REFINING

UOP Fluid Catalytic Cracking (FCC) and Related Processes

Introduction

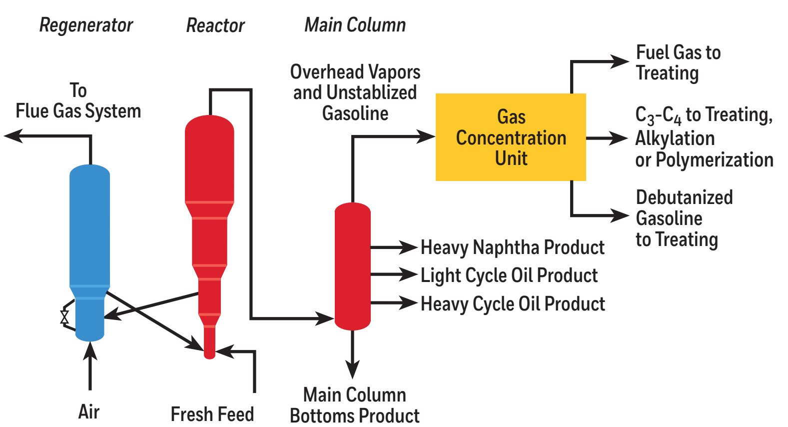
UOP licensed catalytic cracking processes include the fluid catalytic cracking (FCC) process, the Resid FCC (RFCC) process, MSCC℠ process and the PetroFCC℠ process. All of these processes convert gas oil and heavier streams to lighter, more valuable products via high-temperature catalytic cracking.

A fluidized catalyst system is used to facilitate catalyst and heat transfer between the reactor and regenerator. The system is heat-balanced: Combustion of coke in the regenerator provides all the heat necessary for the reactor.

The main products from the FCC process (see Figure 1) are:

Light gas	Primarily H_2, C_1, and C_2s, normally an undesirable by-product of thermal cracking
LPG	C_3s and C_4s – includes light olefins valuable for alkylation (the PetroFCC process targets maximum light olefin production)
Gasoline	C_5 + high octane component for gasoline pool or light fuel
LCO	Light cycle oil blend component for diesel pool or light fuel
HCO	Optional heavy cycle oil product for fuel oil or cutter stock
CLO	Clarified oil or slurry for fuel oil (potential carbon black feedstock)
Coke	By-product consumed in the regenerator to provide reactor heat demand

Figure 1 - UOP Fluid Catalytic Cracking Process



Process Descriptions

FCC: Based on conventional, proven technology, the FCC process features elevated Optimix™ feed distributors, the Vortex Separation System℠ (VSS℠) riser termination device and a combustor style regenerator. Catalyst coolers, the RxCat℠ design and selective recycle can be added to increase flexibility for feed and product demands. (Note: Separate technical data sheets are available for the these various technologies and thepreviously mentioned processes).

RFCC: The RFCC process uses similar reactor technology as the FCC process and is targeted for residual feeds greater than 4 Wt% Conradson carbon. A two-stage regenerator with catalyst cooling is typically used to control the higher coke production and resulting heat.

PetroFCC: Mechanically similar to a conventional FCC, the PetroFCC process incorporates additional reaction severity along with the RxCat design, Optimix feed distribution and VSS riser termination technology to enhance light olefin and/or aromatics production. Depending on the feedstock, propylene yields of 18 to 20 Wt% are possible.

MSCC: Developed by BARCO and licensed exclusively by UOP, the MSCC process reactor technology uses an ultra-short contact time in a proprietary design contact zone (without the use of a conventional reactor riser). It can be applied to all feeds, but its advantages grow when resid feeds are being processed.

Feedstock

The feedstock to the FCC unit is typically VGO but can include many other heavy streams, such as straight run gas oil, coker gas oil, hydrocracked gas oil, atmospheric bottoms, vacuum bottoms and DAO/DMO. The crude source and amount of resid in the feed (from zero to 100%) determine feed contaminant levels. Key contaminants are carbon residue (Conradson carbon, Ramsbottom carbon or MCRT) and metals (primarily nickel and vanadium). Feed quality and contaminant levels are important considerations when proposing a catalytic cracking process for new units (see below).

Technology	Feed/Resid
FCC	Standard feeds and some resid (up to 4 Wt% Con carbon)
RFCC	Highly contaminated and/or resid quality feeds
PetroFCC	VGO, HVGO, and hydrocracked gas oil facilitate light olefin selectivity
MSCC	All feeds are suitable

UOP FCC Technology Features

Features of UOP FCC technology include Optimix feed distributors, Vortex Separation technology, AFTM spent catalyst stripper technology, catalyst cooler, RxCat technology, selective recycle, the combustor regenerator or a two-stage regenerator, power recovery and good catalyst circulation.

Optimix Feed Distribution System

The cracking process starts with the injection of feed to the riser. Elevated, radially installed Optimix distributors are an integral part of UOP's feed distribution system. One of the features that differentiates the Optimix feed distribution system is that, unlike other systems that still use dense-phase feed injection, the acceleration zone below the Optimix distributors produce a moderate catalyst density to achieve good penetration and mixing of the atomized feed spray. Other benefits of the Optimix feed distribution system include reduced dry gas and delta coke, and increased gasoline yield.

