Question 10: What are the problems with low coke operation in CCR reforming and how is it managed?

CHRISTIAN ARNOUX (Valero)

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Low coke regenerator operation became a significant issue after the adoption of the

10% ethanol in gasoline regulation which lowered the gasoline octane required from the refinery. At 10% blending ethanol raises the (R+M)/2 octane of regular gasoline about 2 numbers.

Low octane operation requires less catalyst regeneration and has changed operation of several CCR units to on/off regenerator operation:

- The regenerator shuts down automatically on low air flow to the drying zone electric heater
- On/off catalyst circulation is better than continuous un-regenerated catalyst circulation
- During periods of not regenerating catalyst, activity loss of 10 to 20 deg F might be seen
- There are some strategies for low coke operation that your licensor can help with

VIVEK GHOSH (UOP)

UOP does not have a fixed low coke limit for the design of CCR Platforming™ Continuous Catalyst Regeneration (CCR) sections. The low level of coke at which the normal operation of the regenerator will be constrained will vary depending upon the style of the regenerator and the individual unit.

Atmospheric Units: Major constraints would be low flow air control, lower air flow through the Air heater, insufficient catalyst drying and reduced O2 in Chlorination Zone which will eventually affects the platinum dispersion on catalyst.

Cyclemax Units: There are several constraints that define the low coke limit and they are unit specific such as, for units with Chlorsorb™, the ability of the thermocompressor to provide recirculation gas through the air heater preventing it from low flow trip or the ability to provide sufficient recirculation gas to cool the catalyst in the cooling zone when the catalyst circulation rate is high while the coke on catalyst is low and the controllability of the regeneration gas vent control valve.

Managing low coke operation: There are two ways refiners can approach low coke operations; increasing unit coke make or adjusting 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
- Leaner feed PONA (more paraffinic)

- Higher feed endpoint
- Lower average reactor pressure
- Lower reactor H2/HC

This list may look like there are many options, but 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 affect reformate endpoint and color. Lowering the average reactor pressure significantly would likely require a unit revamp. The best tool an engineer has 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, there may be a low limit on the compressor flow rate based the flow rate required to properly distribute the liquid feed in the Combined Feed Exchanger.

The area where the refiner has more options to manage low coke operations is on the regenerator side. CCR Platforming regenerators are designed to burn catalyst with 5.0 wt% carbon at the design circulation rate. The low side of the design range is approximately 60% of design coke load (about 3 wt% coke at design catalyst circulation rate) however, most regenerators can operate well below that 60% point with some able to maintain stable, normal operation at as low as 30% of design coke.

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 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
- Increases residence time in the drying zone
- Helps keep recycle gas moisture low. Lower circulation means less catalyst is being reduced

- Reduce burn zone oxygen set point and monitor temperature profile closely

- Vent more excess air, if possible

- Maintain minimum air heater flow rate
- Maintain enough drying air flow

Please contact your UOP representative for specific information related to the potential limiting factors for your style of regenerator and responses to low coke operation. For example, for atmospheric units, there is a low coke revamp option of adding vent line from the Chlorination loop, which allows adding excess air, removing the air heater and catalyst drying limitations and helps to maintain a higher O2 concentration in the Chlorination Zone.

What if your coke make is extremely low?
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 enough coke is laid down to restart the regenerator.

JESUS PEREZ (Alfa Laval Packinox)

Low coke operation might require shutting down the regenerator for periods of time. To avoid this disruption, some Refiners lower the H2/HC ratio so that there is some minimum coke production which can keep the regenerator continuously operating. This solution has a direct impact on the Combined Feed Effluent exchanger's performance since proper liquid lift is compromised whether the exchangers used are Texas Towers or the high efficiency Packinox heat exchanger.

Alfa Laval Packinox has developed a liquid lifting monitoring tool to detect insufficient lifting of the liquid,

based on an estimate of the required minimum recycle gas flow rate and temperature and pressure drop measurements. By using this tool, the refiners can safely push the limits of the Packinox exchanger operation while still achieving high energy efficiency.

GAYL MERCADO (Axens North America)

Refiners in the US have been operating reformer units at low severity due to ethanol blending in the gasoline pool. Operating the CCR at a lower severity provides higher reformate yields but can also become an issue in the Regenerator if coke levels become too low. With low coke operation, it is difficult to initiate coke burning and to maintain a good thermal balance in the Regenerator to achieve optimal regeneration conditions. If the entire amount of coke is not burned off at the bottom of the burning zone, coked catalyst will enter the oxychlorination with a high oxygen content and uncontrolled burning will occur. When coked catalyst is present in the oxychlorination, the oxychlorination gas, water and air injections that are necessary to restore the chlorine content on the catalyst and re-disperse the metal phase are completely stopped in the Regenerator. Consequently, catalyst that has not been fully regenerated returns to the reactors with a lower catalyst activity. Refiners usually will have a difficult time to optimize regenerator conditions that are required to achieve full catalyst regeneration and regain catalyst activity.

Axens has assisted with managing low coke operation by adjusting unit operations to help promote coke-make in the CCR. These recommended operational changes are highlighted below.

- Stop catalyst circulation rate
- Lower H2/HC ratio
- Decrease system pressure
- Recycle reformate product
- Increase Feed EBP
- Inject small amount of kerosene or diesel

Low coke operation may be less of an issue for refiners in the future as octane demand is expected to increase due to higher octane demand in the gasoline pool

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