Pressure drop control

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CATALYSING YOUR BUSINESS


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Improve your operation by controlling pressure drop

Pressure drop control

In hydroprocessing, refiners are often faced with pressure drop build-up in the catalyst bed that shortens the on-stream cycle length.

Pressure drop build-up is due to
- deposition of feed contaminants
- crust formation
- catalyst milling
- corrosion products

Pressure drop build-up causes
- channelling or bypassing
- high radial temperature spread
- operating difficulties
- maldistribution

Topsøe's graded bed solutions solve these issues.

Topsøe graded bed solutions

Topsøe's graded bed technology has provided help to many refiners, resulting in significant performance improvements from months to several years. Topsøe has supplied graded bed technology for more than 2,000 units, and we are continually developing our product range to meet new challenges.

Topsøe provides individual solutions in order to achieve optimal performance. We assist in evaluating each unit separately by considering all factors involved, including analysis of spent catalyst, agglomerates, deposits etc. Also, operating history, feed type, feed rate, treat gas rate, unit upsets and unscheduled shutdowns will have a bearing on the problem and, ultimately, on the solution that we will recommend.

To meet all requirements, we have a large number of different products available to combat reactor bed fouling, including specialty traps for feed contaminant such as arsenic, silicon and iron. Altogether, we offer a product range which makes Topsøe uniquely equipped to develop optimal solutions for refiners. Please refer to figure 1, showing the variety of high void and catalytically active products which Topsøe currently offers for catalyst bed grading.

Solid contaminants in feedstock

- iron scale
- coke fines
- catalyst fines or dust
- large carbonaceous scale
- sediment
- salts (Na, K, etc.)

Contaminants from reaction products

- coke (hard or soft)
- vanadium- and nickel sulphides
- iron sulphide
- silica
- arsenic
- Hg, Pb and other metal sulphides

