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DESCRIPTION OF THE CATALYSTS

GUARD BED / TOP LAYER CATALYSTS

Albemarle introduced early 2001 new Guard Bed catalysts for improved protection against fouling and for an improved liquid distribution.

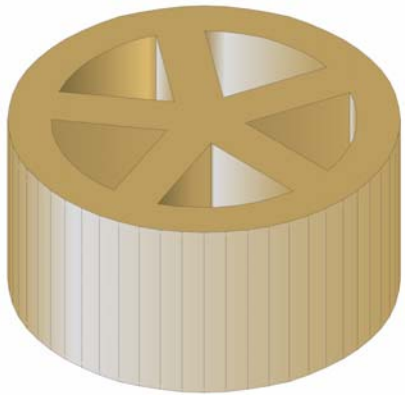
It is our experience that, if pressure drop build up takes place, the pressure drop build up is caused by formation of deposits at the top of the 1.3Q or 1.5E sized catalysts. To reduce the impact of deposition on pressure drop build up, a gradual change of catalyst activity and sizing is required. To achieve this target, Albemarle usually proposes Raschig rings and 3Q-sized catalysts. Instead of inert balls, KG-55 can be used as hold down material with a high void fraction. We recommend sock-loading of the top layers of KG-55 and large size catalyst (9R, 5R, 3Q) and the first 50 cm of the small size (1.3Q, 1.5E) bulk/main catalyst. This sock loaded guard bed/top layer system is specially designed to prevent fouling caused by:

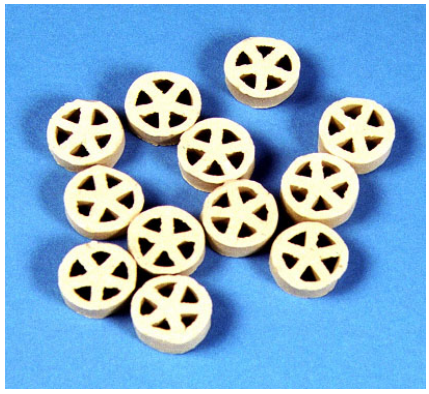
- Particulates (high void fraction)
- Gum formation (graded hydrogenation activity)
- Iron in the feed
- Feed contaminants (Ni, V, As, Si)

In the top grading, a “size factor” of 2 is generally applied when going from one layer (either catalyst or inert material) to another in order to ensure a gradual decrease of void space when moving down from the topmost layer to the main catalyst.

KETJENFINE KG-55

Ketjenfine KG-55 is an inert pentaring support material for hold-down, bed grading and improved pressure drop stability with excellent holding capacity for contaminants and particulate matter. It has 19 mm outer diameter and has a very large void fraction (62%) for scale trapping properties without getting plugged. It serves as large size top layer material for catalyst bed grading and as hold-down material to replace the 1” or ¾” ceramic balls in the top of the catalyst bed.





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KETJENFINE 542-9R/5R

Ketjenfine 542-9R and 5R are moderately active NiCoMo catalysts produced in the form of Raschig rings with 9.0/3.5 mm and 6.0/2.8 mm outer/inner diameter respectively.
Ketjenfine 542 has a moderate hydrogenation activity and a medium denitrogenation and desulfurization activity.
This catalyst provides an exceptionally high void volume in the top of the bed in order to trap scale and other particles without becoming plugged and giving rise to pressure drop build-up and liquid maldistribution.
A top layer of this material will initiate the saturation of olefinic compounds in the feed and prevent the formation of coke and gum deposits in the top of the catalyst bed. Mild desulfurization also begins when the oil is contacted with Ketjenfine 542 and the formation of H_2S also initiates the deposition of heavy metal (such as Ni and V if present in the feed) sulfides in the top of the catalyst bed where generally the demetallization catalysts are also loaded.
The saturation of olefins (and the removal of heavy metals) at the top of the catalyst bed where void fraction and catalyst size are high will prevent these molecules from reacting deeper in the catalyst bed, where void fraction is low and where risk of pressure drop build-up is high.

