THE FCCU IN TRANSITION

How refiners can benefit from an unprecedented opportunity

Warren Letzsch and Rene Gonzalez

Our new multi-client study has been co-authored by world-renowned FCC expert Warren Letzsch. Its primary objective is to inform refiners how they can make their unit operations more profitable. If you can benefit from its insights into just one of the following subjects, the study will have paid for itself many times over:

- Increasing distillate production from FCCUs approaching maximum temperature limits
- Heat integrating FCCU fractionation systems for energy optimisation
- Performance of low density metals resistant catalysts in heavy feeds processing
- Effect of high temperature operations on unit hardware (eg, slide valves, transfer lines)
- Strategies for improving unit pressure profile and optimising MAB and WGC performance
- Synergising integrated FCCU and hydrocracker operations
- Integrating FCCU and petrochemical/olefins operations
- Upgrading FCCU LCO to ULSD
- FCCU energy optimisation versus full-scale cogeneration
- Latest regenerator improvements for reduced NO_x emissions and meeting future CO_2 limits
- When to consider an FCCU revamp versus a new grass-roots unit
- A view of the principles and practices from high complexity index refineries operating FCCUs
- Upgrading FCCU intermediates (eg, in hydrotreaters/FCC post-treaters)

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Pre-eminent FCC expert, Warren Letzsch, and *PTQ*'s editor, Rene Gonzalez, have co-authored an important new study with the single objective of informing refiners how they can make their FCCU operations more profitable

The decision to build a new FCCU or revamp an existing unit comes down to economics. Usually, throughput increases of 10% or less favour the revamp of existing FCCU assets. Short of building a new unit, larger or major changes, such as converting a wider variety of feedstocks while also meeting regulatory emissions requirements, may require a new hardware solution, as discussed in Section 12: Hardware design for high severity operations.

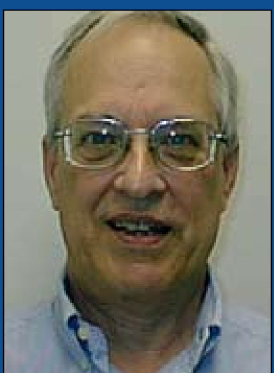
Major factors to consider include the long-term plan for the refining complex (Section 15: Long-term FCC objectives) and the types of feedstock to be processed, as well as the products to be made. In most cases, regulatory factors pertaining to sulphur and aromatics limits of FCC products, stationary source emissions and future CO_2 capture must be taken into consideration, as discussed in Section 2: Regulatory drivers. It is therefore important to know what to expect in terms of processing (Section 5: Process objectives) and operational (Section 7: Operating strategies) issues, which is the essence of this report.

There are three types of FCCU: gas oil, resid and petrochemical. Gas oil crackers typically run heavy atmospheric gas oil, vacuum gas oils and occasionally coker gas oils. They usually yield gasoline with light olefins in the C_3/C_4 range for alkylation and etherification. The conversion from gas oil crackers can also be lowered when diesel is the preferred product.

Resid crackers charge a significant amount of vacuum resid with the gas oil. If the crude source is of relatively high quality, the entire atmospheric bottoms may be charged to the resid cracker (Section 5.5: Heavy feeds options). Alternatively, if the refinery is configured with more than one crude train, the resid from the best crude may be charged to the FCCU (Section 9.3: Processing heavier feeds).

With FCCUs designed for petrochemical production, the refiner has an outlet for propylene and possibly aromatics (Section 5.4: Petrochemicals and propylene production). Propylene yields can be increased from 3–4 wt% to as high as 20 wt% of fresh feed. As the gasoline is overcracked, the remaining gasoline becomes more aromatic and is particularly rich in xylenes.