Vortex separation technology: VSS and VDS℠

The patented Vortex Separation System (VSS) for internal riser reactors and Vortex Disengager StripperSM (VDS) for external riser reactors represent the state-of-the art in riser termination technology. Both systems have critical pre-stripping features and offer the highest post-riser hydrocarbon containment available in the industry. These systems capture the vapor/catalyst mixture at the outlet of the riser and efficiently separate the catalyst without letting the vapor enter the reactor vessel. The vapor stream is fed into cyclones for final clean up. Over 99.5% of the vapors pass through the disengager/ cyclone system without entering the reactor. In this way, post-riser cracking is virtually eliminated, resulting in an improved yield structure. Benefits include reduced dry gas, reduced delta coke, increased olefinicity, increased gasoline yield and reduced clarified oil yield.

Advanced Fluidization Spent Catalyst Stripper

UOP's riser termination systems incorporate a prestripping zone. The design achieves superior contacting and stripping efficiency. Vapors from the stripper enter the riser termination device and do not spend any time inside the reactor vessel. A combination of pre-stripping and primary zone stripping (with due attention to catalyst residence time) provides the best possible catalyst stripping. UOP's AF stripping technology have resulted in increased hydrocarbon displacement efficiency, even at very high catalyst flux rates (>120,000 lb/hr/ft^2).

Catalyst Cooler

Catalyst coolers are relatively easy to add to all styles of regenerators. The dense-phase, low-velocity shell and tube-type cooler was pioneered by UOP in the 1980s for operation on heavy feeds where high delta coke would cause excessive regenerator temperatures. The UOP catalyst cooler uses bayonetstyle tubes and generates medium- or high-pressure saturated steam. Benefits include reduced regenerated catalyst temperature, higher catalyst/oil ratio, ability to process heavy feeds and better yields.

RxCat Technology

This innovative technology recycles carbonized catalyst back from the reactor to the feed contacting zone, taking advantage of inherent activity of modern catalysts that are not really "spent" when leaving the reactor. The result is a much higher cat/oil ratio than is possible via heat balanced regenerator. RxCat is intended for existing low delta coke operations where cold regenerators can become a problem and for those operations where increased light olefin yield is desired. Regenerator temperature will increase when the RxCat design is applied. Benefits include very low dry gas and improved overall yield selectivity. RxCat technology is an integral part of UOP's PetroFCC process.

Selective Recycle

Selective Recycle is the application of once-through recycles of CLO, HCO, LCO or naphtha to reduce undesirable products and improve yields in selective products. A separate reaction zone prevents products from commingling with riser effluent. Selective Recycle is suitable for low-severity distillate operations. Benefits include improvement in selective yields (gasoline + LCO, for example) and reduction in undesirable product (CLO in distillate operation).

Combustor Style Regenerator

UOP's combustor regenerator is considered the most efficient style in the industry. Introduced in the late 1970s, it uses a fast-fluidized combustion zone to achieve the best coke burning and full combustion of CO to CO_2. Benefits include full combustion without use of promotor, minimum afterburn, lowest carbon on regenerated catalyst, no possibility of spent catalyst bypassing the regeneration zone, and lower catalyst inventory.

Two-stage Regenerator

The two-stage regenerator is used for RFCC units where full combustion would result in excessive regenerator temperatures. The upper regenerator (first stage) operates in partial combustion while the lower regenerator (second stage) operates in full combustion, with flue gas and excess O_2 rising into the upper regenerator. The two-stage regenerator has only one flue gas line which exits from the upper vessel. A catalyst cooler(s) is included in the design for control of combustion heat. Benefits include clean catalyst from second stage (less than 0.05% carbon on regenerated catalyst) and ability to process heavy and contaminated residues (up to 10 Wt% Con carbon).

Power Recovery

A power recovery system recovers usable energy (in the form of electricity from the regenerator flue gas), and typically uses it to drive the main air blower. Economic justification depends on local power costs. UOP's Third Stage Separator (TSS) technology is employed to protect rotating equipment.

Catalyst Circulation

Good catalyst circulation is a key factor in FCC unit reliability. Although the benefit of unit reliability is hard to quantify, many refiners believe it has the most influence on overall profitability. Furthermore, the benefits of advanced FCC technology will not be realized unless the unit has good catalyst circulation and stable operation.

UOP FCC units have always led the industry in catalyst circulation. UOP uses "slide valves" to control catalyst circulation, and for decades, operators of UOP units have praised the ease of catalyst circulation, quick response time and quick line-out time at start-up. One of the reasons for UOP's success is that UOP designs give high priority to catalyst circulation. Risers and standpipes are made straight whenever possible. Standpipe dimensions and critical flow angles are maintained to ensure the catalyst will flow with-out injecting fluidization gases. Overall, the UOP design emphasizes simplicity of catalyst flow:

- Straight risers avoid potential erosion situations and preserve a plug-flow reaction regime.
- Close proximity of reactor, regenerator and straight standpipes eliminate situations where catalyst must be horizontally transported. Catalyst flow is greatly enhanced and simplified by gravity flow.

UOP Commercial Experience

UOP has licensed over 215 FCC/RFCC/MSCC units, including nearly 60% of the new unit licenses awarded since 1970. Of the more than 400 FCC units worldwide, over 150 units are operating under a UOP license. During the last 10 years, significant developments – such as Vortex Separation technology (1991), Optimix feed distributors (1994), RxCat technology (1997), AF spent catalyst stripping (1998), Third Stage Separation improvements (2001), PetroFCC Technology (2008) – have allowed UOP to maintain its reputation as the industry leader for FCC technologies. UOP's combination of modern technology features and innovative process designs are unmatched and allow UOP to offer state-of-the-art technology that customers want in any FCC project, revamp or new unit.

For more information

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