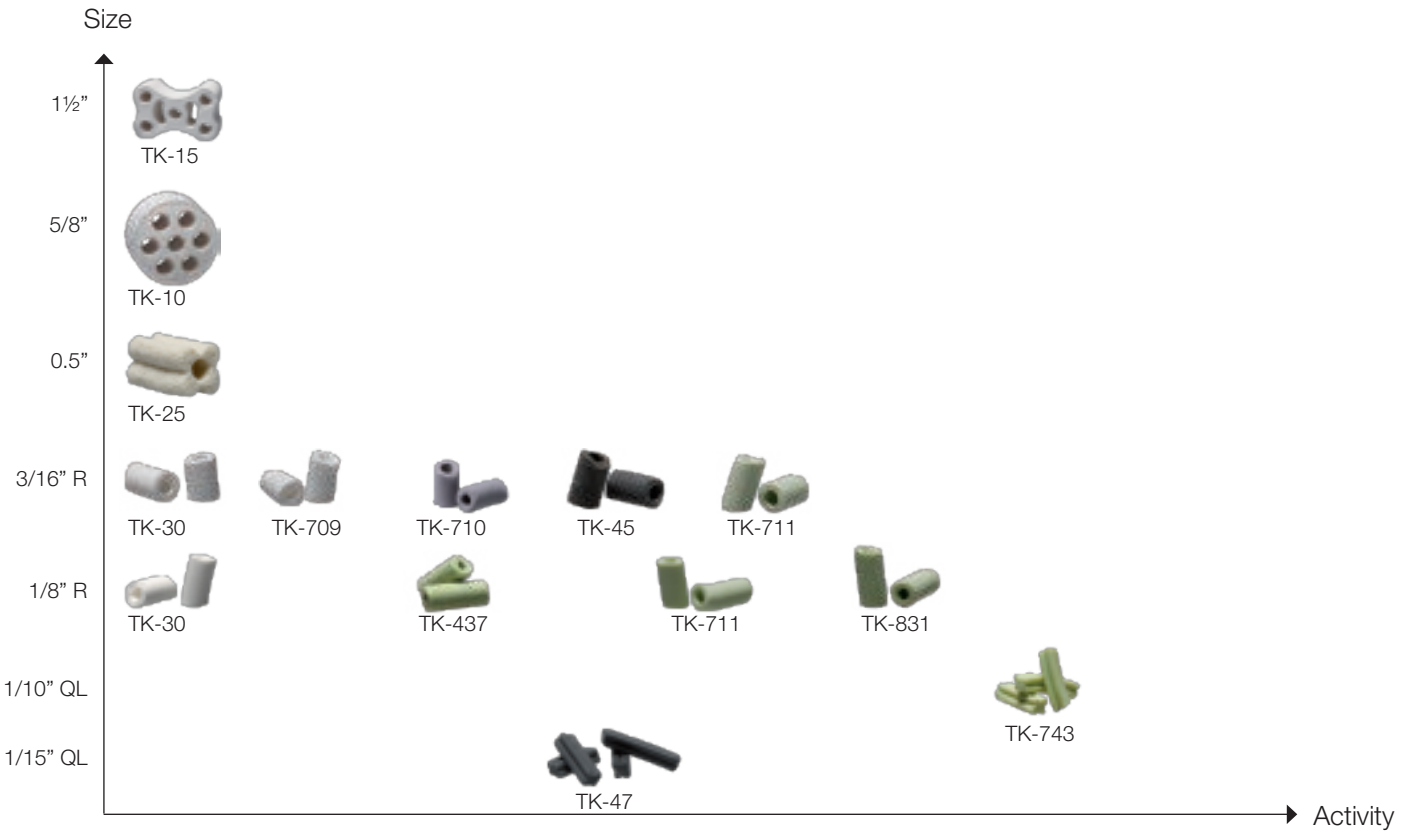


Figure 1: Topsøe offers a variety of products to alleviate pressure drop problems, ranging from large inert topping material to small rings with high catalytic activity. Our high void products are shown in this figure. Catalytic activity of the products increases along the X axis, as shown.

Contaminant deposition – catalyst bed void

Topsøe has gained experience from a multitude of industrial reactors having the operating cycle limited by pressure drop as opposed to catalyst activity. This experience together with that obtained from laboratory modelling has shown that the key to controlling pressure drop is to control bed void and size grading.

A typical reactor loading consists of the following: High void hold-down material followed by large shaped particles followed by large rings on top of smaller rings and underneath these, the high activity bulk catalyst. The rationale behind using rings in different sizes is to create a loading which has a differentiated filtering effect, so that the largest solid contaminants, introduced with the feed, are trapped in the upper layers, and the smaller particles are deposited in the lower layers. It is important that there is a gradual change in size and shape to avoid accumulation of material at the interface of layers.

At the same time, we ensure that there is ample room for the contaminants in the different grading layers of the reactor. Topsøe products have a very high void fraction, and thus, each catalyst layer has high storage capacity.

Crust formation – catalyst activity

Another frequently encountered problem is that of crust formation, normally at the top of the catalyst bed. The crust causes increased pressure drop, flow maldistribution and difficulties during catalyst unloading.

One of the leading factors in crust formation, which is often overlooked, is “too much activity”. Due to the increasing demands made upon refiners, the natural trend is to pack as much catalytic activity as possible into the reactor. If the unit in question is processing a feedstock containing olefins, diolefins in particular, and oxygenates (coker, FCC streams or biofuels), crust formation is likely, unless preventive steps are taken.

The solution to this kind of problem is to grade the top of the catalyst bed by catalytic activity. By catalytic grading we gradually increase catalytic activity from the inert topping down to the main bed by several increments, instead of having one step from inert to maximum activity (figure 2).