KETJENFINE 841-3Q

Ketjenfine 841-3Q features a high pore diameter and high metal resistance. It is a high activity conventional NiMo type catalyst, which is produced in the form of 2.6 mm diameter quadralobal shaped extrudates (3Q). Ketjenfine 841 is a well-proven catalyst, which has outstanding HDN and hydrogenation properties, in combination with excellent HDS characteristics.
These features make this catalyst especially suitable as top layer for units treating cracked feedstocks. More than 10.000 mton of Ketjenfine 841 has been sold to hundreds of units all over the world, treating feeds ranging from light naphtha’s to heavy vacuum gasoils.

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KETJENFINE 757-3Q

Ketjenfine 757 is manufactured following a new design concept that maximizes the number of so-called Super Type-II Active Reaction Sites (STARS).
Extensive pilot plant testing on various feedstocks has demonstrated that this catalyst has a HDS and HDN activity which is at least 30% higher than Ketjenfine 756.

Traditionally, Ketjenfine 757 is produced in the form of 1.4-mm cylindrical extrudates (1.5E), but is now also available in a 2.6 mm quadralobal extrudate (3Q). This is especially of interest for refineries who:

want to maximize HDS activity in their unit and want to include a CoMo catalyst as a guard bed catalyst experience pressure drop restrictions and require a coarser catalyst particle to minimize SOR pressure drop.

Like for the 1.5E version, no spiking agent is required for start up. The sulfur being present in the feed is sufficient for the presulfiding reactions, provided that the start up gasoil contains at least 0.8% sulfur.

KETJENFINE KG 1-5B

Ketjenfine KG 1 is Albemarle Catalysts unique, patent protected iron guard catalyst.

Pressure drop problems occur in many hydrotreaters with a wide variety of causes. A large number of pressure drop problems however, have a similar cause: iron deposition. Iron deposition can originate from scale (e.g. coming from corroded upstream equipment). Scale particles can have sized ranging from very small (1-10 mm) up to well over 100 mm.

This problem is mainly counteracted by applying sufficient scale baskets as well as providing sufficient void fraction in the top of the catalyst bed. More difficult to attack is iron originating from organic Iron-molecules present in the feed. Such molecules are generally present in heavy fractions, such as residues, but can also be formed, especially when acidic crudes are applied and when oxygen-molecules are present (e.g. with long non-N_2 blanketed tankage).

These organic Iron-molecules are highly reactive. In a hydrotreating unit they react immediately in the top of the reactor bed with the hydrotreating catalyst. Hence, the iron is deposited and finely dispersed at the outer surface of the catalyst particle. Iron in a hydrotreater is easily converted into iron sulfides. The latter enhance coke formation, resulting in excessive coke deposition at the outer surface of the catalyst particle. Here not only the activity is blocked as the pores are blocked, but also the pressure drop increases rapidly as the voids between the catalyst particles are rapidly filled with coke.

Ketjenfine KG 1 is a catalyst designed to trap iron scale and iron from organic compounds inside its pores. The pore structure of Ketjenfine KG 1 is unique, giving this catalyst its outstanding performance characteristics. The capacity to trap iron of Ketjenfine KG 1 is at least 20 times higher than found for conventional catalysts or other top layer materials. The storage of iron inside the Ketjenfine KG 1 catalyst strongly reduces the risk of pressure drop problems. Because of its spherical shape (5 mm spheres), the catalyst contributes to distribution of the liquid feeds over the catalyst bed and can replace ¼" inert balls normally loaded. Ketjenfine KG 1 has an excellent track record in hydrocrackers, where it prevented or highly delayed pressure drop problems.

Ketjenfine KG 1 offers the special combination of a unique pore size distribution and a tailored activity. This combination allows the Fe-molecules (and even small Fe particulates in the scale!) to be trapped and deposited inside the pores of KG 1, thus preventing the build-up of coke on the outside of the particles.

KETJENFINE 647-3Q/1.3Q

Ketjenfine 647 is a NiMo 'VGO-Demet' catalyst, produced in the form of 2.6 mm (3Q) and 1.3 mm (1.3Q) quadralobal shaped extrudates. This catalyst is especially designed for removal of metals such as nickel, vanadium, silicon, sodium and arsenic from heavy distillate feeds. Ketjenfine 647 has a high demetallization activity and a high capacity to pick-up metals from the feed, considerably higher than conventional distillate hydrotreating catalysts. At the same time, Ketjenfine 647 has a fairly high HDN, HDS and hydrogenation activity, much higher than conventional resid demetallization catalysts. Many hundreds of tons of VGO-Demet catalyst were sold, mainly as guard catalyst for FCC-pretreaters or Mild and full pressure Hydrocrackers (also 2nd stage).

