Question 19: How are refiners managing low-coke operations in continuous reforming?

BULLEN (UOP LLC, A Honeywell Company)

There are two ways to address the issue: 1) try to increase the coke that you are making and 2) adjust the regenerator. It would be great if you could just adjust how much coke you are making. However, most of the time you are restricted in what you can do with the unit, given your octane targets and the feed flows and qualities are fixed. The people who do have some adjustment ability do so by lowering the hydrogen-to-hydrocarbon ratio. You can do that to some extent, but you must make sure you have sufficient hydrogen to lift the liquid up through the CFE (combined feed exchanger) to be evenly dispersed within the exchanger. Again, depending on whether you are using Texas towers or a Packinox™ will determine how much you can drop the ratio. It varies depending on the design. We have noted that most CCRs are able to get down to about 30% of the normal coke-burning capacity. However, each CCR is individual, in terms of type, regarding what you can do to get down to that level.

In general, UOP recommends trying to keep the regenerator in continuous white burn mode. That will help both save utilities and keep the yield structure and conditioning of the catalyst proper. In general, the regenerator is limited by low coke operation, but you can reduce catalyst circulation. You can change the burn zone targets, but you must monitor the temperature profile. Finally, depending on the design, you can vent more excess air to maintain the drying of the catalyst in the bottom of the regenerator. For individual units, you can contact your UOP representative who can talk to you in more detail. We also can provide engineered solutions for you to modify your unit, so your regenerator burns less coke.

There are levels of coke make where you just have to shut down the regenerator. When you do that, we recommend that you continuously circulate the catalyst while the regenerator is shut down to ensure that you are able to start back up without any plugging (e.g., catalyst circulation issues) and so that you will evenly lay down the coke across all the catalyst.

ADAMS (HollyFrontier Corporation)

Our experience in Artesia is that when we have gotten into those modes, we reduced the hydrogen recycle and lowered the pressure. So it is that hydrogen-to-hydrocarbon ratio management.

PATRICK BULLEN (UOP LLC, A Honeywell Company)

There are two ways refiners can approach low coke operations: increase unit coke make or adjust the regenerator operation to burn less coke. Unfortunately, in most cases units have little control over trying to increase their coke make. The “typical” ways to try to increase coke on catalyst are as follows:

• Increase feed rate,

• Increase octane,

• Use leaner feed PONA (paraffins, olefins, naphthenes, and aromatics) (more paraffinic),

• Use higher feed endpoint,

• Lower average reactor pressure, or

• Lower reactor H2/HC.

This list may look like there are many options; but in reality, a refiner may not have control over many of these items. Typically feed rate, target octane, and PONA are dictated by the Planning department and cannot be easily changed. The engineer can request a higher feed endpoint, but that is subject to refinery economics and is only adjustable up to a certain point because it can effect reformate endpoint and color. Lowering the average reactor pressure significantly would likely require a unit revamp. The best tool an engineer has to try to increase coke make is to reduce the recycle gas H2/HC ratio. This will also have an added benefit of utilities savings (lower compressor load). However, the lowest compressor flow rate is often associated with the flow rate required to properly distribute the liquid feed in the CFE.

The area where the refiner has more options to manage low coke operations is on the regenerator side. CCR Platforming™ process unit regenerators are designed to burn catalyst with 5.0 wt% (weight percent) coke at the design circulation rate (e.g., 1000 pph CCR section is designed to burn 52 pounds of coke per hour). The low side of the design range is approximately 60% of design coke load; however, most regenerators can operate well below that 60% point (some as low as 30%). UOP recommends keeping the regenerator in continuous white burn operation for both utilities savings and proper reconditioning of the catalyst. White burn is the normal operating condition for the UOP CCR Platforming™ process unit regenerator. Continuous regeneration in white burn allows the air and chloride injection to be sent to the normal locations rather than the startup or black burn locations.

Each style of CCR Platforming™ process unit regenerator has its own limitations in low coke operation, but the typical responses to low coke are as follows:

• Reduce catalyst circulation. – Provides additional residence time in the burn zone to reduce residual coke,

– Provides additional residence time in the chlorination zone to maintain optimal platinum dispersion,

– Raises drying air to catalyst ratio to 5 scf (standard cubic feet) gas/lb cat (0.3 Nm3 /kg-cat) (Normal meter cubed per kilogram of cat), and

– Helps keep recycle gas moisture low. Lower circulation means less catalyst is being reduced.

• Reduce burn zone oxygen setpoint and monitor temperature profile closely.

• Vent more excess air, if possible.

– Maintain minimum air heater flow rate and

– Maintain drying air to catalyst ratio to 5 scf/lb cat (0.3 Nm3 /kg-cat).

Please contact your UOP representative for specific information related to the potential limiting factors for each style of regenerator and responses to low coke operation.

Regarding extremely low coke make, in some instances, Platforming™ unit coke make is so low that it is not practical to keep the regenerator running in white burn. In this case, it is recommended that the catalyst be continuously circulated until sufficient coke is laid down to restart the regenerator.

MARK ADAMS (HollyFrontier Corporation)

Artesia: The recycle hydrogen is turned down and pressure reduced to minimum during low severity operation to enhance coking and avoid shutting down the regeneration system.

Tulsa: The CCR at Tulsa has not been in a low-coke operating mode since startup. The alternatives are to reduce pressure and hydrogen recycle to the extent possible and try to maintain catalyst circulation. Otherwise, the regeneration system can be shut down for three to four days and then restarted.

SONI OYEKAN (Prafis Energy Solutions)

If I believe that this question was addressed in a previous AFPM or NPRA Q&A conference. A number of changes in process conditions and naphtha characteristics type suggestions were provided for improving low coke naphtha reforming operations in CCR units. More recently, improved design enhancements of the regenerators have also been offered by a process technology licensor. Those who have limited naphtha reforming productivity, due to low coke naphtha reforming in their CCR units, and wish to assess some of the mechanical designs for improved CCR operations should consult their technology provider.

As a review, typical past suggestions for managing low coke naphtha reforming included the following:

(a) Manipulation of reforming process variables via changes in the octane severity, recycle gas H2/HC molar ratio, LHSV (liquid hourly space velocity), and reactor pressure;

(b) Changes in naphtha feed characteristics: paraffinic naphtha, naphtha N+A quality, naphtha feed EP, and light ends in naphtha feed; and,

(c) Processing schemes to manage intermittent regenerator operations and exercising special care to avoid catalyst and regenerator screens damages.

Process and catalytic developmental studies continue on innovative approaches for improving refiners' low coke naphtha reforming operations. Stay tuned as I expect some useable innovative solutions soon.

CHRIS STEVES (Norton Engineering)

With changing specifications for gasoline (lower benzene, lower octane demand) and cheaper sources of hydrogen (natural gas reforming), many refiners now find that their reforming units are operating well below nameplate capacity. With low feed rates (and sometimes lower endpoint naphtha as well), the unit will produce lower coke and the regenerator may not be able to continuously operate at the low coke levels (control of oxygen in the regenerator can run up against turndown limits). If this is the case, the regenerator circulation can be stopped and coke levels allowed to build so that a good burn can be obtained when the circulation is restarted. Calculation tools to predict the coke on catalyst are recommended so that the increase in coke on catalyst can be tracked and regenerator circulation restarted at the appropriate time (within regenerator coke burning capacity).

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