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## **Question 42: What design modifications, such as pre-reforming and ATR (Autothermal Reforming), do you consider for greater feedstock flexibility, higher efficiency and capacity debottlenecking?**

**Deepak Agarwal** (Criterion Catalysts & Technologies)

One can use thermometry to provide insight on performance and when to optimize. Utilizing a process model to compare actual temperatures vs. estimated slip will give you an idea of adjustments required. Too high of N slip will require additional HC temperatures to reach target conversion, thus operating to a target/design N slip will help optimize the HC catalyst. We try to calculate N-slip based on heat release across the treating and cracking beds. We run our kinetic model to predict N-slip from the treating reactor on the basis of total observed treating bed delta T. On the basis of actual unit operating WABT and calculated N-slip we try to re-balance the reactor temperature profile to maximize unit cycle life and improve product selectivity.

One can also sample the product for N slip and adjust HT WABT against expected or target value. Reactor inlet temperature adjustments that is greater than the deactivation rate is also another parameter that can be monitored to help optimize catalyst utilization.

**Paul Zimmerman** (UOP)

Hydrocracking units without an intermediate sample point between the pretreating and hydrocracking catalysts are becoming more common due to units with both catalyst types in a single reactor or due to reluctance or safety concerns with taking the inter-reactor sample. Without the sample, it is difficult to optimize between the pretreating and hydrocracking catalysts. Knowing the nitrogen slip from the pretreating catalyst allows determining the relative performance and stability between the two catalysts to make optimum use of each. Over-converting of nitrogen can result in accelerated deactivation the pretreating catalyst. Under-converting of nitrogen can result in higher temperatures for the hydrocracking catalyst along with reduced yield selectivity and product quality.

Without the intermediate sample, judgment must be made based on the information available, although this is difficult to do accurately. First priority is that both catalysts must be operated within the safe operating limits of the unit including heater duty, quench availability, and bed temperature rise limits. If these conditions are satisfied, then the bed temperature rise, and feed properties can be considered.

The total temperature rise of the pretreating catalyst is the primary indication of hydrotreating severity. To interpret that total rise, the sulfur, nitrogen, aromatics, and olefins in the feed all must be considered as these all contribute to the temperature rise. Often, the nitrogen may be the lowest contributor to the pretreating temperature rise, which greatly complicates estimation of the nitrogen slip.

With a given feed composition, the relative temperature rise between pretreating and hydrocracking can

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be considered. A decreasing pretreat temperature rise along with increasing hydrocracking temperature rise may imply a shift of the hydrotreating reactions to the hydrocracking catalyst. In this case, a higher pretreating temperature may return balance to the catalyst severities.

In the past, a decreased temperature rise in the first hydrocracking bed was interpreted as an increased nitrogen slip, particularly with noble metal catalysts. However, today's base metal hydrocracking catalysts are more nitrogen tolerant and can often have a significant temperature rise from hydrotreating reactions alone. Therefore, the hydrocracking temperature rise may not always be reliable for this purpose.

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