Question 89: What are the best practices in the industry for profitable LCO maximization? Please elaborate on (a) FCC catalyst/additive technologies, (b) Cetane maximization, (c) process design and operations strategies and (d) any impact on naphtha octane and how you mitigate it?

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Maximizing light cycle oil (LCO) is largely a slurry management process. To increase LCO, refiners can simply change operating conditions and lower catalyst activity to shift operations into a lower conversion regime. The negative impact of shifting to a lower conversion regime is that this shift will typically decrease volume swell and also increase bottoms, unfavorably impacting profitability. The true challenge is to maximize LCO without producing incremental bottoms while maintaining volume expansion. In general, refiners tend to focus on the following strategies to maximize LCO yield:

1.Distillation changes (reduce gasoline end point and increase LCO endpoint)

2.Feedstock

- •Removal of diesel range material from the FCC feedstock

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 lower gasoline endpoint and/or increased LCO endpoint. Flash point specification and main fractionators salting often will determine how low a refiner can reduce the LCO initial boiling point (reduce gasoline end point).[1] Maximum main fractionator bottoms temperature, slurry exchanger fouling and diesel hydrotreating constraints will often determine how much the LCO endpoint can be increased.

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.

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. The effects of different recyclestreams are discussed in detail in the AFPM paper “Strategies for Maximizing FCC Light Cycle Oil” (Hunt, et al, AM-09-71). The 650°F – 750°F recycle stream produced the most LCO and gasoline at the lowest coke for a given conversion.[1] However, this stream is not produced in sufficient quantities to fully maximize LCO. The 650+°F and 750+°F streams have high Conradson carbon levels (consistent with higher quantities of tetra-aromatics and heavier compounds) which limit the yield of LCO when these streams are recycled to the FCC.[1] The 650°F to 800°F or 650°F to 850°F recycle streams produced the highest LCO when recycled against a coke burn and bottoms constraint.[1]

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 increase[2], but so will slurry. The primary challenge in the FCC unit is to increase LCO, while minimizing incremental slurry yield and maintaining volume swell. Gasoline octane may also be a concern due to lower reactor temperature and lower conversion. This is why a catalyst reformulation strategy is needed to address the incremental slurry, lower volume swell, and lower gasoline octane when operating conditions are adjusted to maximize LCO.

Application of the correct catalyst technology is critical for high LCO yield and minimal bottoms and coke yield. Keep in mind that 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. Grace typically considers our MIDAS® technology in LCO maximization applications due to premium high matrix bottoms cracking ability. Due to the economic penalty with lower volume swell, ZSM-5 additives such as OlefinsMax® or OlefinsUltra® should be considered to maintain or improve volume swell and/or gasoline octane while operating at a lower conversion. If butylene has a greater value than propylene, a reformulation to the Grace’s Achieve® 400 FCC catalyst could be optimal.[3] Achieve® 400 features a moderate Z/M ratio and dual-zeolite functionality, delivering increased gasoline octane and butylene yield at minimum bottoms.

There are several avenues that can be taken to increase LCO yield on the FCC, but overall refinery economics will dictate which move or combination of moves proves the most beneficial to the refinery. Catalyst reformulation strategy should always be considered in LCO maximization cases since this can address the incremental slurry and lower volume swell in a lower conversion regime.

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