

# MAXIMUM DIESEL PRODUCTION FROM EXISTING ASSETS

NEBULA® catalysts help refiners to meet rising global demand

The world's increasing demand for diesel over recent years has outpaced the growth of other mineral oil fuels and shows no sign of abating. This is particularly evident in India. Constructing new facilities can be a long and costly process. However, using innovative catalyst solutions to optimize existing assets is an economically attractive alternative.

Indian refineries with and without hydrocrackers face different challenges. For those without, the Bharat IV specification on diesel density, cetane number and cetane index can limit increased diesel production. Many give product quality away to meet the T95 specifications. Increasing the density reduction that can be achieved by diesel hydrotreaters enables them to raise diesel yield.

However, when high-pressure hydrocrackers are used, hydrocracked diesel becomes a source of low-density, high-cetane blending material that can correct diesel hydrotreater deficiencies. Use of these blending materials may be limited, particularly where refineries produce a low-density diesel pool. Low-density products are often sold separately, even when margins are lower than for diesel. Increasing the feed's distillation end points is a relatively easy alternative for increasing diesel pool density. Aromatics saturation can only provide limited T95 reduction, however. The ASTM D86 T95 specification determines the maximum feed end point. However, incorporating some form of T95 reduction in diesel hydrotreaters enables refineries to extend the boiling range of their diesel hydrotreater feed and, thus, increase diesel yield.

## Ultra-deep aromatics saturation

One solution to extending the boiling range of diesel hydrotreater feed is ultra-deep aromatics saturation. Diesel fuel is a blend of paraffins, naphthenes and aromatics. New studies on the effects of hydrotreating on these three constituent groups have highlighted options for increasing production. If additional density reductions were needed to meet specifications or if excess hydrogen could be used to increase the diesel pool volume, the only historic option was to use a noble metal platinum/palladium catalyst. Because these catalysts cannot tolerate the presence of sulfur and nitrogen, a two-stage unit was necessary with inter-reactor removal of hydrogen sulfide (H<sub>2</sub>S) and ammonia (NH<sub>3</sub>).

By introducing the NEBULA family of catalysts in 2001, Albemarle provided a different solution. NEBULA is a base metal catalyst technology that can operate in an H<sub>2</sub>S and NH<sub>3</sub> rich atmosphere. It offers a drop-in solution for refineries seeking ultra-deep aromatics saturation for maximum density reduction and cetane improvement. When combined

with Albemarle's STAX® methodology for optimizing hydrotreating catalysts loads, the quantity of NEBULA required can be reduced to typically 20–25% of the total catalyst volume. This minimizes costs.

Ultra-deep aromatics saturation is attractive where diesel yield is limited by the diesel pool's density or cetane index. It has the lowest naphtha make while maximizing diesel yield. Product quality giveaway on ASTM D86 T95 can be reduced or eliminated. However, this reduction does not increase significantly because of the increased aromatics saturation, a factor related to the composition of the heavy diesel fuel fraction after hydrotreating.

There is an upper limit to the T95 reduction that aromatics saturation can achieve. If the refinery's diesel pool is limited by the feed's end point, some form of T95 reduction through a cracking mechanism is required to increase diesel yield. The instinctive response of most refineries is to dismiss this. Their perception is that diesel yield will decrease. However, the key aim is to increase

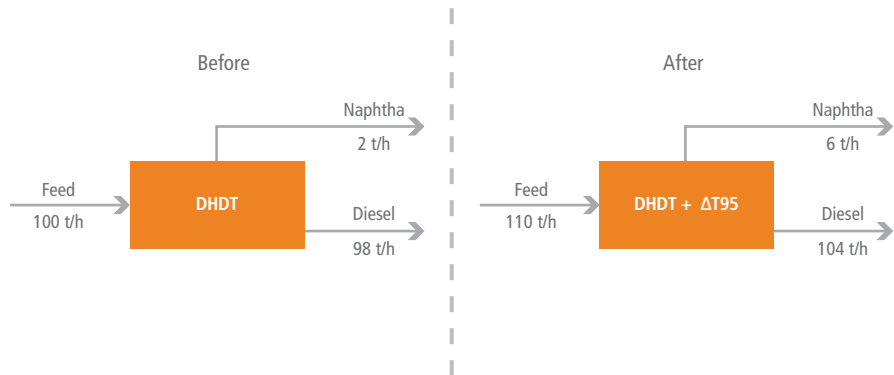


Figure 1: Comparative unit mass balance before and after the implementation of T95 reduction.

