Question 26B: What concerns should be addressed before applying dewaxing catalyst in diesel service? What changes can be expected in unit operation with dewaxing?

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Dewaxing involves isomerization or / and cracking of linear paraffinic molecules to improve cold flow properties such as cloud and pour point. It may be required in winter season in cold climates to maintain flow properties of diesel. Economic benefits of dewaxing include ability to upgrade heavier or renewable feeds which have higher cloud and pour points without use of cold flow additives (cost) or kero blending (high value in many places). The main items to be considered when applying dewax catalysts are:
• HSSE: A thorough safety evaluation should be done to ensure adequate safety systems are in place for use of dewax catalysts
• Delta cloud point target: Use of additives or kero blending can be economically favorable if target delta cloud point is low i.e. only trim dewaxing is needed. A thorough evaluation is needed to evaluate economic feasibility of catalytic dewaxing.
• 1st Stage versus 2nd Stage Dewax: The dewax catalyst is in series with the hydrotreating catalyst in 1st stage dewax. 2nd stage dewax is done in a separate reactor with inter-reactor separation. For revamp applications, 1st stage dewax has lower capex while 2nd stage dewax provides higher diesel yield at higher capex.
• Catalyst design: Replacing a portion of the hydrotreating catalyst with dewax catalyst will lead to higher LHSV and thus increased severity. A customized hydrotreating catalyst system is essential to achieve target HDS cycle life and ensure optimum feed quality to the dewax bed.
• Operability: Adequate heat input and quench gas capability is needed to ensure target temperature profile is achievable in winter and summer months. Back end work-up section should be evaluated for increased naphtha yield.

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Dewaxing may become necessary to improve the cold flow properties (pour point, cloud point, cold-filter plugging point) of diesel. These properties are strongly related to normal paraffin content of the diesel fuel. There are two ways to improve cold flow properties catalytically; one, by selectively cracking long-chain n-paraffins to lower molecular-weight of n-paraffins; and two, by hydro-isomerization (HI) of n-paraffins to iso-paraffins. Maximum retention of diesel yields, low hydrogen consumption, cycle length, and maintenance of diesel fuel properties (e.g., cetane) are key aspects of a good dewaxing system. There is some loss in diesel yields in selective cracking, which increases as the severity of dewaxing increases. In general, HI will retain more diesel than selective cracking.

When applying dewaxing catalyst in diesel service, one should first review the requirements for such application. Some of the questions that need to be addressed are –

- What specification for diesel product are targeted? Cold flow property specifications for summer, winter, or arctic conditions vary widely and depending on what specifications are targeted, severity of dewaxing will vary.
- Is flexibility to make different products critical? Many operators need dewaxing to meet winter/arctic

specifications only. They prefer to ‘turn-off’ dewaxing during summer to maximize diesel yields.
- Is capital investment anticipated? Adding a new reactor for dewaxing provides considerable flexibility in turning dewaxing on during winter and off during summer, allows operation in ‘sweet’ environment and use of noble metal HI catalysts to maximize yields, and allows for processing of diesel from multiple units. If capital investment is not possible, then dewaxing needs to be carried out in ‘sour’ environment with base metals dewaxing catalysts. Either selective-cracking or hydro-isomerization catalyst can be considered for sour service. As mentioned above, HI catalysts have better retention of diesel and the difference in yields between HI and selective cracking increases as required severity for dewaxing increases.

Additional considerations for ‘sweet’ and ‘sour’ service are as follows.

1. Dewaxing in Sour service: Sour services are generally a cheaper option where in the dewaxing catalyst can be loaded within an existing reactor by sacrificing some of the volume of hydrotreating catalyst. This brings up some challenges -
a. The hydrotreating catalyst would run at a higher space velocity, require higher temperatures, and will have shorter cycle length.
b. Activity match between hydrotreating and dewaxing catalyst becomes critical. If there is a mis-match in activity and if the dewaxing catalyst is less active than hydrotreating catalyst, then hydrotreating catalyst needs to operate at higher temperature than required. This will increase hydrogen consumption, reduce diesel yields, and increase hydrotreating catalyst deactivation.
c. The dewaxing catalyst downstream of the Hydrotreating system will see a clean feed, and it would deactivate at a lower rate than the hydrotreating catalyst. This creates additional challenges -
i. Quench requirement between the hydrotreating and dewaxing beds: Is the gas rate adequate to keep the dewaxing catalyst temperature controlled throughout the cycle, while still allowing the unit to meet ULSD specification?
ii. Is the unit design covered to handle increased light end make?
d. Hydrotreating and dewaxing catalyst temperatures tuned for one feed may not work optimally for other feeds. Any feed flexibility will be limited within available quench system capability.
The temperature control is the key factor that would give the flexibility to the unit allowing it to run different modes during summer and winter and maximizing profitability.

In a new sour service dewaxing unit design, it is possible to take this into account and design for a higher compressor margin or even put in a more exotic temperature control system. In those cases, one would need to evaluate whether higher yields possible with sweet service noble-metal dewaxing catalytic system would provide an economic benefit throughout the cycle

Dewaxing in sweet services involves the use of noble metal catalysts. While these units have a higher initial Capex for a new reactor, they provide considerable flexibility as discussed above. The yields of these units are much better than an equivalent sour service dewaxing system. Sweet systems have the flexibility of processing multiple hydrotreated feeds without being linked to the deactivation of the hydrotreating catalyst in any single unit. The units can be run at multiple capacities based on refinery demand as well.

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