**Maximizing the use of regenerated Gas Oil Hydrotreating (HDT) catalyst for re-utilization in Kero HDT & Naphtha HDT units**

Nilesh Chandak1, Adel Hamadi, Menwa Dakhan, Ashjan Alkatheeri, Abraham George, Stephane Morin and Mikael Berthod

*ADNOC Refining, Research Centre Division, P.O. Box: 3593, Abu Dhabi, U.A.E.*

*\*Corresponding author*1 *, Email: nchandak@adnoc.ae*

**Highlights**

* Applied research work for the refinery process optimization
* Experimental data from pilot plant to calculate reaction kinetics, analyze aromatics & H consumption
* Study Impact of the changes on catalyst activity, product yield & product quality
* sustainability objectives to reduce waste generation, recycle and reuse of spent catalyst

**1. Introduction**

Gas Oil (GO) hydrotreater in the ADNOC refinery is designed to process Heavy Gas Oil (HGO) and Light Gas Oil (LGO) coming from crude/condensate units and produce Gas Oil with total sulphur ≤ 10 ppmw. During turnaround, GO hydrotreating (GO HDT) catalyst was unloaded from this unit after serving one cycle of 4 years. On other hand, at the time of catalyst selection it was envisaged that this catalyst can be used for two cycles. So this catalyst still having useful life leftover was considered for reuse in other hydrotreaters viz. Naphtha HDT and Kerosene HDT units in the refinery. Naphtha HDT unit is processing Whole Naphtha (WN) coming from Crude Distillation Unit (CDU) to produce max 0.5 ppm sulfur content of Heavy Naphtha (HN) which is the feed stock of Catalytic Reforming (CR) unit. Kerosene HDT unit is processing Kero or light gas oil to produce Kero with less than 10 ppm sulphur. Hence pilot plant study was undertaken to evaluate the reuse of catalyst for the second cycle to process WN and Kero, to produce on spec product, to evaluate regenerated GO HDT catalyst, Estimate the H2 Consumption, Analyze product PONA at higher WABT & Assess the performance of catalysts at higher nitrogen content more than 10 ppm wt.

**2. Methods**

Hydrotreating experiments were carried out according to refinery unit test conditions, with reference feed stock Whole Naphtha & raw Kerosene and were processed using a GO HDT regenerated catalyst in a pilot reactor at fixed operating conditions, as listed below Table # 01. The pilot plant test started with LHSV 4 hr-1 at 275 ˚C and on specs product for Nitrogen were achieved but sulphur was at 1.3 ppm. Hence WABT was increased to 280 ˚C temperature to achieve product target sulphur content below 0.5 ppm. Test points were created for increased throughput upto to 5 hr-1 for NHDT. For Kero HDT, test points were also varied for pressure, temperature & LHSV.

**3. Results and discussion**

Whole Naphtha has low nitrogen content but the performance of the catalyst was tested at high nitrogen content in the feed (>10 ppm) because GO HDT catalyst has higher HDS activity than HDN activity and it was observed that this GO HDT catalyst is capable to handle feeds having the higher nitrogen range. Hydrogen partial pressure was reduced from 25.5 kg/cm2 to 23.7 kg/cm2 and there was no noticeable change in catalyst performance.

Table 1. Test operating conditions

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test | FEED | Pressure | LHSV | H2/HC | Temp | Sulfur in Product | N in Product |
| Nº |  | (kg/cm2) | (h-1) | (Nm3/m3) | (°C) | (ppm) | ppm |
| 1 - 7 | Naphtha | 25.5 to 23.7 | 4 to 5 | 44 | 275 to 320 | 1.2 to < 0.5 | <0.3 |
| 8 | Naphtha(10 ppm N) | 23.7 | 4.5 | 44 | 280 | < 0.5 | <0.3 |
| 9-11 | Kero | 44.24 to 40.26 | 2 to 2.5 | 305 | 275 to 280 | 3.8 to 1.4(Mercapan S) | - |

For kerosene HDT, pilot plant test was started at LHSV 2 hr1 at 275˚C and product specs were observed within acceptable range. The mercaptan sulphur in the product was reported around 3 ppm (on specs) for the first test point, then temperature was increased to 280 ˚C to compare the results with current operation of Kero HDT unit. Also at higher LHSV of 2.5 hr-1, on spec Kero with <10 ppm mercaptan sulphur was achieved. Furthermore, hydrogen partial pressure was reduced from 44.24 kg/cm2 to 40.26 kg/cm2 and there was no noticeable change in mercaptan sulphur.

Hydrogen consumption has been estimated to 14.67 Nm3/m3 Kero HDT & 2.63 Nm3/m3 for Naphtha HDT, by performing a material balance for the selected test points at stable operating conditions accompanied by a series of analysis.

**4. Conclusions**

Based on the pilot plant test, it was concluded that the GO HDT catalyst is suitable to re-utilize to process whole naphtha and kero to produce on spec product. As per the results from the variable test points, both units can operate satisfactorily at higher LHSV and at lower hydrogen partial pressure without any impact in the product quality. For Naphtha HDT Unit, there is no tendency of aromatic saturation at higher temperature i.e. 320 ˚C. Hence there is no effect on feed selectivity for downstream reforming unit. Also it was observed that this catalyst is capable of handling higher nitrogen content i.e. 13.3 ppm in Naphtha feed. Taking into consideration the lower SOR temperature for Naphtha HDT unit at 280 ˚C and for Kero HDT unit at 295 ˚C, expected cycle length will be more than 4 years.

**References**

1. M. Marafi, A. Stanislaus, Resources, Conservation and Recycling, 53 (2008) 1–26
2. P Laveille,, A Riva, A Salameh, P Dufresne, S Morin, M Berthod, https://doi.org/10.2516/ogst/2018053
3. R. Iwamoto, H. Koshika, N. Takahashi, K. Inamura, Japan Petroleum Institute, 48 (2005) 319-323
4. I Guibard, S.Kressmann, V.Harle, www.eurecat.in/Technical\_Doc/A\_fresh\_performance\_2.pdf.
5. [J. Ancheyta](http://pubs.acs.org/author/Ancheyta%2C%2BJ), [P. Morales](http://pubs.acs.org/author/Morales%2C%2BP), [G. Betancourt](http://pubs.acs.org/author/Betancourt%2C%2BG), [G. Marroquín](http://pubs.acs.org/author/Marroqu%C3%ADn%2C%2BG), [J. Muñoz](http://pubs.acs.org/author/Mu%C3%B1oz%2C%2BJ%2BA%2BD), Energy Fuels, 18(4) (2004) 1001–1004
6. N Chandak, A George, A Chaudhry, S Khalifa, S Morin, Cat Today, [Volume 305](https://www.sciencedirect.com/science/journal/09205861/305/supp/C), 1 May 2018, Pages 82-91
7. R Venkatesh; M Bhaskar; S Sakthivel; N Selvaraju ; M Velan, Pet Sci Tech, 28:93–102, 2010