Engineering Consulting & Training Services

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Opportunities for Refinery and Petrochemical Plant Integration

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Changes in the transportation fuels industry, dictated by environmental and political pressures, will significantly impact the demand for conventional refinery fuel products and put increased pressure on refining margins. However, refinery facilities are valuable assets that can be used for the co-production of products other than conventional transportation fuels. As capacity is freed-up by reduced demand for conventional refinery fuels, more opportunities become available for production of such alternate co-products.

Refineries basically co-produce petrochemicals in addition to fuels. For instance, petroleum refining processes generate light olefins (e.g., ethylene, propylene, and butylenes) as well as aromatics (especially benzene, toluene, and xylenes). Butylenes, toluene, and xylenes are important components of the major refinery fuel products (e.g., gasoline). Alternately, these chemicals can be recovered from the refining units for chemical sales. In periods of high gasoline demand, refining operations tend to be optimized to maximize production of fuels; chemical co-production mode is not emphasized. In the future scenarios, there will be opportunities to shift from fuels emphasis to increased chemical co-production.

In addition to recovering chemical products co-produced in the refinery, intermediate streams can be redirected to associated chemical production facilities (such as steam crackers for ethylene and propylene production, and naphtha reformers for aromatics production). Again, disposition of intermediate refinery streams to chemical production facilities will become more advantageous as refinery fuel product demand is impacted by the new trends.

Employing Refining Streams in Chemical Conversion Units

The disposition of refinery streams should be optimized between fuels and chemical facilities. If fuels demand is declining, the value of certain refinery streams will be higher in chemical outlets. Typically, optimizer software is used to select the optimum disposition for all streams in a refinery/chemical complex.

The optimizer will incorporate models of each process unit, and will predict the effect of each of its potential feed's characteristics on the yields and qualities of products from the process unit. Product gasoline and other fuel products are produced by blending according to specified property specs for each grade. Similarly, chemical products are blended according to their specified purity specs. Product pricing information and any product sales constraints are specified.

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- Course 910, *Process Plant Piping Systems Design and Maintenance*, June 29-30, July 1, 2010

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Work Highlights

Mechanical

Provided mechanical engineering assistance in the evaluation and repair of cracks that occurred in a large diameter, stainless steel piping system at a Canadian oil sands facility. A temporary welded lap band design was provided and ultimately installed, which minimized the length of costly unit downtime.

Process, Operations & Safety

Performed an Independent Project Review (IPR) of the next generation ethylene cracker research and development material developed by a major multinational petrochemical company. The IPR team addressed viability of basic principles, approach/ criteria, and provided commentary and suggestions regarding the next phases of development.

Process unit operating costs and capacity constraints also are modeled. Capacity constraints of existing equipment may limit the amount of redirection allowed, but studies can be done to assess the economic incentives for debottle-necking or new capacity additions. In addition, the operation of some refining process units can be modified to favor chemical production. This will require modifying the models of those process units in the optimizer.

These optimizer tools allow the user to respond to any shifts in fuel product demands or product values by recovering light olefins and aromatics out of fuels disposition for chemical sales, or by redirecting the appropriate feed streams from refining units to chemical units.

For example, a hydrocracking process may be employed in the refinery to convert heavy gas oil streams to gasoline, kerosene, jet fuel, and diesel. In the most commonly used configuration, the uncracked residual oil product stream is recycled to maximize conversion of feed to the desired fuel products. However, due to the high hydrogen pressure and catalyst involved, the uncracked residual recycle stream typically could be used as a high quality feedstock in either a steam cracker or a fluid catalytic cracker. Therefore, consideration may be given to divert some or all of this stream from hydrocracker recycle (thereby reducing fuels production, as well as hydrocracker operating costs) and using the uncracked residual stream to improve olefin production in one or both of these alternate dispositions.

Recovering Olefins from FCC

A typical fluid catalytic cracker (FCC) yield includes light olefins (ethylene, propylene, and butylenes) totaling 10-15 wt.% on feed. In some cases, the C2- gas is processed for ethylene recovery. Propylene typically is recovered, at least in larger capacity FCC units. In fact, FCC propylene is second (to steam cracking) in the worldwide propylene supply, and in the US is the largest source of propylene supply.

FCC total light olefin yield can be increased to 25-30 wt.% on feed with the proper selection of catalyst and operating conditions. This increased light olefin production comes from more conversion of cat naphtha olefins, which results in a reduction in gasoline production. Even higher yields also are possible with improved FCC feed qualities.

Achieving such major increases in FCC light olefin yields may be constrained by the capacity limitations of existing equipment. Higher light molecule production significantly increases the volumetric load on the FCC reactor and overhead recovery equipment. FCC feed rates may need to be reduced. Debottlenecking or new capacity additions could be considered.

Another approach is to divert the FCC olefinic naphtha to a dedicated catalytic cracking process to produce light olefins (predominately propylene). Some have proposed recycling the naphtha to the FCC unit itself, possibly injecting it into a separate parallel riser. However, this still would encounter capacity limitations in the existing FCC reactor and overhead system. Another option is to build a separate dedicated fluid catalytic cracking unit, with associated overhead product recovery facilities. The catalyst and conditions would be optimized to maximize propylene yield. Such a unit could feed a variety of refining and chemical plant naphthas containing olefins to be converted to the desired light olefins.

Approach for Identifying Opportunities

Refinery facilities need to be optimized as product demands and pricing change. In addition, process modifications should be considered, employing both existing and newly emerging technology options. A team approach, employing expertise with both refining process and chemical process technology, is needed to identify maximum benefits from the existing assets.

Phil Ruziska is a refining and chemical process specialist with Carmagen Engineering, Inc. and has extensive experience in developing new strategies and new technologies for production of chemicals and chemical feedstocks at integrated Refinery/ Chemical sites. Please contact Jerry Lacatena (jlacatena@carmagen.com) if you'd like more information on Carmagen's expertise in this area.

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