|                          | HYDROTREATING ONLY | HYDROTREATING + T95 REDUCTION |
|--------------------------|--------------------|-------------------------------|
| Product ASTM D86 T95, °C | Base               | 0.84                          |
| Naphtha yield, wt% of FF | Base               | Base +4.2                     |

Table 1: Commercial example of T95 reduction.

the feed's end point while keeping the remainder of the feed constant. The feed rate to the unit will increase as the end point increases. Although the naphtha make will increase, both in weight and as a percentage of fresh feed, this is offset by the diesel yield increase.

Figure 1 shows a numerical example of a simultaneous increase in feed end point and T95 reduction. The base case naphtha yield of the diesel hydrotreater is 2 t/h or 2 wt%. When T95 reduction is applied through a cracking mechanism, naphtha yield increases to 6 t/h or 5.4 wt%. This is not economically attractive for most refineries.

However, because the feed rate increases from 100 to 110 t/h because of the extended feed end points, the diesel output increases from 98 to 104 t/h: a net gain of 6 t/h. Evaluating a T95

reduction purely in terms of percentages is misleading. Refineries may dismiss profitable opportunities. If diesel hydrotreater capacity is fully utilized, but spare capacity is available in a lower-pressure diesel hydrodesulfurization unit, the same overall diesel pool increase can be achieved by transferring some lighter feed components from the diesel hydrotreater to the diesel hydrodesulfurization unit and applying T95 reduction on the heavier feed to the diesel hydrotreater.

## Implementing T95 reductions

In a commercial unit, catalyst selection can be crucial to achieving the right selectivity to maximize diesel yield. Figure 2 compares naphtha yield between a standard mild hydrocracking catalyst and a catalyst designed specifically for T95 reduction of heavy diesel fractions.

The standard mild hydrocracking catalyst, designed to crack heavier VGO feeds, will overcrack the diesel feed's lighter portion to naphtha, which leads to a higher naphtha make per degree of T95 reduction. Moving up the selectivity–activity curve towards a higher selectivity and lower activity catalyst increases the required start-of-run temperature. This reduces the cycle length to unacceptably low levels.

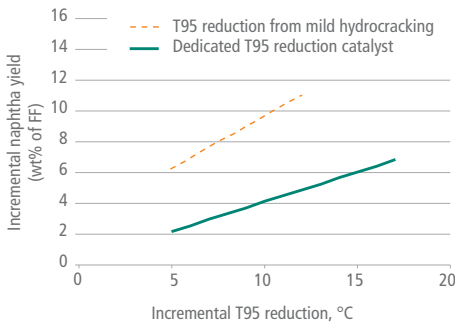


Figure 2: Incremental naphtha yield versus incremental T95 reduction.

In contrast, a dedicated selective T95 reduction catalyst operating on a different principle offers the right activity and selectivity combination to reduce naphtha make to acceptable levels.

Table 1 shows a commercial example using Albemarle's dedicated selective T95 reduction catalyst. The catalyst system enables the refinery to switch off T95 reduction activity. The data considers a period where T95 reduction was not used: the unit only operated to reduce sulfur and density. It then compares this with when the catalyst system's T95 reduction capability was used.

Here, an additional 8°C of T95 reduction was possible with an incremental naphtha yield of 4.2 wt%. This refinery also achieved an incremental feed rate by extending the feed's end point by 8°C of 10 wt%. The overall diesel output increased by 5.8 wt%.

T95 reduction can increase the diesel output very effectively. Optimizing feed diet and reallocating feed to other hydrotreating units maximizes this benefit. One final consideration is whether the naphtha yield of the entire complex changes. If, for example, the heavy diesel stream is taken from the FCC or hydrocracker feed, the refinery's overall naphtha make will be unchanged. Both units produce copious amounts of naphtha.

FOR MORE INFORMATION, CONTACT:  
Pieter Lusse  
Email: pieter.lusse@albemarle.com