In many cases, a refiner will choose to revamp an existing FCCU rather than build a new unit (Section 6.3: Revamp and upgrade). A revamp to increase unit capacity typically involves an increase in unit pressure. This helps reduce the volume of gases to be separated in the gas plant and keeps the cyclones operating within their design parameters (Section 12.6: Cyclones). The least complicated revamp scenario is when the feedstock is hydrotreated gas oil and gasoline



WARREN LETZSCH is an independent refining consultant with an extensive FCC background. He has 41 years' experience in petroleum refining, including petroleum catalysts, refining and engineering and design. His positions have included R&D engineering, technical service and sales, leading to senior management positions in sales, marketing, technical development and oversight. He was one of the prime developers of the Shaw/Axens R2R technology that has become the leading resid catalytic cracking process in the world. He has written over 90 articles on refining, authored chapters on catalytic cracking for various books and holds eight patents. He is a member of the AIChE, ACS and has been active with the NPRA for 38 years, for which he received the Peter Andrews award for lifetime service. Letzsch holds BS and MS degrees in chemical engineering from the Illinois Institute of Technology and received the Harry McCormack award as the outstanding senior chemical engineering student.

is the primary product (Section 9.4: FCC feed pretreatment). However, major modifications need to be considered when targeting resid processing or petrochemical production. In these cases, significant hardware changes may be justified.

Raising the pressure in the FCCU process has several consequences. First, it increases the delta coke or lay-down of coke on the catalyst in the reactor section of the FCCU. Stripping also becomes more difficult, because the hydrocarbons do not desorb as easily due to the higher hydrocarbon partial pressure in the reactor/stripper (Section 12.5: Air distributors/steam strippers). Saturated C_3 and C_4 paraffins are increased at the expense of olefins. The gasoline will also be less olefinic and consequently lower in octane.

Catalyst entrainment will be higher in both the reactor stripper and the regenerator at a given superficial velocity due to a higher gas density. The horsepower required for the main air blower (MAB) will also be higher, since the air must be pumped into the vessel at a higher pressure (Section 11.1: Main air blower).

The typical regenerator is designed for a superficial gas velocity of about 2–5 ft/sec. When the rate exceeds 3.5 ft/sec, the amount of catalyst entering the cyclone system exceeds that being circulated. Further increases in gas velocity cause catalyst entrainment to increase almost systematically.

A new regenerator will need to be considered when the feed rate exceeds 50% of the original design value, assuming the base design employed a zeolitic cracking catalyst with minimal recycle. A new regenerator will also need to be considered if the regenerator coke burn is to be increased (Section 7.3: Increasing operating severity). If resid is to be processed and the coke yield is increased by more than 50%, the same reasoning will apply as with the case of higher feed rates. Also, adding a catalyst cooler to an existing unit will almost always trigger this event.

This report shows how every FCCU feed has an optimal catalyst-to-oil ratio for a particular set of processing circumstances. Since the coke make is defined as weight of coke (fresh feed basis) = delta coke x catalyst-to-oil ratio, any increase in the weight of coke on a fresh feed basis results in a loss of liquid product. For a 50 000 bpd FCCU, a 1.0% increase in coke would result in about 155 000 lb/day of lost product.

Refining has evolved over the past few years with rapid fluctuations in the feedstocks to be processed and the associated costs to produce high-quality fuels from lower quality feedstocks. To meet the changes that have developed in the refinery's fuel balance (ie, more distillate, biofuels, petrochemicals and less gasoline), significant investments in hydrocracking and crude unit processing (eg, recovery of straight-run diesel from vacuum tower) are being made, even though the current economic downturn limits available capital, as discussed in Section 1: Global market trends: fuels and petrochemicals.

The FCCU continues to evolve with these changes (Section 6.6: FCCU synergy with other refinery units), cracking heavier and more contaminated feedstocks, increasing operating flexibility, accommodating environmental legislation (Section 2: Regulatory drivers) and maximising reliability.

RENE GONZALEZ is the Editor of *Petroleum Technology Quarterly*, based in Houston, Texas. Prior to taking up this position in 2000, he was Editor of World Refining and Senior Process Editor of *Hydrocarbon Processing*. He has published several industry studies pertaining to fluid catalytic cracking, hydrocracking, MTBE/TAME etherification, refinery product supply and distribution, and terminal blending. Prior to joining the publishing industry in 1990, he spent eight years working for Glitsch (now Koch-Glitsch) in Dallas, Texas, and Coastal Refining (now Citgo Refining) in Corpus Christi, Texas. Gonzalez has a BS in chemical engineering from Texas A&M University.

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