High	High
TK-751	TK-753	Transition	Medium	Medium	Medium
TK-771	TK-773	Tail End	Very High	Low	Moderate

Table 1. Topsøe's catalysts for resid hydroprocessing.



lyst types from excessive amounts of metals.

For optimal protection of the tail-end high activity catalysts, transition catalysts are installed in the middle part of the reactor train. Transition catalysts have properties in between those of HDM and tail-end catalysts with respect to HDS activity, metals pick-up and metals tolerance.

Tail-end catalysts have high HDS activity and are used in the back of the reactor train, where the metals content of the oil has been significantly reduced. The HDS type catalysts are the “work horses” of the resid hydroprocessing system with respect to HDS, hydrodenitrogenation (HDN) and Conradson Carbon Residue reduction (HDCCR).

New Unique Catalysts

Topsøe's new resid hydroprocessing catalysts are developed to match the requirements of today's refiner in an increasingly competitive market place. Based on a proprietary improved alumina technology, Topsøe has been able to develop catalysts having a unique pore system, high porosity and high metals storage capacity - features, which are essential for obtaining high activity, low deactivation rate and long cycle length. Additionally these catalysts have lower bulk density giving lower filling costs, which again provides economic benefits to the refiner.

This new TK-series comprises a range of catalysts necessary to define the optimal solutions for all applications of fixed bed resid hydroprocessing. Table 1 provides an overview of these new catalysts along with the

well-established Resid I catalysts.

TK-719 is an HDM catalyst with very high HDM activity and a superior metals storage capacity. TK-719 is used in the first part of a reactor train in applications where the feedstock has a high content of nickel and vanadium or the feedstock contains very reactive metal compounds (e.g. organic iron compounds).

The unique pore system of TK-719 enables this catalyst to maintain high demetallisation activity and large storage capacity even for large catalyst particles. These properties make this catalyst ideal for use in guard reactors as part of the grading.

TK-733 and TK-743 are also HDM catalysts with high HDM activity and very good stability. These catalysts are used in applications where deep demetallisation is required. TK-743 has a higher HDS activity than TK-733 and is mainly used to maximise HDS activity in cases where large volumes of HDM catalysts are required, for instance, in units where the feedstock contains high levels of Ni, V, and Fe.

The transition catalyst TK-753, has properties in between the HDS and HDM catalysts and is used in the middle part of the catalyst system. It is formulated to exhibit good HDS and HDM activity while maintaining a significant metals storage capacity.

TK-773 is the high HDS activity catalyst with modest tolerance for metals. This catalyst is loaded in the tail-end of the catalyst system and should be protected from metals contamination by an adequate quantity of both HDM and transition catalysts.

Catalysts for All



Determining the optimal ratios of each catalyst type is an important challenge to obtain a long cycle length while meeting all product requirements. The optimal ratio will vary from unit to unit and will depend strongly on feedstock properties, operating conditions and product requirements. Topsøe has extensive experience in the resid upgrading field including commercial experience and a large number of long term pilot plant tests combined with accurate prediction tools. Based on this experience Topsøe is able to design resid catalyst systems for optimum performance in any given scenario.

Pilot Plant Tests

Topsøe devotes a great deal of the vast R&D efforts to resid catalyst testing. This testing encompasses newly developed catalysts and catalyst formulations. In addition, considerable time is spent on long term industry-

related testing. It is of paramount importance that test results obtained in this manner can be translated into the client's actual operation. Therefore, Topsøe performs tests on customer feed, at customer operating conditions and on the actual, recommended catalyst configuration.

The pilot plant data in figure 1 demonstrates how selecting the proper ratio between the HDM, transition and HDS catalysts can increase the cycle length.

Performance of New Catalyst System

The new series of TK resid hydroprocessing catalysts are tested extensively in Topsøe's research facilities. Figure 2 shows an example of the outstanding performance of the new catalyst system. This test was performed using feed from an industrial resid hydrotreater using operating conditions as close as possible to the actual operation. The catalyst loading used in this test was the same as recommended for the unit. The achiev-

