Question 13: What factors do you consider when co-processing jet fuel in a distillate hydrotreater versus processing the jet separately (including feedstock and unit consideration)?

ROBERT STEINBERG (Motiva Enterprises)

There are several considerations when deciding if jet fuel and diesel should be co-processed or hydrotreated separately. The most important consideration is if the jet fuel will be blended into the diesel product or if separate products are desired. The decision may depend on if you are looking at constructing new facilities or making the best use of existing equipment.

If a refiner needs to build a new unit to increase distillate hydrotreating, building a jet fuel unit and using existing units for diesel will normally be less expensive than building a new diesel hydrotreater. If more capacity is required than there is jet fuel for, some straight run diesel can be blended into the jet fuel hydrotreater. However, if the existing unit is too low a pressure to handle the diesel effectively it may be preferred to build a new unit for the most difficult to treat streams such as light cycle oil or light coker gasoil instead.

If a new refinery was being built and new jet fuel and distillate hydrotreaters are needed it will normally be simpler and cheaper to build a single unit and co-process the jet fuel with the diesel. Exceptions would be if the capacity would be too large for a single unit or separate jet fuel and diesel products were desired.

For a refiner looking to optimize existing facilities it is assumed that a separate jet fuel product is not required. If it was required, the feeds would need to be processed separately unless there was a fractionator on the back end to make jet fuel and diesel cuts. Having such a fractionator is probably unusual and would require a lot of energy to vaporize the jet fuel to remove it from the diesel. For a refiner with only a single hydrotreater this becomes a question of batch processing diesel and jet fuel or blending them and processing together. If the refiner has multiple hydrotreaters it will generally make sense to send the easiest to treat streams, such as jet fuel, to the lowest pressure or mildest hydrotreater. Or blend just enough of the easiest streams into the more severe unit to let it achieve its desired run length.

Alternately batch processing jet fuel and diesel in the same unit instead of co-processing would generally not be recommended unless there were special circumstances. This would be more complicated as it would require frequent switching of feeds and changing operating conditions; during such changes lower charge rates may be needed to reduce the risk of making off-spec products or having to pull more naphtha out of the Stripper than otherwise required to maintain product flash point.

Diesel requires more severe reactor conditions than jet fuel to make the same product sulfur. Mixing jet fuel into the distillate hydrotreater lowers the average boiling point of the feed as well as the feed sulfur and nitrogen content. This means lower reactor temperatures and less chemical hydrogen consumption, less treat gas is needed to maintain the desired ratio of hydrogen availability to consumption, smaller exotherms and less quench gas. The lower start-of-run temperature can extend the catalyst run length.

Pressure drop for jet fuel and diesel in the same hydrotreater would be similar if the same amount of hydrogen circulation was used – more of the jet fuel would vaporize and increase velocity but the diesel has more mass at the same barrel per day charge rate and is more viscous. However, less treat gas is needed for jet fuel due to the lower chemical hydrogen consumption and exotherms are generally low enough with jet fuel to not need any quench. This effectively means less hydrogen circulation with jet fuel and lower pressure drop in the reactor, exchangers and furnace. Blending jet fuel into the diesel hydrotreater will reduce pressure drop, if the run length is limited by pressure drop this can extend the catalyst life.

Another consideration can be product blending and diesel cetane. If there are multiple units, or jet fuel and diesel are batch processed, some of the products may not meet sulfur, cloud point, cetane or other product specs. In some cases, the products from different units can be blended to make an on-spec ULSD. This makes operations more complicated, adjusting the amount of jet fuel that is blended into each unit can help keep all products on-spec and reduce the risk of having to deal with an off-spec product tank. However, jet fuel has a lower boiling point than diesel and thus a lower cetane number. If a refiner makes both a higher and a lower cetane product it may be necessary to minimize the jet fuel in the high cetane product, this is like making a separate jet fuel product in that it can require separate processing.

