Refiners often use hydrogen in coke as a parameter to judge the performance of their FCC catalyst stripper. However, the use of this parameter for process monitoring is often the subject of significant debate. The main questions are what hydrogen in coke number truly indicates good catalyst stripping and how valid is the number itself.

I propose refiners use the hydrogen in coke number to help confirm the accuracy of their coke make, other heat balance parameters and flue gas analysis. Any hydrogen in coke value less than 5 wt.% or greater than 9 wt.% is likely due to poor flue gas analysis.

Since the flue gas analysis is the basis for the heat balance calculations, it influences many of the calculated operating parameters such as the unit coke production, heat of reaction, catalyst circulation rate, and most dramatically, the hydrogen in coke. An artificially low hydrogen in coke number resulting from an incorrect flue gas analysis will result in a calculated coke production from the unit that is higher than actual.

An accurate flue gas analysis and hydrogen in coke number is especially important when you consider that many throughput limitations are set by emission regulations based on coke production. When considering this, the use of the hydrogen in coke number to judge stripping efficiency should be a secondary concern.

Calculating Hydrogen in Coke Practical Limits

If your heat balance calculations yield a hydrogen in coke result of 4 wt.% does this mean you have a world-class stripper? Or if your hydrogen in coke is 12 wt.% should you plan on a stripper revamp during the next turnaround? The answer to both questions is likely “no”.

David Hunt
Generally the industry accepts 5 to 6 wt.% hydrogen in coke as the lowest attainable from ideal stripping. This is based on the assumption that if the FCC stripper performed perfectly it would only allow coke consisting of highly unsaturated hydrocarbons to pass through to the regenerator.

In order to define the upper reasonable limit for hydrogen in coke, you might consider a case where a substantial amount of product is burned in the regenerator. Burning the equivalent of slurry oil (main fractionator bottoms) in the regenerator as coke could be considered an extreme case. In this circumstance, the hydrogen in coke would be ~ 9.0 wt.%, which is the nominal hydrogen content of a slurry oil with an API of ~ 0.1.

So, at best you may argue that the stripper produces coke with a hydrogen content of 5 wt.% and at an extreme case it might produce up to 9 wt.%. Data outside this range is likely explained by bad flue gas data. An inaccurate value of CO₂ is often the culprit; however, poor O₂ results will cause errors in the calculations as well.

**The Influence of CO₂ on Hydrogen in Coke**

Figure 10 shows the calculated hydrogen in coke and coke yield as a function of the measured flue gas CO₂ content for a FCC operating in full combustion with constant excess O₂. Questionable data is indicated by the dashed lines for hydrogen in coke data outside of the 5 to 9 wt.% range. The impact of CO₂ is significant and can affect not only the hydrogen in coke value but perhaps more importantly the calculated coke yield. Figure 10 suggests that coke yield could be off more than 10% due to bad flue gas data. Many FCC emission regulations, like MACT II, are based on coke production so accurate coke measurement is critical.

The coke yield was calculated using the method described in the Grace Davison Guide to Fluid Catalytic Cracking, Part One.

Next time you see a high or low hydrogen in coke number in your operating data, instead of immediately thinking about your stripper performance, you may want to check the validity of your flue gas analyses and realize that the reported coke yield (as well as other heat balance parameters) may be in error.

**References**


**Figure 10**

Influence of Flue Gas CO₂ Value on Hydrogen in Coke and Coke Yield