Question 13: When the regenerator in a CCR unit is shut down for an extended periodof time, how do you predict coke on catalyst with no catalyst circulation?

VIVEK GHOSH and **STEVENPHILOON (**Honeywell UOP)

There are two broad scenarios which might result in the catalyst circulation of a CCR Platforming™ unit being stopped for an extended period of time. The first is that there is maintenance being performed that requires the regenerator to be taken off-line for several days. The maintenance may be scheduled, such as screen cleaning or unscheduled due to a mechanical or other operating problem. In either of these cases, it is not possible to circulate catalyst. The other scenario represents an operational choice. The most common instance of this case occurs when the severity of the reactor operating conditions is so mild that there is insufficient coke deposited on the catalyst to maintain normal operation of the burn zone. For units operating in “low-coke mode", catalyst circulation can be stopped to allow additional coke to lay down on the catalyst. For those units with atmospheric regenerators that routinely run in low-coke mode, Honeywell UOP has a revamp offering that extends the operating envelope significantly. Implementing the revamp has allowed a number of units to operate at lower coke levels and achieve more stable reactor-side operations.

Assuming that no other operating changes can be made to increase the rate of coke formation, for those units operating in “low-coke mode”, UOP recommends that the burn zone be shut down while catalyst circulation continues. This allows for the catalyst to develop a uniform level of coke while avoiding issues associated with restarting catalyst flow. An alternative is to use “batch catalyst movement”. With this approach, catalyst is circulated for a short period, every day or two, which is long enough to collect representative sample of spent catalyst. With either of these approaches, the coke on catalyst is determined by laboratory analysis. The third approach is to have no catalyst circulation. UOP does not recommend this option because of the uncertainty when estimating the coke on the catalyst and the rare, but real, risk of problems restarting catalyst circulation. If the level of coke on the spent catalyst cannot be determined by lab analysis, the following discussion will be helpful for estimating the rate of coke formation.

When the regenerator section is shut down for maintenance while the reactor side continues to operate, it is important to track and control the rate of coke formation so that the regenerator can be brought back onstream before the coke level gets too high. The rate of coke laydown is a function of many factors that may be either easy to control, difficult to control, or essentially uncontrolled at the unit level. The feedrate, H2/HC (hydrogen gas/hydrocarbon) ratio and weighted average inlet temperature (WAIT) are all directly controlled at the unit. The feed distillation and product quality requirements are not directly controlled at the unit, and any change must be negotiated ata multi-unit level. The current condition of the catalyst, the quantity of the coke precursors in the feed, and the risk of an upset are essentially uncontrolled.

If the reactor operating conditions will remain the same –after the regenerator shutdown –as they were prior to the shutdown, the refinery can make an assumption that the coke laydown rate in the reactors

during the CCR shutdown period will also not change significantly.

Based on operating experience with CCR and semi-regen units and data from pilot plant studies, it is UOP's understanding that the rate of coke formation in the last reactor is higher than that in the lead reactors. This result is true because the average bed temperature is higher in the last reactor and coke precursors that are formed in the lead reactors will become coke in the last reactor. For units with about 50%of the total catalyst volume in the last reactor, the rate of coke formation in that reactor can be estimated to be about two-times that of the previous reactors. Using this rule of thumb, the rate of coke laydown in the last reactor can be estimated on a daily basis. This rate can then be used to predict the level of coke on the catalyst in the last reactor.

If the reactor-side operating conditions during the CCR shutdown period change, then the Relative Coking Factor charts in the UOP CCR Platforming General Operating Manual can be used to estimate the new coke laydown rate. As is always the case with estimations, the greater the magnitude of the changes in the operating conditions, the greater uncertainty in the new estimated coke formation rate.

When operation of the regeneration tower and catalyst circulation is first restarted, it is expected that the coke on the spent catalyst will be high. If the catalyst can be circulated at the design rate, the coke level will decrease during the first catalyst cycle as the unit returns to regular operation and normal catalyst coke levels. If, for any reason, the catalyst circulation rate is significantly below design, the amount of coke on the catalyst may continue to rise.

At the end of the day, past experience with the unit will provide the best basis for coke prediction. If you need to know the maximum number of days you can operate without the regenerator in order to plan for a CCR section shutdown, it would be beneficial to conduct operational tests to quantify the rate of coke formation with your unit, feed, operating conditions, and catalyst.

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2016