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GASOLINE PROCESSES
Questions 1-27

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GASOLINE PROCESSES

Theme

Question 7: Comment on your experience with the value generation potential of each of the refinery gasoline processing units: reforming, naphtha hydrotreating, isomerization, alkylation, and FCC-gasoline post-treating. What interplay exists between the units that can be leveraged?

Question 7: Answer Book Response

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The naphtha catalytic reforming unit can be partially unloaded by subtracting from its traditional feedstock the higher-boiling C6 hydrocarbons including naphthenes, benzene and hexane. Typically, the optimum allocation of this material unloaded from reforming is the isomerization unit. The deriving setup of reforming and isomerization has the potential of generating value in several ways and in no way destroys any value. However, also in case of an allocation of the above material different from the isomerization, its unload from reforming keeps a significant value generation potential.

The main components of the optimum reforming+isomerization setup generated value are the following:

- Hydrogen net production gain;

- Gasoline yield gain;

- Gasoline octane number gain, changeable at will into additional gasoline yield gain;

- Compliance, with margin, with the most severe limits of gasoline benzene content in the world such as the 0.62 vol% (volume percent) content required by the United States Environmental Protection Agency, in the U.S. resulting in saleable benzene content credits;

- Significant energy savings besides the hydrogen net availability gain one;

- Emissions reduction of all of the pollutants and greenhouse gases types, in addition to the above, both in the gasoline production and consumption segments, which also carry out a gasoline lifecycle emission reduction of a few percent of CO2 equivalent;

- Higher octane gasoline production capacity increase;

- Improvement of the engine operation and maintenance.

The case study experimental results pointing out the above and the relevant theoretical explanation can, for instance, be seen in the *PTQ* and *Digital Refining 2013 Q1* article, "*Improved Hydrogen Yield in Catalytic Reforming"* or in the *Gasoline Processes* transcript from the 2011 NPRA Q&A and Technology Forum.

That said, a more detailed analysis of the generated value inherent to hydrogen net production gain looks to be useful. While it is clearly apparent that there is great value of hydrogen net production gain worldwide, a particular case, instead, has to be attentively examined: the case of North America. The reason for particular attention is North America's availability of the very cheap shale gas.

Referring to the particular North America case, we premise that the optimum setup of reforming and isomerization carries out the production of gasoline and hydrogen in lieu of fuel gas. With this premise, we can conclusively deduce that the above hydrogen gain is much more convenient than the hydrogen production carried out by means of special units consuming the cheap shale gas, i.e. the SMR (steam methane reformer) generation units.

Precisely, neglecting here the gasoline-fuel gas replacement value, said hydrogen production gain is over three times cheaper, as far as the variable (operating) costs alone are concerned. In fact, in the case of the optimum reforming-isomerization setup, the shale gas should be used, for combustion in the furnaces, in order to replace the fuel gas no longer produced by reforming. In such a way, the rate of substitution of fuel gas by shale gas is 1:1. On the contrary, any use of shale gas for producing hydrogen would require the consumption of more than three units of shale gas (taking into account all the energy flows, both consumed and produced by the SMR unit) per each unit of produced hydrogen (rate of substitution: >3:1).

Moreover, depending on the specific refineries, the relevant hydrogen gain can even avoid the capital costs of either installations or revamps or even duplications of the special, highly energy consuming, hydrogen generation units.

On top of the value generation potential of the feedstock transfer interplay between isomerization and reforming, interplay also exists between the whole of these two processes and FCC-gasoline post-treating. The FCC-gasoline post-treating consumes hydrogen and energy and causes reduction of the FCC-gasoline octane number and yield, due to saturation of high octane olefins.

It is apparent that the above described optimum setup of reforming and isomerization, as it provides hydrogen gain, reduction of energy consumption and gasoline octane plus yield gain, counteracts the FCC-gasoline post-treating negative effects. Plus, it provides additional very low sulfur combined reformate-isomerate gasoline blending component, due to its yield gain, thus allowing a higher sulfur content of the post-treat FCC-gasoline for a given full gasoline sulfur content. This allows further reduction of the FCC-gasoline Post-Treat negative effects.

The two last paragraphs outline the qualitative aspect of the matter. As far as the quantities in play are concerned, HOP (Hydrogen OPtimization) analyzes and optimizes the operation and any asset of the specific refinery as a function of the specific refinery plant structure, supply slate, and predicted FCC-gasoline PT's upcoming additional needs of hydrogen, energy, gasoline octane, and gasoline yield, and also provides alternative cases results.

Here we owe an explanation: HOP is an Alliance established between Chemical & Energy Development and Prometheus, rendered very suitable by the worldwide hydrogen thirst that deserves the maximum operational efficiency. Chemical & Energy Development brings to the new Alliance its deep knowledge and practice of the specific, above-indicated technology, and Prometheus brings to the new Alliance its deep knowledge and practice of planning and optimization procedures and of refinery engineering design.

The provided gains of hydrogen, energy, gasoline octane, gasoline yield and FCC-gasoline sulfur content, can be higher than the predicted FCC-gasoline PT's upcoming additional needs and remain partially available for other foreseeable needs deriving from the

- Existing or to be installed FCC pre-treats,
- Heavy and sour crudes,
- Medium-heavy products quality requirements, and
- Tight oil.