Question 51: What is your minimum Cloud Point Improvement that makes economic sense to apply catalytic dewaxing vs. traditional (i.e. additives and kero blending) Cold Flow Improvement methods?

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At low temperatures, products with “waxy” components start to crystallize and affect the flow characteristics of the product. To avoid problems of fuel supply to an engine or lubricating problems under low temperature conditions, diesel fuels and lube oils often have stringent specifications on flow properties at low temperature. To ensure that the various products meet low temperature flow properties, three main cold flow property specifications are used. Pour point (PP) is mainly used for base oils specifications. Cloud Point (CP) and Cold Filter Plugging Point (CFPP) are usually used for diesel fuels.

Small amounts of cold flow improvement additives can reduce the CFPP and PP significantly. However, CP cannot be significantly improved using additives and/or kerosene blending. With additives, CP can typically be improved to a maximum of 5-7°F (2-4°C) and for every 10 vol% of kero blended into the final product; the CP is reduced by ~2°F (1°C). Kerosene blending; however, is limited by other product specifications (e.g., Flash Point). Catalytic dewaxing is usually the most economically attractive solution for middle distillates if the CP improvement requirement is higher than 10 - 12°F (5-7°C).

Catalytic dewaxing is typically employed in either a single stage or in a two-stage configuration. In single stage dewaxing the dewaxing bed is part of the main hydrotreating section, and a base metal dewaxing catalyst (SDD-800) is used that can withstand the severe operating conditions that are encountered. Single stage dewaxing can provide a low-cost and flexible solution. For an existing unit, a number of key checks are required to ensure that a drop-in solution is feasible.

In Two Stage Dewaxing the feedstock is subject to hydrotreating in the first stage of the process after which it is separated from the gas phase containing H2S and ammonia and treated with the dewaxing catalyst in a second stage. This provides a cleaner environment (low sulphur and nitrogen), so that a high activity noble metal catalyst (SDD-821) can be used. Investment costs may be higher with this configuration, but product qualities and yields can be maximized.

In addition to the minimum required level of Cloud Point improvement, the attractiveness of the catalytic dewaxing solution is highly dependent on available unit hardware (number and size of reactors/beds, inter bed quench and appropriately sized separator and fractionation capability). Brian Watkins and Charles Olsen (ART) The target market for these products requires much more than several degrees decrease in cloud point below the value of the feed which is generally beyond that observed by hydrotreating alone. Whether the application of catalytic dewaxing makes sense needs to be balanced against the costs/benefits of other cold flow improvement methods.

The ability to improve the cold flow properties of the diesel in the hydrotreater using a dewaxing technology can have significant economic advantages that other options do not provide especially if the degree of cold flow improvement desired is high. Understanding the cold flow requirements is necessary to create an individually tailored process and avoid the pitfalls associated with inappropriate quantities of HDW catalyst such as yield losses and not having the flexibility to meet market demands.

The typical process of dewaxing utilizes a ZSM-5 type catalyst. The structure of ZSM-5 is such that only straight chained hydrocarbon molecules (normal paraffins or n-paraffins) fit inside the cage structure and are cracked into smaller, lighter molecules. These molecules have significantly lower cloud and pour point characteristics. One of the keys to successfully combining a dewaxing catalyst with an HDS system is an understanding of the tradeoffs between dewaxing and HDS activity as the amount of dewax catalysts changed. Similar to a hydrocracking reactor, as the temperatures are increased over the bed of HDW catalyst, the ability to break the n-paraffins increases. The extent of cloud point reduction at a given temperature depends on the LHSV over the dewax bed as well as the hydrogen partial pressure of the unit. Once the temperature is high enough to begin dewaxing, the kinetic response for converting the n-paraffins is linear for both catalyst systems.

As discussed earlier, the HDW function is to break the n-paraffins into smaller molecules in order create less waxy molecules in the finished diesel product. This chain breaking reaction does have the potential disadvantage that it can convert diesel boiling range material into naphtha and lighter materials. These materials, if the refinery is able to tolerate and utilize them, can be considered quite valuable as well. One concern is that if a significant volume of diesel is converted to lighter products, the downstream equipment might not be capable of handling excess light materials.

ART’s pilot testing has shown that there is a complex interaction between dewaxing and hydrotreating in ULSD applications. There is a balance between dewaxing activity and HDS activity which needs to be understood when designing a catalyst system. Furthermore, the liquid yield needs to be considered at both SOR and EOR as this is highly dependent on the amount of dewax catalyst in the system. ARTs technical services staff can work with refiners in order to provide the right catalyst system tailored for maximum refinery profit.

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