KETJENGUARD KG 6-3Q

KG 6 is a NiMo catalyst being very effective in arsenic trapping. KG 6 traps 2-3 times as much arsenic as other demetallization catalysts. KG 6 has a moderate HDS and HDN activity and is made in 2.6 mm quadralobes (3Q). As arsenic can be present in almost all refinery oil streams, the catalyst can be used in a wide range of applications.

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MAIN CATALYST GRADES

KETJENFINE 756-1.3Q

Ketjenfine 756 is our highest activity conventional CoMo catalyst, developed together with a major oil company in the mid nineties for activity limited mid-distillate hydrotreater operations. With cracked feedstocks such as visbreaker or cat cracked gasoil, the performance of Ketjenfine 756 further improves compared to other catalysts. Apart from diesel HDS, Ketjenfine 756 is widely applied in naphtha and VGO pretreat operations to benefit from its relatively high HDN activity compared to other CoMo catalysts.

KETJENFINE 841-2E/3Q/1.3Q

Ketjenfine 841 is an active NiMo catalysts produced in the form of 2.1-mm (1/12") cylindrical extrudate (Ketjenfine 841-2E) or 2.6 mm diameter and 1.3 mm diameter quadralobal shaped extrudates (Ketjenfine 841-3Q and Ketjenfine 841-1.3Q respectively). Ketjenfine 841 is a well-proven catalyst with outstanding denitrogenation (HDN) and hydrogenation activities and good desulfurization (HDS) activity, combined with excellent stability and outstanding metals tolerance. This unique combination of features makes Ketjenfine 841 an excellent choice, especially when cracked feedstocks are processed.

KETJENFINE 1022-1.5E

Ketjenfine 1022 is our high activity amorphous silica-alumina cracking catalyst.
This CoMo type mild hydrocracking catalyst combines highest cracking activity with high desulfurization and denitrogenation activity, which are typical for conventional FCC pretreat catalysts. These properties make this catalyst excellently suited for those applications where next to optimal middle distillate production and also high levels of HDS and HDN are required. Ketjenfine 1022 belongs to the same catalyst family as Ketjenfine 1012 and 1014 both also CoMo type and Ketjenfine 1015, which is a NiMo type.

STARS CATALYSTS

KETJENFINE 757-3Q/1.5E

In 1998 Albemarle introduced a new superior catalyst for the deep desulfurization of distillates to the refining industry, Ketjenfine 757. This catalyst was manufactured following a new design concept that maximizes the number of so-called Super Type-II Active Reaction Sites (STARS). Extensive pilot plant testing on various feedstocks has demonstrated that this catalyst has a HDS and HDN activity which is at least 30% higher than Ketjenfine 756. When operating at ultra deep desulfurization levels, corresponding to a product sulfur level of 50 ppm or below, activity advantages up to 60% have been observed compared to Ketjenfine 756. These features make that this catalyst is very suitable for those units, which are severely activity limited: the high activity allows refiners to significantly lower the operating temperature required and thus to extend cycle length considerably, while producing ultra low sulfur product.

- Ketjenfine 757 is produced in the form of 1.4-mm cylindrical extrudates (1.5E). Pilot plant testing at most major oil companies has confirmed the superior quality of this catalyst. Commercial performance in a meanwhile overwhelming number of ULSD-units confirms the performance found in pilot plant testing.

Meanwhile KF-757 has been regenerated and reused many times. Commercial performance of the regenerated KF-757 is good, as published in Catalyst Courier no. 47, but activity recovery upon regeneration is less than with conventional catalysts. To achieve close to full activity recovery a special REACTivation procedure has been developed. A number of batches of REACTivated KF-757 have meanwhile been taken in operation and confirm at least 90% of fresh catalyst activity. These benefits make Ketjenfine 757 a very economical catalyst to use. In summary, those benefits are:

- Direct savings due to better cycle length (less production loss, regeneration costs)
- Volume gain
- Improved product quality, lower sulfur, increased Cetane Number
- No need for spiking agent during presulfiding
- Excellent regenerability and REACT-ability, resulting in long catalyst life.

