Mid-cycle skim doubles run time and throughput

Not long after a recent summer turnaround, a major Gulf Coast refinery had a problem. The engineering team noticed a pressure drop (dP) increase in bed 1 of their hydrocracker pretreat reactor shortly after start-up, all but guaranteeing they would not meet their cycle length goal without performing a mid-cycle skim. The site's challenges did not end there. A year later, they experienced an unexpected two hour equipment shutdown. Upon restart, the team observed a dP increase in bed 2 while the state of bed 1 continued to worsen.

The engineers had little time to dream about extending the cycle length – they needed just to keep the reactor online and to run at required rates. As in most refineries, the hydrocracker needed to deliver consistently high throughput for stable operations and to meet demand.

The refinery's engineers knew that the increased pressure drop could limit the hydrocracker's performance. With their standard configuration, which utilised traditional grading, the run times were short. Downtime from mid-cycle skims reportedly ranged from 20 to 60 days. At high-complexity facilities, disruptions like these can seriously impact availability, profitability, and risk associated with turnaround and maintenance operations.

Having worked with Crystaphase to solve tough challenges at other locations, the engineers turned to the company's filtration technologies to deliver results with a novel, empirically based solution to a common reactor problem – pressure drop due to crust layer formation.

Working with the site's process engineer, Crystaphase collected samples from two previous cycles to analyse and better understand the reactor's foulant profile. After lab analysis of these samples, the Crystaphase team identified the foulants that appeared most likely to be contributing to pressure drop.

From this detailed analysis, Crystaphase's process and development engineer, Umakant Joshi, and director of technology, Austin Schneider, developed a tailored solution that could optimise the reactor's configuration. Following the next mid-cycle skim of the hydrocracker pretreat reactor, Crystaphase installed an ActiPhase TRANS solution designed with enough capacity to reach the next scheduled changeout, about one year later, without dP limitations.

With the system installed, the customer met that goal, and when the reactor was shut down for a scheduled full catalyst changeout, the customer installed an optimised ActiPhase system designed, together with Crystaphase, to extend the cycle length even further. Over the duration of that cycle, the reactor suffered several unrelated setbacks, including equipment failures. Despite all of these events, the pressure drop remained virtually flat after each restart.

Through the mid-point of the hydrocracker's first complete cycle with the Crystaphase solution, the pressure drop appeared to remain effectively flat. Given the impressive results, the customer approached Crystaphase to see if the system could continue past its next scheduled shutdown. Because of Crystaphase's work with the customer and understanding of the reactor's foulant profile, the Crystaphase team could turn to its data modelling capabilities for a projection of the pressure drop over the next several months. The customer received some good news – the system would likely continue to perform without dP limitations over an extended cycle.

At the time of its most recent shutdown, the hydrocracker's run time and throughput were each roughly twice what the reactor had been able to achieve before.

With help from Crystaphase to tackle pressure drop and extend run time, the site's mid-cycle skims became a thing of the past, helping the reactors stay online longer and reduce related costs and risks. Ultimately, it was a day-and-night change for the customer's hydrocracker.

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Lessons for ethane cracking

As automation technology becomes more and more essential, plant operators need to glean everything they can as legacy systems are modernised. That is exactly why, when a Texas facility experienced a strange process upset in the steam cracking furnace, a team of experts applied knowledge gained from a different facility's upgrade to solve the mystery. The lessons learned from the experience enabled the development of best practices for safer and more efficient operations across all natural gas processing plants.

The breakdown

At the heart of an olefins plant is the ethane cracking furnace. To get from natural gas to the products we use every day, you need to break it down into smaller, usable hydrocarbons. To accomplish this task, steam cracking begins the process. Here ethane is fed into a cracking (or pyrolysis) furnace to produce ethylene (80%), propylene (3%), butylene (2%), and other high-value chemicals (remaining 15%).

Coke residue is an unavoidable by-product of this process. Coke formation clogs the furnace and transfer lines, hurting product yields and impairing heat transfer. If the build-up is left to continue, the tubes can burst, causing catastrophic failure resulting in expensive repairs and significant down time. These shutdowns cost the industry millions of dollars in unrealised revenue every year.