Engineering Consulting & Training Services

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Fluid Cat Cracking – Still a Profitable Refining Process

By Bruce J. Artuso

In the current climate of significantly reduced refining margins, it is critically important to maintain perspective and emphasis on the areas that still produce a good financial return. Fluid Catalytic Cracking (FCC) has been, and remains, one of the most important and most profitable processes in a refinery operation.

The basic process (illustrated in the attached sketch) is one in which a relatively low value feedstock is converted into a wide range of much more valuable products. These include yields of about 60% of high-octane gasoline product, about 20% of a diesel-boiling-range product, and significant amounts of lighter gases, some of which become feedstocks for other downstream processes, as well as a major contribution to the refinery fuel gas system. In addition, the total volume of products represents an actual overall increase over the volume of feedstock. The process also has great flexibility to handle a wide range of feedstocks, and operating conditions can be manipulated to satisfy differing product requirements. Thus, optimizing FCC operation has a very significant bearing on overall refinery profitability.

What Contributes to Optimum FCC Operation?

Because of its great complexity and flexibility, a Cat Cracking unit has a variety of components which can contribute to a profitable result. Some of these are: Unit Design Features, Catalyst Selection, Operating Conditions, Mechanical Reliability, and Operator Capabilities. These are briefly discussed below.

FCC Design Features

Some of the most important features of most modern FCC unit designs are:

- Short contact time cracking. This maximizes the production of more valuable products by minimizing the effects of re-cracking and thermal cracking in older reactor configurations.
- High efficiency feed injectors. These optimize product distribution by efficient atomization of the feed and effective mixing with hot regenerated catalyst in the reaction zone.
- Efficient spent catalyst stripping. Good catalyst stripping minimizes carry-under of potentially recoverable products, as well as maximizing regeneration air available for combustion of coke in the regenerator.
- Effective catalyst regeneration. Regenerator features which optimize regeneration of spent catalyst are important because of the impact that catalyst has on reactor cracking results. The type of regeneration (e.g., Full- or Partial-CO Combustion) can also be of great importance to unit profitability. Efficient cyclones, properly designed diplegs, trickle valves, and air distribution in the regenerator also play a large part in smooth operations.

Work Highlights

Mechanical Engineering

Developed a new design for inter-mediate tube supports for a CO Boiler that experienced significant failures during a short period of operation. The new design included a material change that incorporated foundry casting recommendations, changes to mechanical design and installation details, and improved inspection requirements. A supplementary support arrangement was also recommended as an alternative to having to replace multiple existing tube supports.

Process, Operations & Safety

Provided process engineering support on the successful startup of licensed units, including a lube hydrocracker, dewaxer, and white oil unit, in Asia.

Completed PIMS modeling and refinery planning support for a major technology licensor on a major middle-eastern project involving over $1B capital expenditure. The project is moving forward into the FEED phase at the contractor's office shortly.

- Modern equipment to minimize environmental impacts. These include such auxiliary features as an Electrostatic Precipitator (ESP) and Wet Gas Scrubber, both designed to mitigate emission of catalyst particulates and to reduce SOx and NOx concentrations in regenerator flue gas. Other features are available to minimize certain emissions; these include catalyst additives and other process add-ons.
- Direct supervisory control. This feature is usually combined with an online refinery optimization program, to continually adjust unit operation conditions to achieve optimum results within the context of the overall refinery plan. In addition, unit operation can be more stable than in manual control.
- Effective emergency systems. These are designed to activate at predetermined abnormal conditions, to put the unit in an initial safe condition in the event of an upset or emergency situation.
- Where economically feasible, a high degree of energy recovery can be obtained in flue gas expanders and/or CO Boilers.

Optimum Catalyst Selection

Modern catalyst technologies can tailor FCC catalysts for most feedstock, operating conditions, and emissions combinations. Selection of the best catalyst for a specific refining and FCC application can be critical to effective and profitable unit operation. The selection process is usually enhanced by utilizing the expertise available in catalyst suppliers, who have access to extensive pilot unit and testing facilities, and a broad background of experience.

Optimization of Operating Conditions

It is obvious that the profitability of an FCC unit is very dependent on the conditions under which that unit operates. The choice of optimum conditions must, of course, recognize actual unit constraints. Within those constraints, optimization can be determined externally by studies involving availability of multiple FCC yield structures within a refinery linear program. More commonly, however, that optimization is currently developed on a continuous basis, utilizing unit supervisory control within an overall refinery economic plan. This yields more immediate, continuous, and probably more accurate economic benefits.

Mechanical Reliability

The FCC reactor/regenerator section is complex, with large vessels that operate at fairly high temperature under an erosive, severe environment for long process runs before turnaround, unless problems dictate otherwise. Planned turnarounds can be 4-5 years apart; so, ensuring the mechanical reliability of equipment, piping and refractory linings, etc., for the duration of the run is a major consideration.

The unit must process feedstock safely and reliably, and minimizing down-time is paramount to achieving optimum refinery economics. This also includes advance turnaround and maintenance planning.

Effective Operator Interface with Unit Operation

Even on a unit which has supervisory control, continuous and effective monitoring of the operation by the operator is still extremely important. In addition to routine tasks such as changing unit objectives as required, the operator has a critical role in proper handling of non-standard operations such as upsets and emergency conditions.

