Question 69: What are some of the advantages and challenges in processing FCC slurry in a vacuum tower along with conventional atmospheric residue streams?

SLOLEY (CH2M Hill)

If you feed FCC slurry to the vacuum unit, the major benefit is recovery of diesel range material. High temperature limits in the bottom of the heavy cycle oil slurry fractionation system limit diesel recovery from slurry. Typical limits in this section in the FCC are 720°F, or 382°C; above that, coking starts to be a major issue. Significant diesel is still present at this condition. Diesel content of the slurry varies from 10 to 12% at a minimum, but many units run much higher. Industry average is in the range of 14 to 15% of the slurry.

Processing the slurry in a separate vacuum flasher is one method of recovering this diesel. The vacuum flasher typically suffers from solids deposit from the catalyst present. Processing slurry in the crude vacuum tower allows for some recovery of the diesel, and that implies that you have a diesel recovery section in the vacuum tower. However, it puts the FCC catalyst in the vacuum residue. As long as the solids in the vacuum residue do not get too high, this may be acceptable.

Most refiners processing FCC slurry in the vacuum unit produce asphalt as the vacuum tower bottoms product. The largest problem with slurry processing is that the slurry is a reactive product that is not going to a stable reactive equilibrium. High temperature plus the reactive slurry components tend to cross-link and see higher fouling rates in the vacuum residue circuit. Keeping the slurry percentage low and quenching in the vacuum tower bottoms to keep the temperature below 700°F, or 371°C, helps reduce fouling rates in the vacuum residue exchanges.

SRIVATSAN (Foster Wheeler USA Corporation)

We see limited advantage in processing FCC slurry in a vacuum tower. However, as Andrew mentioned, in some cases a dedicated vacuum flasher to recover the gas oil fraction could be beneficial. FCC slurry has a distillation range similar to HVGO (heavy vacuum gas oil), but it is inferior in properties compared to straight-run material, making it more difficult to hydrotreat.

A much more common option of disposing the FCC slurry oil is to introduce it as feed to the delayed coking unit. A number of discussions have taken place in previous Q&A forums on how much of the slurry oil can be introduced into the delayed coker. We normally recommend a maximum limit of 10%. Depending on the coker unit design, though, you may have to cut back on your vacuum residue feed rate. Only a small portion of slurry oil converts to coke; most of it just goes for a ride in the coke drum and ends up with the HCGO (heavy coker gas oil) fraction. If this HCGO is sent directly to the FCC without be hydrotreated, it will build a recycle loop that is difficult to handle. Also, if the coke drums are velocity-limited as opposed to coke-make limited, the addition of slurry oil, while still retaining residue

capacity, could lead to excess velocity in the coke drum which may result in carryover to the fractionator.

SIMON ARENDS (Marathon Petroleum Corporation)

Are there any concerns about fouling with the catalyst or on the vacuum tower exchangers? Is it filtered or not filtered?

SLOLEY (CH2M Hill)

There are some concerns on coking. Normally, the content of slurry is restricted to such a low percent (less than 10%) that the additional solids do not present a major problem. Vacuum residue itself is not the easiest stream to deal with, and reprocessing slurry does not make the operation easier. But if the slurry content is low enough, it is not a catastrophic increase in the severity in the operation on fouling in most units.

VILAS LONAKADI (Foster Wheeler USA Corporation)

Andrew, you mentioned that you will be putting the slurry into the vacuum tower itself, right? If you do that in the main vacuum unit, the slurry will likely contain solids. Most of the transfer lines and velocities there are at the sonic velocities. So the catalyst and that velocity are going to these internals. Have you seen any kind of erosion which can happen to these internals and damage them?

SLOLEY (CH2M Hill)

There has been evidence of erosion. It is clear it is not a huge issue, but it has to be managed and tracked. Absolutely, there has been erosion.

XIOMARA PRICE (GE Water & Process Technologies)

I have a question about processing SCC (stress corrosion cracking) slurry in the vacuum tower. It is my understanding that the recommended wash oil rate is 0.3 to 0.5 gallons per minute per square foot for that tower. So if you are going to process slurry oil that has higher amounts of contaminants through there, do you recommend that they not change to help with the fouling?

SLOLEY (CH2M Hill)

There is some difference of opinion about that number, but I think the two issues are separate. The presence of slurry does not change what packing wetting rates need to be in the wash section.

JOHN HUGGINS (Huggins & Associates)

I want to emphasize the point made a moment ago about yields in a vacuum tower. That slurry is predominantly gas oil. So, if it is put back to the vacuum tower, it will predominantly recycle back to a catalytic cracker, if that is where gas oil goes in that unit. If that is the situation, why not recycle the slurry in the catalytic cracker and recycle the HCO (heavy cycle oil)? It is usually a bad economic decision because you can make more money by running virgin stocks through the catalytic cracker.

SRINI SRIVATSAN (Foster Wheeler USA Corporation)

We see limited advantages for processing FCC slurry in a vacuum tower. However, a dedicated vacuum flasher to recover the gas oil portion could be beneficial in some cases. FCC slurry has a distillation range similar to HVGO, but the properties are inferior (cetane, sulfur, and nitrogen, two-ring aromatics, etc.) compared to straight-run (SR) material, making it more difficult to hydrotreat. A more common option of disposing FCC slurry is to introduce it as feed to the delayed coking unit (DCU). We typically limit this amount to approximately 10% of feed; and depending on the limitations of the coking unit, you may have to cut back on vacuum residue (VR) feed rate. Since only a small portion of the FCC slurry/decant oil converts to coke, the remaining portion goes through the coker along with the rest of the cracked VR and mostly ends up with the HCGO. If the HCGO is sent directly to the FCC without hydrotreating, this may create a recycle stream that could become difficult to handle due to buildup of refractory type material. If the coke drums are velocity-limited (as opposed to coke-limited), the addition of slurry oil, while still retaining residue capacity throughput, could lead to excess velocity issues in the coke drums.

CHRIS STEVES (Norton Engineering)

Care must be taken if processing FCC slurry in a vacuum tower with atmospheric residue. In some cases, the condensed asphaltenes present in the FCC slurry oil may precipitate when mixed with the more paraffinic atmospheric residue, leading to fouling and plugging problems.

Aromatics

Catalysts

Coker

Corrosion

Crude Quality

Crudes

Delayed Coking

Distillation

Fouling

Heat Exchangers

Vacuum Tower

Year

2013