A Honeywell Company

UOP CCR Platforming™ Process for Aromatics Production

Petrochemical

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Application

The CCR Platforming process, is used throughout the world today in the petroleum and petrochemical industries. It produces aromatics from naphthenes and paraffins, either for use in motor fuel or as a source of specific aromatic compounds. In aromatics applications, the feed naphtha is generally restricted to C_6 through C_8 compounds to maximize the production of benzene, toluene, and xylenes.

The distribution of the hydrocarbon types (paraffins, naphthenes and aromatics) will determine how easily various naphthas can be reformed. Aromatic compounds pass through the Platforming unit relatively unchanged. Naphthenes react rapidly and efficiently to aromatics, while paraffins react slowly and with less selectivity.

Process chemistry

Four major reactions occur in the reactors to produce the desired products:

- Dehydrocyclization of paraffins to 5-membered rings
- Isomerization of 5-membered to 6-membered rings
- Dehydrogenation of 6-membered rings to aromatics
- Hydrocracking of large hydrocarbons to smaller hydrocarbons

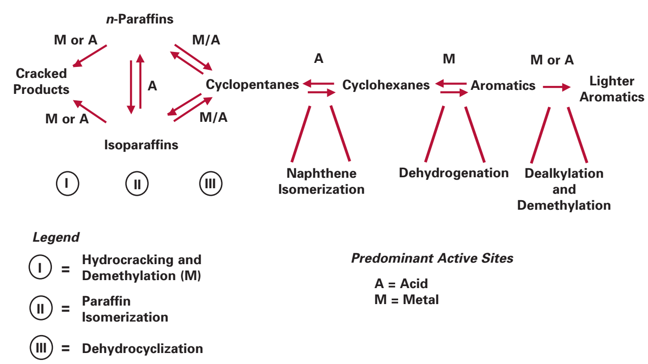
The function of the reformer is to efficiently convert paraffins and naphthenes to aromatics with as little ring opening or cracking as possible.

A generalized reaction scheme that identifies these key reactions, as well as the reaction pathways that are required to achieve high product yields, is depicted below. Two key catalyst functions are served by acid and metal sites. The performance of the catalyst system, as measured by its activity and selectivity to the desired reactions, is a function of the balance achieved between these acid and metal sites.

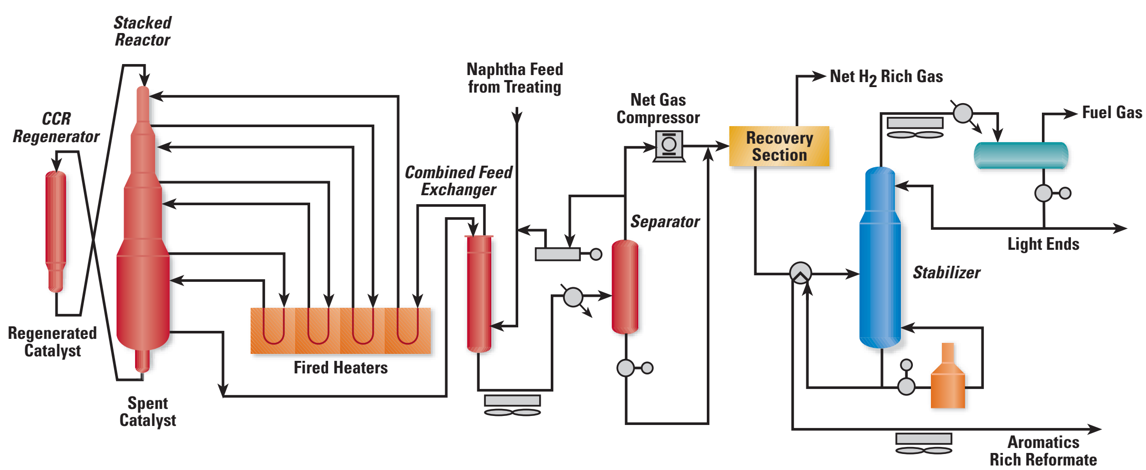
Process description

Hydrotreated naphtha feed is combined with recycle hydrogen gas and heat exchanged against reactor effluent. The combined feed is then raised to reaction temperature in the charge heater and sent to the reactor

Generalized Platforming Reaction Scheme



CCR Platforming Process



section. Typically four adiabatic, radial-flow reactors are arranged in a vertical stack. Catalyst flows vertically by gravity down the stack, while the charge flows radially across the annular catalyst beds. The predominant reactions are endothermic, so an interheater is used between each reactor to reheat the charge to reaction temperature. Flue gas from the fired heaters is typically used to generate high pressure steam, but other heat integration options are available.

