Question 45: What are your options to maximize light cycle oil from the FCCU (e.g. operating conditions, feedstock, recycle, equipment, catalyst, etc.)? What are the typical unit constraints? What projects have been considered at your facility to capture the increased value of diesel?

TODD HOCHHEISER (Johnson Matthey)

There are multiple ways to maximize light cycle oil from the FCC including reducing conversion, reformulating the fresh catalyst, utilizing additives, and adjusting fractionation.

Reducing conversion will increase LCO yield. Some methods to lower conversion are reducing riser temperature, reducing cat/oil ratio by increasing feed temperature or decreasing cat cooler duty, and reducing ecat activity by lowering fresh catalyst addition rate or lowering fresh catalyst activity.

The lower conversion will usually lead to an unwanted increase in slurry yield. The slurry yield increase can be offset by reformulating the fresh catalyst to a lower zeolite to matrix ratio or by adding a separate bottoms cracking additive. These catalyst and additive changes can also be used independently of conversion of maximize LCO production.

Another side effect of reduced conversion is lower LPG olefin yield. For most refineries with access to low-cost isobutane, there is a strong incentive to maximize alkylation unit rate. LPG olefin yield can be held constant or even increased when lowering conversion with the addition of ZSM-5. There are also FCC technologies that include independent addition rate control for Y-zeolite, active matrix, and ZSM-5. This allows the catalyst formulation and selectivity of LPG, gasoline, LCO, and slurry to be actively adjusted as economics change.

LCO yield can also be increased by recycling slurry or HCO. The optimal recycle stream and quantity is usually based on product cutpoints and unit constraints such as regenerator temperature, air rate, or the wet gas compressor capacity. There was a study published by Grace in 2009 showing the impact various HCO and slurry cuts have on yields. In general, recycling the 650–750-degree F or 650–800-degree F cuts showed the largest increase in LCO yield.

The main fractionator operation and/or design can be adjusted to increase LCO yield. Reducing the gasoline cutpoint will increase LCO yield. Minimum gasoline cutpoint is often set to prevent salting in the main fractionator overhead. LCO endpoint can be increased to boost heavy LCO yield. LCO endpoint is typically limited by diesel product quality or downstream processing units. Main fractionation projects have been installed to improve the fractionation efficiency. The fractionation efficiency improvements increase LCO yield at constant cutpoints by reducing the distillation front end and tail. Some projects include main fractionator tray or packing modification, improved heat removal in pump-around circuits, or installation of a heavy naphtha product draw. The heavy naphtha can then be blended into LCO.

ANN BENOIT (W. R. Grace & Co.)

Operational changes and catalyst reformulation are options that can be employed to increase light cycle oil (LCO) from the FCCU. Keeping in mind that the strategy to ensure profitability while maximizing LCO is to maintain volume swell without producing incremental slurry at lower conversion, a dual approach of operational moves and catalyst reformulation is typically used to increase LCO without sacrificing refinery profitability. These different options and typical unit constraints will be discussed in the answer below.

Refiners tend to focus on the following routes to maximize LCO yield.

1. Distillation changes (reduce gasoline end point)

2. Feedstock

- Removal of diesel range material from the FCC feed

3. Recycle streams

- Heavy cycle oil (HCO) or bottoms

4. Operating conditions:

- Lower reactor temperature
- Higher feed temperature
- Lower equilibrium catalyst activity

5. Catalyst optimization

- Increased bottoms conversion

- Lower zeolite-to- matrix surface area
- Maintenance of C3+ liquid yield and gasoline octane

A quick, simple, and effective way to increase LCO is to make distillation adjustments such as lowering gasoline endpoint and increasing LCO endpoint. Flash point specification and main fractionator salting often will determine how low a refiner can reduce the LCO initial boiling point (reduce gasoline end point).1 Since most refiners are at the optimum LCO endpoint, based on their maximum main fractionator bottoms temperature, slurry exchanger fouling, and diesel hydrotreating limitations, typically no adjustments are needed to go from a gasoline mode operation to a LCO maximum operation. If this is not the case, the refinery should consider making adjustments to the LCO endpoint.

Regarding feedstock, it is recommended that diesel range material be removed from the FCC feedstock. This material is typically higher quality diesel for the overall refinery diesel pool than the LCO that would be produced from the FCCU. Typically, upstream distillation limitations will determine the amount of diesel capable of being removed from the FCC feed.

In addition, recycle streams can be employed to fully maximize LCO at reduced conversion. The quality of the recycle stream can make a difference in the products being produced. HCO recycle typically is a better recycle stream than slurry. In a low conversion regime, the HCO will favor more LCO versus coke and dry gas. The effects of different recycle streams are discussed in detail in the AFPM paper “Strategies for Maximizing FCC Light Cycle Oil” (Hunt, et al, AM-09-71).

Adjustments to operating conditions such as reactor temperature, preheat, and/or catalyst activity to lower conversion and increase LCO can be made, but this may come with a price. By reducing conversion through operating conditions, LCO yield and, potentially, cetane will increase2, but so will slurry. A drop in gasoline octane may also be a concern due to lower reactor temperature and lower conversion. Adjustments made on operating conditions will depend on unit and refinery constraints. Typical limitations for maximizing preheat temperature are furnace coil outlet temperature and firing limitations on the furnace. Reactor temperature may not be able to be lowered due to minimum regenerator temperature limits. In addition, hydraulic and/or downstream treating capacity could be constrained when maximizing LCO.

The preheat and reactor temperature adjustments mentioned above will drive the unit in a low conversion regime, which will increase LCO, but which will also decrease volume swell, decrease gasoline octane, and increase slurry. This is why a catalyst reformulation strategy is needed to address these issues. Application of the correct catalyst technology is critical for maximum LCO operations. A balanced approach is required to achieve maximum bottoms upgrading to LCO and other valuable products.

An LCO maximization catalyst is typically an improved bottoms cracking catalyst with a lower zeolite-to-matrix ratio. Due to the economic penalty with lower volume swell, ZSM-5 or butylene selective additives should be considered to maintain or improve volume swell and gasoline octane while operating at a lower conversion. If butylene has a greater value than propylene, a reformulation to a butylene selective catalyst with the proper Z/M ratio could be optimal.3 Unit constraints such as LCO hydraulics and downstream processing will determine the best catalyst options in conjunction with FCC operating adjustments.

In conclusion, there are several avenues that can be taken to increase LCO yield on the FCC, but overall refinery economics and unit constraints will dictate which move or combination of moves proves to be the most beneficial to the refinery. Based on operating conditions and refinery constraints, the refiner should work with their catalyst supplier to evaluate the optimum catalyst for a maximum LCO operation.

Reference:

1. Hunt, D.A., et al, “Strategies for Maximizing LCO” National Petrochemical & Refiners Association AM-09-71

2. Ritter et. al., “Light Cycle Oil from the FCC Unit,” National Petrochemical & Refiners Association AM-88-57

3. Bryden, K.; Federspiel, M.; Habib, E.T.; Schiller, R., “Processing Tight Oils in FCC: Issues, Opportunities and Flexible Catalytic Solutions,” AM-14-16, 2014 AFPM Annual Meeting, March 2014, Orlando, FL.

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As has been reported from Chinese sources, operation with higher cat/oil ratio but lower reactor temperatures will increase the yield of LCO from the reactor. The actual increase will be dependent on catalyst type and feed quality and will need to be evaluated at each unit.

Tags

Blending

Distillation

Feed Quality

Heat Exchangers

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