Motiva has a relatively mild hydrotreater than was revamped for ULSD 15 years ago. Initially it charged mostly straight run diesel to make ULSD. Later, the refinery was expanded, a new diesel hydrotreater was built and the additional jet fuel was charged to this unit. The unit now charges only jet fuel and operates in ultra-low sulfur kerosene (ULSK) mode, the product has less than 5 ppm S and can be blended into either jet fuel or diesel as desired. The unit has minimal catalyst aging. It illustrates that jet fuel can be the easiest product in the refinery to hydrotreat giving very long catalyst life and that adding jet fuel to a diesel hydrotreater results in milder reactor conditions and longer catalyst life.

Motiva normally produces more kerosene in our crude units than we have capacity for in our jet fuel hydrotreaters. The surplus kerosene is mixed into our diesel hydrotreaters. This is the easiest feed the diesel hydrotreaters process, with more kerosene reactor temperatures can be lowered while maintaining product sulfur. While this reduces the required reactor severity there are some drawbacks:

- The lighter feed reduces the delta API gravity between feed and product meaning volume swell is reduced.
- The lighter feed reduces the density of the feed going through the charge pump and the discharge pressure that the pump can produce. One of the diesels hydrotreaters sometimes needs to lower operating pressure to maintain charge rate.

Motiva normally hydrotreats as much kerosene as there is capacity for in our jet fuel hydrotreaters and blends the remaining kerosene into diesel hydrotreaters. One of the jet fuels hydrotreaters swings between sending its product to jet fuel and diesel but operates to be on-spec for both products. We do not have any units where we switch feeds or operating conditions to sometimes make jet fuel and sometimes diesel.

JOHN KULACH (UOP)

Considerations for co-processing jet and distillate in the same unit are the feed rates and feed quality, which go into the selection of operating pressure, space velocity, and catalyst. Distillate hydrotreating for ULSD typically requires higher hydrogen partial pressure, lower LHSV and more active catalysts compared to treating jet, because of the need to convert stable sulfur compounds such as benzothiophenes and dibenzothiophenes. If the distillate feed includes coker gas oils, LCO or other difficult to process streams such as extracts and condensates, the design would call for a more severe operation with higher reactor temperatures. Inorganic contaminants such as silica and arsenic can be removed from the feed upstream of the active desulfurization catalysts by using filters, particulate traps, and demetalization catalysts in the top of the reactor.

Jet hydrotreating requires enough catalyst and hydrogen partial pressure for mercaptan sulfur and TAN removal. This is usually a low severity operation compared to distillate hydrotreating as jet fuel can be very color sensitive exasperated by high reactor temperature operation. On the other hand, jet fuel hydrotreating can require more severe operation if the feed contains high aromatics or naphtenes which will require some saturation to meet composition and combustion specifications such as aromatic content and smoke point. In some cases, this might require a noble metal catalyst or a second stage operation.

While a typical distillate hydrotreater fractionation section would consist of a stripper column to remove light ends and meet flash point specification, a hydrotreater co-processing distillate with jet feed would require a more complex fractionation section. The fractionation configuration would depend on the relative rates of distillate and jet as well as the need to meet jet fuel volatility and fluidity specifications such as distillation and freeze point.

Whether a co-processing unit is more economical than individual DHT and KHT units will depend on the relative feed rates, feed quality and product specifications. Co-processing might be favored if the DHT feed is relatively easy (such as a SR Diesel) and if the jet feed is more difficult to treat. The key take-away is that jet fuel processing is very dependent on the feed quality and required specifications.

RICHARD TODD (Norton Engineering)

Co-processing of Jet Fuel in a distillate unit may result in poorer unit performance than expected due to higher vaporization of the jet fuel components, which in turn causes lower H2 partial pressure. This varies based on unit conditions, partial pressure of H2, LHSV, etc. The heavier distillate desulfurization is normally controlling, so reactor temperatures are set by the distillate requirements. Cracked stocks in the jet fuel range may have higher olefins increasing H2 consumption, and again in turn, decreasing H2 partial pressure, causing an increase in deactivation.

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