The effluent from the last reactor is heat exchanged against combined feed, cooled and split into vapor and liquid products in a separator. The vapor phase is rich in hydrogen gas. A portion of the gas is compressed and recycled back to the reactors. The net hydrogen-rich gas is compressed and charged together with the separator liquid phase to the product recovery section. This section can be engineered and optimized to provide the required performance. The liquid product from the recovery section is sent to a stabilizer where light saturates are removed from the aromatics-rich reformate product.

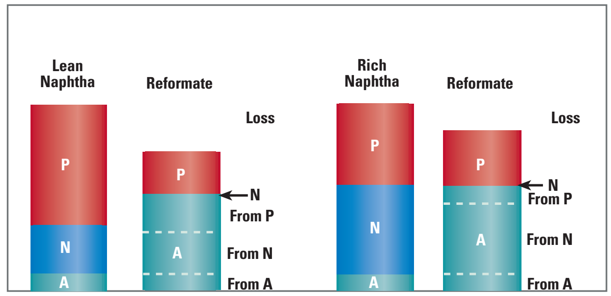
Over time coke builds up on the Platforming catalyst at reaction conditions. Partially deactivated catalyst is continually withdrawn from the bottom of the reactor stack and transfered to the UOP CCR™ regenerator. The catalyst flows down through the regenerator where the accumulated carbon is burned off and the moisture and chloride levels are adjusted. Regenerated catalyst is lifted with hydrogen to the top of the reactor stack. Because the reactor and regenerator sections are separate, each can operate at its own optimum conditions. In addition, the regenerator section can be temporarily shut down for maintenance without affecting the operation of the reactor and product recovery sections.

Process performance

An understanding of process chemistry explains the loss of volumetric liquid yield across the reaction zone. Yield loss comes from two sources: natural shrinkage resulting from the higher density of aromatic, and cracking reactions that form lower-value light products.

The conversion of naphthenes and paraffins to aromatics causes an increase in the density of the reaction material. The following diagram shows the volumetric conversion of typical lean and rich naphthas across the Platforming

Platforming Process Reactions



process. A lean naphtha is one in which the paraffin content of the feed is high, typically above 65%. Rich naphtha has a lower paraffin content and a smaller density shift between feed and reformate. The catalyst system cannot control the volumetric change in yields caused by the density increase to aromatics. However, by decreasing hydrocracking reactions, selective catalyst systems have a tremendous effect on yield loss. Coupling a selective catalyst system with optimized reaction conditions provides an increase in the catalytic reaction selectivity and the suppression of the hydrocracking reactions. Both of which are key to attaining maximum aromatic and hydrogen yields.

The fact that yields in the reforming reaction system are favored by low pressure is well known. UOP has made great advances over the past two decades in coupling improved catalyst compositions with lower operating pressures. At reactor operating pressures of 3.5 kg/cm^2 (50 psig), which are typical of UOP's latest designs and recent commercial start-ups, the selectivities of the more difficult reactions are clearly better. Under such conditions, reaction selectivities for heavier paraffin species and heavy 5-membered and 6-membered naphthene ring species range from 80 to 100%. Thus, through pressure reduction and using current catalyst technology, UOP has made dramatic progress toward closing the actual-to-theoretical yields gap.

The lower operating pressures increase the rate of coke formation on the catalyst and can cause an eventual loss of performance. This problem was solved in 1971 with the startup of the world's first CCR regenerator, which was designed and developed by UOP. In the 32 years since the start-up of this first unit, UOP has continued to improve and expand regeneration capability to keep the CCR regenerator system in balance with the requirements of the reactor section.

Economics

A summary of investment cost and utility consumption is given in the table below for a 500 KMTA (12,000 bpd) CCR Platforming unit operating at an average severity (104.5 RON) to produce BTX as a feed stock to an aromatics complex.

C_5^+ yield, LV-% of feed	81.5
C_5^+ yield, wt-% of feed	90.1
Hydrogen gas yield, wt-% of feed	3.0
Estimated ISBL cost US$ MM (including initial catalyst inventory)	46

Utilities

Electric power, kW	1851
Fuel fired, Gcal/hr	32.2
Cooling water, m^3/hr	438
High pressure steam, MT/hr	0.7
Low pressure steam, MT/hr	0.1
Boiler feedwater, MT/hr	15.8
Condensate, MT/hr	15.8

Commercial experience

UOP commercialized the CCR Platforming process in 1971 and now has 177 units on stream (more than 3,900,000 bpd of capacity) with another 30 in various stages of design, construction and commissioning. The combination of radial-flow, reactor stack and a CCR regenerator has proven to be extremely reliable. On-stream efficiencies of more than 95% are routinely achieved in commercial CCR Platforming units and every CCR Platforming unit that ever started is still operating today.

For more information

Platforming technological services are available on request. For more information, contact your local UOP representative or our Des Plaines sales office:

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