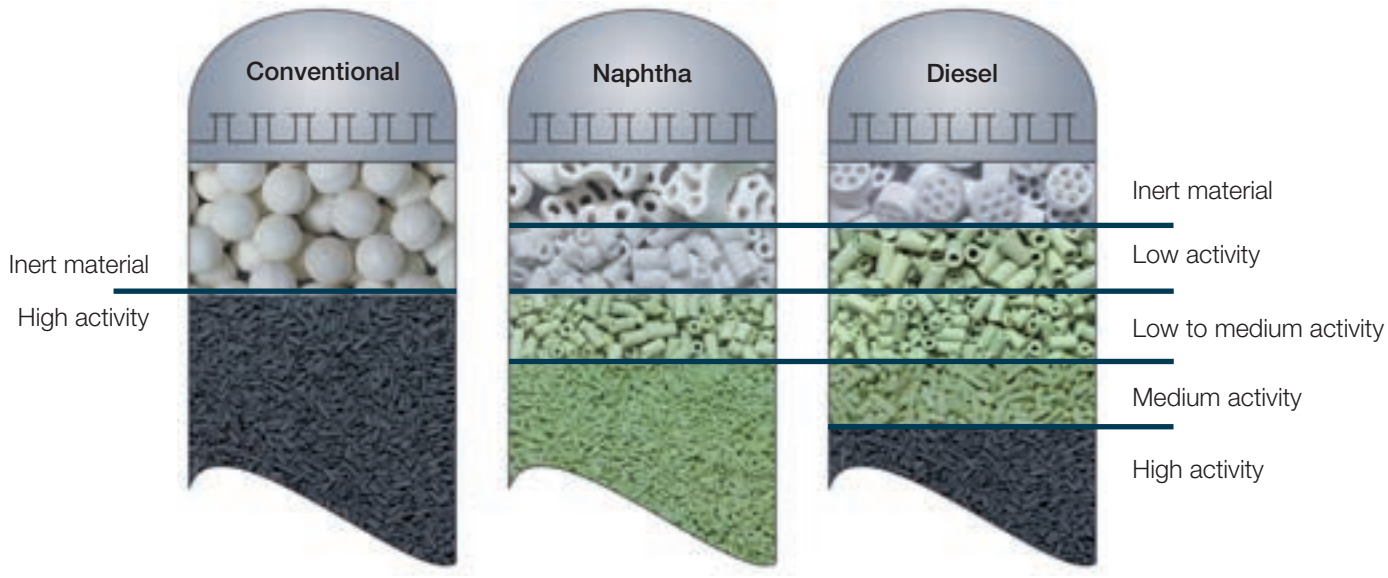


Figure 2: Example of Topsøe versus conventional activity grading. Furthermore, spheres have the lowest void fraction of all available material and thus very limited space for contaminants as opposed to Topsøe material.

Catalyst milling – product density

Catalyst milling is seen occasionally, particularly in naphtha units where the gas rate is high and no gas liquid distributor is used, and also in units where the inlet splash plates are not designed properly.

In order to avoid catalyst milling, especially for naphtha hydrotreating services, Topsøe recommends installing a top layer of very dense material, TK-15. The special shape of TK-15 makes these particles eminently suitable to provide the hold-down function on top of the catalyst bed, and at the same time it provides high void.

Metal, silicon and arsenic deposition – catalyst pores

Topsøe is also capable of handling metal deposition by grading the bed with respect to catalyst pore size. Some metals (e.g. organic iron) penetrate into the pores of hydrotreating catalyst, where they rapidly react and cause plugging of the pore mouth and subsequently a decrease in catalyst life. We provide demetallisation capability by loading catalysts with large pores at the top of the reactor. Our demetallisation catalysts are characterised by having high hydrodemetallisation activity and high tolerance towards metals deposition, again affording protection of the main bed catalyst below. In fact, many of our ring products have dual functionality, since they both trap metals inside the pore system as well as enable retention of interstitial material in the void fraction.

In case of feedstocks containing small particulates not trapped by the feed filters, such as corrosion products, Topsøe recommends installing the macroporous inert material, TK-25. Due to the unique macroporosity, TK-25 is ideal for trapping corrosion particulates. TK-25 should be installed just below the high-void topping TK-10 or TK-15.

In addition, increasingly more crude oil contains arsenic which is a severe catalyst poison, and most coker-derived products are contaminated with silicon. To protect the main catalyst, Topsøe has therefore developed a series of specialty traps for these contaminants.

Example of Topsøe graded bed

As an example of a graded system, we show a typical Topsøe graded bed of the simple variety in figure 3. It consists of four layers of grading material on top of the main catalyst bed, which is 1/20" threelobes. At the very top, we have replaced the conventional spherical topping with a high-void TK-10. A layer of TK-711, 3/16" ring catalyst, followed by a layer of TK-831, 1/8" ring catalyst and TK-743, 1/10" quadrolobes completes the grading. In this example, we have achieved the following improvements at the same time:

- grading by void size
- grading by activity
- grading by pore size

With this combination, we have provided space for accumulation of metal sulphides and debris, while providing activity grading to spread out polymers formed from diolefins and other highly reactive species. In addition, we have installed different sizes of void space to enhance the pick-up capacity. The same principles apply in designing more complicated graded beds.

Commercial experience with Topsøe grading is shown on the following page.

Topsøe services

Distribution trays

To ensure an efficient utilisation of the bulk catalyst, it is not only important to have protection against pressure drop build-up. It is equally important to have good distribution of the reactants in the catalyst bed. The most critical factors for ensuring efficient catalyst performance are the liquid distribution trays and quench mixing devices. For more information on this, please refer to our brochure on distribution trays.