**Comparison of the Activity of Two Catalyst Systems
Constant Sulphur Content in the Product**

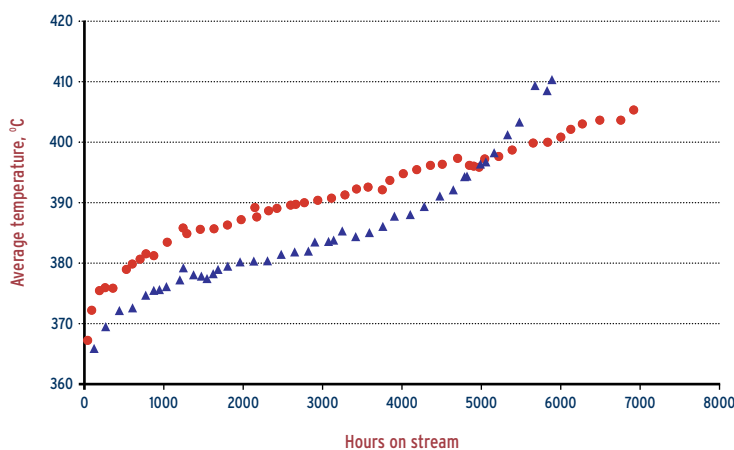


Figure 1. The activity comparison illustrated in this plot shows the required temperature in two tests to produce a low sulphur fuel oil with a sulphur content of 0.5 wt %, processing the same feedstock and operated at same conditions. The metal uptake after 7,000 hours in operation is 32 wt % (based on fresh catalysts). Selecting the correct loading can extend the cycle length by more than 2 months.

TK-719	25%	10%
TK-733	25%	20%
TK-753	25%	30%
TK-773	25%	40%

Applications



able cycle length proved to be more than 9,000 hours before EOR temperature was reached. At that point, the overall metal uptake of the catalyst system was in excess of 55 wt %, as determined by metals removal data together with analysis of the spent catalysts.

Optimising Flow Conditions

A large number of resid hydrotreaters experience problems with bed fouling. This causes maldistribution, hot spots and excessive pressure drop resulting in inefficient utilisation of the installed catalysts. By implementing the unique Topsøe grading approach, involving use of different catalyst types, sizes and shapes, pressure drop increase can be either eliminated or kept under control.

Topsøe has more than 20 years experience in this field and a family of more than 20 high-void grading products

is available. More information about these graded systems can be found in a separate brochure.

Satisfactory performance of any catalyst system requires optimal distribution of feed and treat gas. Topsøe has considerable expertise in the area and, in connection with catalyst supply, offers to evaluate the suitability of critical reactor internals such as distributor trays and quench equipment. Furthermore Topsøe can offer a distributor tray tailored to the feedstock and operating conditions in question.

Know-how and commercial experience in resid hydroprocessing have put Topsøe in the forefront of this challenging field. Let Topsøe improve your operation by composing the optimal filling for your resid unit.

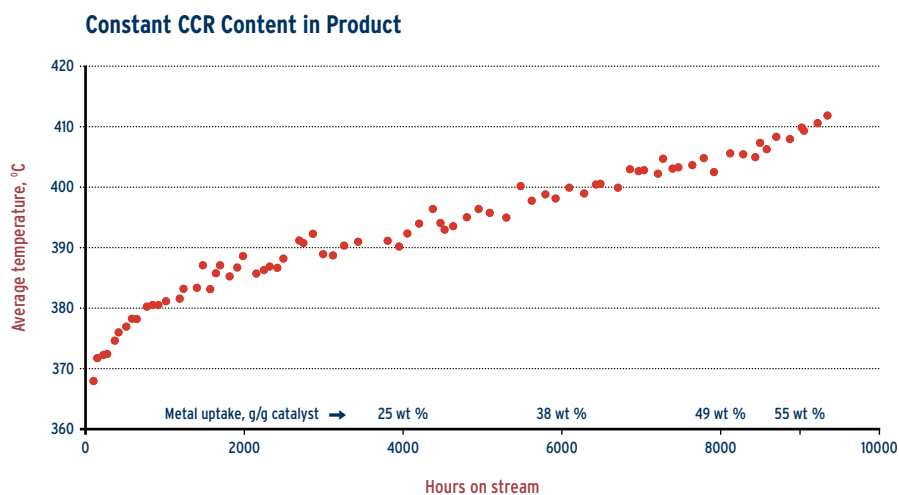


Figure 2. This plot shows the required temperature to meet the target CCR in a laboratory test. The catalysts TK-719, TK-743, TK-753 and TK-773 were tested. The feedstock metal content (Ni + V) was 179 wt ppm. The total metal uptake on the catalyst system is 55 wt % at EOR (410 °C).

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
- * Alkylation
- * Flue/Waste Gas Treatment

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The information and recommendations have been prepared by Topsøe specialists having a thorough knowledge of the catalysts. However, any operation instructions should be considered to be of a general nature and we cannot assume any liability for upsets or damage of the customer's plants or personnel. Nothing herein is to be construed as recommending any practice or any product in violation of any patent, law or regulation.

