uop
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UOP RxCat™ FCC Technology

Refining

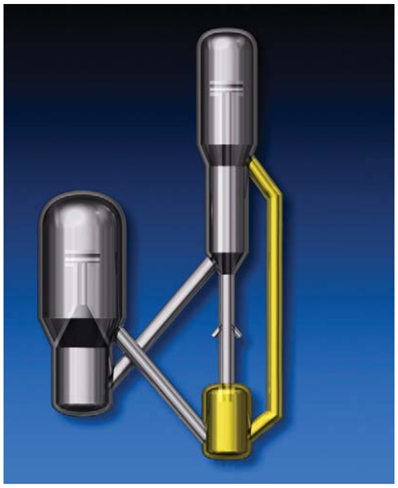
Introduction

Many of today's state-of-the-art FCC units utilize UOP's advanced technologies such as UOP Optimix™ feed dis UOP tributors, UOP VSS™ riser termination devices, and UOP AF™ spent catalyst stripping technology. These technologies have resulted in enhanced catalytic cracking and reduced thermal cracking thereby producing significant yield benefits. These technologies, along with an increasing trend toward more complete hydrotreating of FCC unit feed and improved catalyst formulations, have resulted in an operation of reduced delta coke. The lower delta coke achieved in a modern FCC unit has created an opportunity that current technology does not address. The "spent" (or "carbonized") catalyst leaving the reactor vessel still has considerable activity, but that activity is wasted when the carbonized catalyst goes directly to the regenerator. To utilize this activity, and improve the conversion and selectivity of the FCC unit, UOP developed UOP RxCat™ technology.

Processs description

The RxCat technology provides the ability to increase both conversion and selectivity by recycling a portion of the carbonized catalyst back to the riser (see Figure 1).

Figure 1 ■ **RxCat Technology**



Since the recycle of catalyst back to the riser is a heat-balance neutral step, the catalyst circulation rate up the riser can be varied without increasing the coke yield. RxCat technology allows the refiner to decouple the unit heat balance, or break the link, between catalyst circulation and coke yield. In a traditional FCC unit, anything done to increase the catalyst circulation, also increases the coke yield. This is no longer true with RxCat technology.

Regenerated catalyst flows from the regenerator to the base of the riser, changes direction and is accelerated prior to meeting the atomized feed injected in an elevated position. The catalyst-oil mixture continues its endothermic reaction as it passes up the riser, ultimately being separated and pre-stripped by the VSS riser termination device. A portion of this pre-stripped catalyst is directed through the recycled catalyst standpipe to the UOP MxR™ mixing chamber where it combines with the hot regenerated catalyst. Inside the mixing chamber, the catalysts are blended thoroughly and result in a catalyst stream that is cooler than the hot regenerated catalyst. With the total amount of active catalyst sites available in the riser now increased, the well-mixed blend of catalyst flows up the riser, contacting the feed, resulting in improved conversion. Similar to a conventional FCC unit, a portion of the pre-stripped catalyst travels through the stripper to the regenerator, where the coke is burned off before returning to the base of the riser to continue the circuit.

Benefits

RxCat technology provides numerous benefits in both revamp and new unit applications:

Increased conversion is achieved as a result of the substantial increase in the riser catalyst-to-oil ratio. At a 1:1 blend of carbonized and regenerated catalyst, the catalystto- oil ratio in the riser will typically increase 3 to 4 numbers. At a constant reactor temperature and catalyst activity, conversion can increase 3 to 5 lv-%, Alternately, the large increase in the catalyst-to-oil ratio with its corresponding increase in conversion allows reactor temperature (and hence thermal cracking) to be reduced and still maintain or exceed the original conversion level.

Improved product selectivities are achieved through various routes:

- **Increased gasoline yield** - when operating in a gasoline mode, a gasoline yield increase of 2 to 5 lv-% results from the increased conversion combined with the improved gasoline selectivity that accompanies the reduced thermal cracking. The improvement in gasoline yield following an increase in the catalyst-to-oil ratio is one of the most basic tenets in FCC technology.

- **Decreased dry gas yield** - the temperature at which the blended catalyst contacts feed is typically 150°F lower compared to a conventional FCC unit. A major portion of the thermally cracked (dry gas) products are formed at the initial point of catalyst-feed contact due to the hot catalyst. A large reduction in catalyst temperature results in a large reduction in C_2^- yield.
- **Increased propylene yield** - Because RxCat technology emphasizes catalytic reactions over thermal reactions, the selectivity to light olefins (rather than dry gas) can be significantly improved with the combination of adjusting operating severity and catalyst formulation/additives to maximize propylene yield.

Increased throughput can be achieved through various de-bottlenecking mechanisms:

- **Dry gas limited FCC unit** - the large reduction in the temperature of the catalyst contacting the feed along with the lower reactor temperature that is frequently used can reduce dry gas yields by 20%. In addition, with a 1:1 regenerated to carbonized catalyst blend, only half of the catalyst going up the riser comes from the regenerator. Thus, fewer inerts are carried from the regenerator to the riser. This decrease further decreases the light gas flow from the reactor. The combined effect can produce an overall reduction in wet gas (at the compressor) of 10%.
- **Catalyst circulation limited FCC unit** - because approximately half of the catalyst that would otherwise exit the reactor for the regenerator is now returned to the base of the riser the catalyst being moved between these two vessels is halved.
- **Air blower limited FCC unit** - the ability to improve conversion and selectivity provides the operator the ability to meet processing objectives at lower temperature that can translate to reduced coke make and air blower demand as well as a reduction in CO_2 emissions.

Increased process flexibility occurs by adding another independent FCC process variable. Catalyst circulation up the riser can now be independently controlled in a heat-balance neutral manner by controlling the flow of catalyst from the reactor vessel back to the riser inlet. This increased flexibility enables the unit to more easily handle changes in feed quality. The technology is particularly useful in units that periodically switch from gasoline mode to olefin mode, or even distillate mode, throughout the year. Normally, this shift in operating mode is accomplished by a change in reactor temperature and a change in the rate or activity of the makeup catalyst. With RxCat technology, the desired change in catalyst activity in the riser can be accomplished by merely changing the amount of carbonized-catalyst recycle and as such, the change from gasoline mode to/from olefin mode is nearly instantaneous.

Commercial experience

The concept of blending two fluid catalyst streams in a mixing chamber, followed by fast-fluidized transport up a riser, is not a new concept at UOP. The combustor portion of the UOP combustor-style regenerator, developed 25 years ago, uses the same design concept as is used in the MxR chamber. Good catalyst mixing has always been a characteristic of the combustor-style regenerator.

One new and two revamped FCC units have been designed with RxCat technology. Two of these units are now under construction, and the first unit is expected to go on-stream in early 2004.

For more information

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