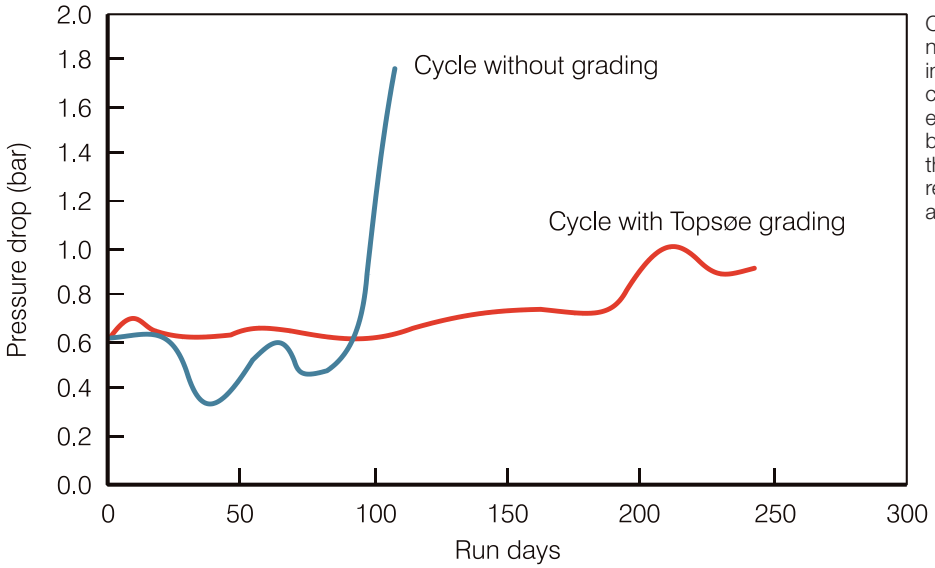
Optimise your operation

Today, where refiners are required to produce very low sulphur products, super high activity catalysts are required. In order to obtain the maximum potential from these catalysts, it is necessary to have a graded bed and good distribution. Topsøe distributor trays will provide the ideal dispersion of reactants, and Topsøe grading will provide insurance against pressure drop build-up and promote the good distribution.

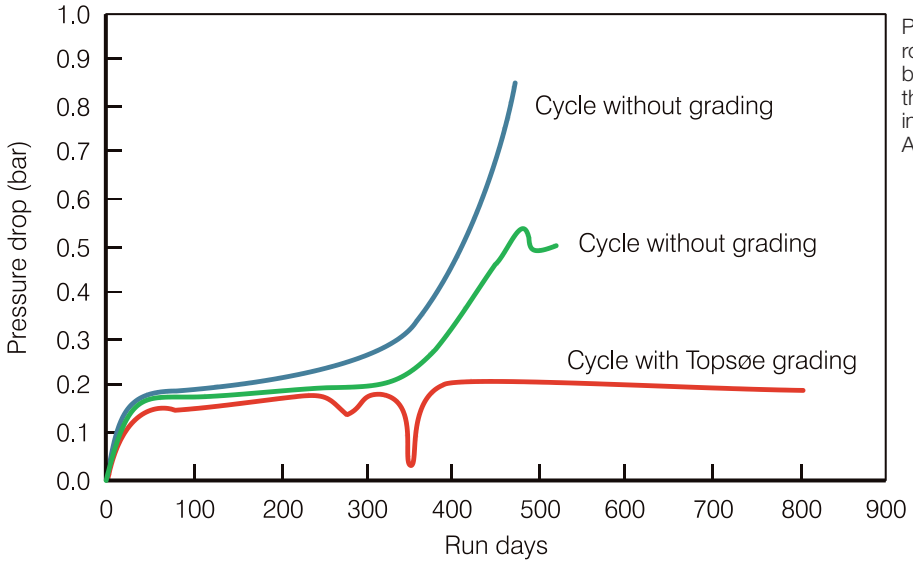
Know-how and commercial experience have made Topsøe the leader in pressure drop control. Let Topsøe improve your operation by controlling your pressure drop development.

	Void size	Void fraction	Activity
Distributor			
TK-10 inert material	very large	55%	none
3/16" TK-711 R	large	53%	low
1/8" TK-831 R	large to medium	53%	low to medium
1/10" TK-743 QL	medium	48%	medium
1/20" TK-576 BRIM™ TL	small	45%	high

Figure 3: Typical example of Topsøe graded bed solution.



Commercial experience with Topsøe grading. This naphtha hydrotreater was experiencing severe fouling in and on the top of the catalyst bed. It was due to carbonaceous material, spalling from the heater and heat exchangers. Using a Topsøe graded bed removed this bottleneck and extended the cycle length. It is obvious that by avoiding three plant turnarounds, including replacement catalyst cost savings, the financial impact at this refinery was substantial.



Prior to using the Topsøe graded bed, the pressure drop rose exponentially after about one year on stream. As can be seen from the pressure drop curves, the application of the graded bed has doubled the cycle length with no increase in pressure drop from Start of run to End of run. Again, this resulted in major economic advantages.

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