As mentioned above, most units have at least several basic emergency systems (ESD) to put the unit initially in a safe condition when an emergency situation occurs. However, it is critically important for the operator to implement the necessary follow-up actions to:

(1) Ensure that the automatic systems have functioned as intended,

(2) Initiate any actions that have not been taken by emergency instrumentation,

(3) Take the follow-up actions that are necessary to fully achieve a safe and stable unit condition,

(4) Assess the cause of the upset/emergency, and remove it if feasible, and

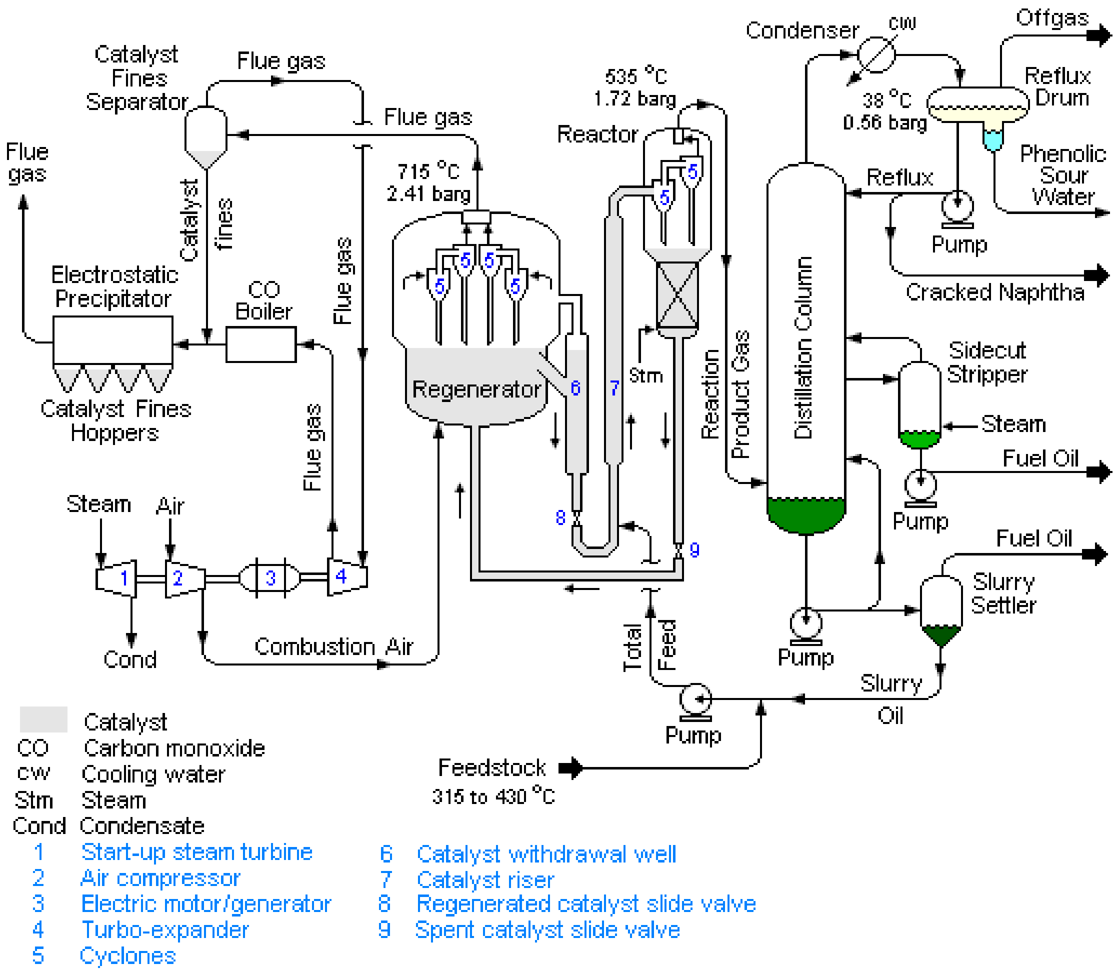
(5) Proceed to restore normal unit operation in an expedient and safe manner.

To ensure the necessary degree of knowledge and expertise by the operator, both for monitoring normal unit operations, as well as effective handling of abnormal conditions, the refinery must provide adequate and extensive training programs.

How Can These Objectives be Realized?

Achievement of these goals necessarily requires a high degree of expertise within a refinery's engineering staff. Alternatively, and especially for smaller organizations on tight budgets, that expertise can be secured by utilizing "outside" technical specialists in the various areas (e.g., design, computer control, catalyst selection, optimization of operating conditions, mechanical reliability, and effective training of process operating personnel). "Outside" specialists can similarly be effectively utilized in studying and resolving operating problems such as unsteady catalyst circulation and regenerator afterburning, or even perform broader data analysis and process troubleshooting in areas that may impact the FCC feed quality and ultimately unit economy.

In many cases, combining that outside expertise with the knowledge and unit familiarity that is available within a refinery will yield very beneficial and economically attractive results.



Bruce Artuso is a process specialist for fluid solids processes and has extensive experience in design, operations, startup, and troubleshooting of Fluid Catalytic Cracking units and fluid iron ore units. Please contact Jerry Lacatena (jlacatena@carmagen.com) if you'd like more information on Carmagen's expertise in this area.

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