Ways for refiners to capitalize on the benefits of ultra-high activity catalysts

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ExxonMobil and Albemarle launched the first commercial Bulk Metal Catalyst in 2001. The commercialisation of Nebula® (Catalyst A) represented a whole new class of hydroprocessing catalysis innovation that reset industry expectations for activity advantage. Celestia™ (Catalyst B) is a second generation Ultra-high activity Bulk Metal Catalyst that offers even greater hydroprocessing margin potential. It provides an unprecedented level of catalytic performance for hydrotreating unlocking a completely new realm of opportunities.

ExxonMobil has successfully commercialised catalyst B in stacked configuration in more than four units including ultra-low sulphur diesel (ULSD) Distillate Hydrotreating and Hydrocracking Pretreat units since 2015. These commercial operations have confirmed that catalyst B has step-out activity and performance, with over three time's higher performance versus leading NiMo conventional catalyst activity. As highlighted in the case study below there are multiple ways to deliver improved margins. Typical examples include increasing feed rate, increasing feed difficulty, increasing yield, and improving product quality:

1. Feed Diet Improvements The ultra-high activity catalyst implementation provided the ability to process more challenging feeds without sacrificing unit run-length from increased deactivation. This was also true when the feed diet was extended to cracked stocks, such as light cycle oil (LCO) or coker derived feeds. Upgrading cracked stocks presented the opportunity for higher margins.

2. Product Quality Improvements and Yield The ultra-high activity catalyst provided additional saturation of the feed, which led to volume swell and increased yield as hydrogen is converted into liquid products. In many cases, an improvement in diesel cetane and related lower product aromatics was achieved, the extent depended on feed quality and process conditions. Profitability arises from selling a higher value product, as premium stock to the fuels blending plant, or by a reduction of cetane Improving additives.

In hydrocracking pretreat, the ultra-high activity catalyst improved the conversion performance of the hydrocracking stage by lowering the amount of organic nitrogen slip and by reducing the aromatic content to the hydrocracking catalysts. Value was gained by tuning the hydrocracker operation to higher volume yields and more valuable products while simultaneously meeting cycle length targets.

3. Run Length The additional activity provided by the catalyst helped manage unit run length to better coordinate outages in the overall refinery schedule. Cycles were matched up with larger refinery outages to preclude situations where spare units sit idle, resulting in improved efficiency. Typically, buying additional activity to increase a single unit run length is not economically justified. However, the economic justification can change when other refinery units are affected by non-optimum cycle timing.

4. Energy Consumption The ultra-high activity catalyst provides a higher exotherm compared to conventional catalysts due to its higher aromatic saturation capability and overall higher hydroprocessing activity. This resulted in a lower start of run temperature for the overall reactor, and improved heat capture in the feed-effluent heat exchange system, both of which resulted in significantly reduced furnace firing.

Ultra-high activity catalyst in action

A stacked load of catalyst A and the new ultra-high activity catalyst B was loaded into the pretreat section of a once-through heavy feed hydrocracker, processing a challenging blend of high endpoint virgin and coker VGOs to produce fuels and steam cracker feed. The unit pretreat reactor was loaded with approximately 30% of bulk metal catalyst (a combination of catalyst A and the rest with catalyst B) compared to a load of 30% catalyst A as part of prior reactor loads. The volume load of both catalysts was evaluated to balance staying within the unit process and engineering constraints, while simultaneously ensuring the deployment generates an attractive return.

The hydrocracker performance and economics were evaluated using advanced hydroprocessing kinetic modelling technology to optimise the bulk metal catalysts – catalysts A and B – and supported NiMo catalyst load splits and locations. The addition of the new ultra-high catalyst B presented performance benefits for the unit.

- The feed rate of a highly challenging coker VGO was maximised during most of the cycle
- Nitrogen slip reduced from 50-70 ppm to 10-20 ppm
- Unit conversion increased with higher diesel and jet yields
- Product qualities increased, higher diesel cetane and jet smoke point
- Higher heat recovery led to a reduction in furnace firing and significant energy savings
- The catalyst stability of both catalysts matched supported catalysts, with cycle length meeting the planned duration while maintaining high performance levels.

Conclusion

Incremental improvements in hydrotreating catalyst activity are welcome, but offer refineries limited choices on how to take advantage of performance improvements. High activity bulk metal catalyst can enable a refiner to take advantage of many improvement opportunities simultaneously. Deploying additional activity at each refinery and operating unit will ultimately depend on the unit constraints and process objectives, but a solution based approach can help optimise catalyst load and operating strategy to deliver increased profitability.

* Bulk Metal Catalyst A refers to Nebula®

** Bulk Metal catalyst with Ultra-high activity- Catalyst B refers to Celestia™

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