As Ketjenfine 757 is produced with a unique and proprietary technology, further information can only be provided and supply of the catalyst can only take place after execution of a secrecy agreement.

KETJENFINE 767-1.5E

Ketjenfine 767 is a new CoMo STARS catalyst which replaces Ketjenfine 757 in a number of applications. Compared to Ketjenfine 757, further improvements in metal impregnation technology have been accomplished thereby increasing the intrinsic activity of the metal sites. HDN activity has also been increased and because of this, nitrogen inhibition of the active sites is reduced and HDS activity enhanced. This means that Ketjenfine 767 shows an activity improvement over Ketjenfine 757 if product nitrogen can be reduced to sufficiently low levels (<20 ppm). Under these conditions, Ketjenfine 767 shows from 30-70% or 6-10°C higher activity than Ketjenfine 757. Ketjenfine 767 is especially of interest for refineries producing ultra low sulphur or 'sulphur-free' diesel at medium to high pressure. In comparison with Ketjenfine 757, Ketjenfine 767 consumes approximately the same amount of hydrogen at constant product sulphur. Ketjenfine 767 is produced in 1.4 mm cylindrical extrudates (1.5E).

As Ketjenfine 767 is produced with a unique and proprietary technology, execution of a secrecy agreement is required in order to provide further information on this catalyst and also for the supply this catalyst.

KETJENFINE 848-1.3Q

Ketjenfine 848, is by far the highest activity NiMo catalyst available today. This catalyst is manufactured following our STARS design concept that maximizes the number of so-called Super Type-II Active Reaction Sites and features an extremely high denitrogenation, desulfurization and hydrogenation activity. Ketjenfine 848 is produced in the form of 1.3 mm diameter quadralobal extrudates (1.3Q).

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Initially, Ketjenfine 848 was developed for Hydrocracker pretreat service. Subsequent test work has shown that at medium to high operating pressures (>40 bar ppH_2), Ketjenfine 848 is also the catalyst of choice for ultra-deep diesel HDS. Ketjenfine 848 is especially of interest if at the same time also cetane uplift or aromatics saturation is required.

As Ketjenfine 848 is produced with a unique and proprietary technology, further information can only be provided and supply of the catalyst can only take place after execution of a secrecy agreement.

Interesting features of STARS Catalysts
Aside from the high activities, other interesting features of STARS catalysts are that:

- No spiking agent is required for start up. The sulfur being present in the feed is sufficient for the presulfiding reactions, provided that the start-up gasoil contains at least 0.8% sulfur.
- STARS catalysts give more volume swell, better color and cetane improvement, compared to the best former generation catalysts.

Color of STARS catalysts:
Albemarle's STARS catalysts may have a different color than conventional catalysts. Variations in color are most commonly associated with exposure to light, air and humidity. We have established that color variation has no impact on the activity of STARS catalyst. It is a perfectly normal consequence of STARS technology and indicative of the presence of Type II active sites from which STARS catalysts derive their outstanding performance.
The color of KF-757 (CoMo) can range from blue-gray to reddish-brown. The color of KF-767 is grayish blue. The color of KF-848 can range from light grayish-green to blue.

NEBULA

NEBULA-20-1.5Q

Albemarle Catalysts introduced in 2001 the development of the next generation of hydrotreating catalysts – NEBULA technology. This breakthrough technology reaches previously unattainable levels of desulfurization, denitrogenation and aromatics saturation. Nebula catalyst is a totally novel and patented catalyst technology jointly developed by Albemarle Catalyst/Nippon Ketjen and ExxonMobil. It represents in our opinion the greatest step forward since the beginning of hydroprocessing catalyst development in the 1950's. Nebula is a catalyst developed on the basis of base metals, so no noble metals are included. The catalyst needs to be sulfided before use just as normal catalysts, with the difference that in case of the Nebula more sulfur needs to be added.

Compared to Nebula-1, Nebula-20 features an improved accessibility and is therefore also suitable for VGO applications, such as FCC and hydrocracker pretreat.

Note that the loading density is significantly higher than today's catalysts, primarily due to higher skeleton density of the material.