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ARTICLE

Quality of the feedstock: A silent factor impacting UFCC performance

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Introduction

When the UFCC operations team least expects it, the yields start to change. The conversion drops a few points, gasoline production decreases, the RON of naphtha slightly reduces, and coke formation begins to increase. The temperatures appear to be normal, the thermal balance shows no obvious deviations, and the operational variables remain within the expected range. Even so, something in the unit no longer behaves the same way. **At this moment, management starts asking questions: what has changed? What is happening at UFCC?**

In daily operations, the control of variables such as the temperature of the riser, feedstock preheating, the steam flow rates, and the replenishment of the catalyst usually receives more attention. However, experience shows that variations in feedstock composition can significantly affect the unit's performance, even when operational conditions remain stable.

FCC units can process a wide variety of streams from different refinery units. In practice, the composition of the UFCC feedstock depends not only on the type of current sent to the unit but also on the operational conditions of the upstream units, which can alter the quality of the feed.

Due to this variability, the quality of the feedstock becomes a determining factor for the behavior of the process, directly influencing conversion, product yields, coke formation, naphtha quality, and catalyst stability.

For this reason, the systematic execution and continuous monitoring of feedstock quality analyses constitute a fundamental tool for correctly interpreting the unit's behavior, acting proactively in daily operations, and identifying opportunities for process optimization.

1. Main feedstock characterization analyses

Understanding what is really entering the unit is the first step to interpreting the behavior of FCC. In the refining process, monitoring the quality of the feedstock is primarily based on a set of relatively simple and widely available laboratory analyses, which are part of the routine determinations in refineries.

It is important to emphasize that no isolated analysis can fully explain the behavior of feedstock in the FCC unit. Each parameter provides a piece of information, and it is the combination of these results that allows for a more complete understanding of the nature of the feed and its potential impact on the unit's operation.

Among the most commonly used analyses for monitoring the operational quality of FCC feedstock are:

- **Density or API gravity**
  - Indicates the nature of the feedstock
  - Affects the conversion and yields of products
- **Carbon residue (CCR or MCR)**
  - Indicates the tendency to form coke
  - Affects the thermal feedstock of the regenerator
- **Metal content (mainly Ni and V, as well as Na and Fe contaminants)**
  - Promotes dehydrogenation reactions
  - Contributes to the deactivation of the catalyst
  - Can cause blockage of the catalyst pores
- **Nitrogen content**
  - Neutralizes the acidic sites of the catalyst
  - Reduces catalytic activity
- **Sulfur content**
  - Affects the quality of the products
  - Influences the emissions of the process
- **Distillation characterization**
  - Indicates the presence of heavier fractions in the feedstock
  - Affects the conversion and the formation of coke
- **Viscosity**
  - Indicates the nature of the feedstock
  - Influences the atomization of the feedstock in the feed injectors

Each of these parameters provides clues about how the feedstock may behave within the riser and what its impact may be on conversion, product yields, and coke formation.

When these indicators are monitored systematically, the operation team can anticipate optimization opportunities and take action before the impacts become significant and the yields and quality of the products start to be affected.

2. Complementary indicators for interpreting feedstock quality

In addition to the basic analyses used for the routine monitoring of the feedstock, there are other determinations that, although not always performed with the same frequency, can provide very valuable additional information about the nature of the feed entering the FCC unit.

Among these complementary analyses are, for example:

- aniline point
- refractive index
- average molecular weight
- hydrogen content
- hydrogen-carbon (H/C) ratio
- more detailed characterizations, such as the **SARA** analysis

These analyses allow for a deeper understanding of the chemical structure of the hydrocarbons present in the feedstock and to more accurately estimate their degree of aromaticity, their paraffinic or naphthenic character, and consequently, their potential behavior during the catalytic cracking process.

In addition to these direct determinations, it is also possible to obtain additional information through indicators calculated from basic analyses. One of the most well-known indicators is the Watson characterization factor or UOP K factor (KUOP), widely used in the refining industry to estimate the paraffinic or aromatic character of a stream.

This indicator is calculated using results from basic feedstock analyses, such as density and average boiling temperature.

The relationship between these properties is expressed by the following equation:

$$K_{UOP} = \frac{T_b^{1/3}}{SG}$$

where:

Tb: average boiling temperature in degrees Rankine.

SG: specific gravity of the feedstock.

The value of this indicator allows for a first approximation of the nature of the current:

KUOP	Interpretation
> 12,5	Predominantly paraffinic feedstock
11 – 12	Mixed feedstock (paraffinic/naphthenic)
< 11	More aromatic feedstock

In general, streams with higher KUOP values tend to show greater conversion potential in the FCC and higher production of light products, while more aromatic streams usually exhibit lower reactivity and a greater tendency to form coke.

In addition to the KUOP factor, the technical literature also describes other indicators derived from the characterization of the feedstock that allow for a deeper interpretation of its behavior in the process. Among them, the following stand out: hydrogen-carbon (H/C) ratio; hydrogen content of the current; Aromatic Ring Index (ARI) and n-d-M structural method. In practice, these indicators allow translating laboratory results into useful information for the unit's operation.

3. Operational interpretation of feedstock quality in FCC

The characterization of the feedstock through the analyses and indicators presented in the previous sections allows for a better understanding of the nature of the feed that enters the FCC. However, the true value of this information emerges when the results are interpreted together and translated into operational actions capable of optimizing the performance and profitability of the unit.

The following presents a general guide that relates some typical variations in feedstock quality with their expected effects on the unit and possible operational optimization actions that can be considered.

In this guide, it is assumed that the steam from the stripper is adjusted for maximum efficiency, as well as the steam from the injectors and the lift, properly optimized. Thus, the guide focuses on the main independent operational variables that allow for immediate action by the unit's operation team.

Variation in feedstock quality	Interpretation	Expected effect on the unit	Recommended operational actions
↑ Density (0,005) ↓ °API (-0,8)	Heavier feedstock	→ Conversion loss (-1,3 %wt)	→ Increase the TRX → Increase the specific catalyst replacement
↑ CCR (0,5 %wt)	Greater tendency for coke formation	→ Increase in coke yield (0,08 %wt) → Increase in TFD (24 °C) → Conversion loss (-1,7 %wt)	→ Increase the TRX → Increase the specific catalyst replacement
↓ KUOP (-0,1)	More aromatic feedstock	→ Conversion loss (-1,3 %wt)	→ Increase the specific catalyst replacement → Increase the TRX
↑ N basic (100 ppm)	Neutralization of acidic sites	→ Conversion loss (-1 %wt)	→ Increase the replacement of fresh catalyst
↑ Na (1000 ppm)	Zeolite deactivation	→ Conversion loss (-3 %wt)	→ Review the desalination units of the atmospheric systems → Increase the replacement of fresh catalyst
↑ V (1000 ppm)	Zeolite deactivation	→ Conversion loss (-1 %wt)	→ Increase the replacement of fresh catalyst

↑ **Ni (1000 ppm)**	Increase in dehydrogenation reactions	→ Increase of H_2 (40–60 scf/bbl) → Increase in coke yield (0,20 %wt)	→ Increase the dosage of inhibitor (when used) → Increase the replacement of fresh catalyst
↑ **S (1000 ppm)**	Less sweet feedstock	→ Increase in SOx emissions (1000 ppm) → Increase in sulfur content in gasoline (100 ppm)	→ Increase the injection of SOx reducing additive → Optimize the separation in the fractionator → Reduce the final point of gasoline
↓ **H in the feedstock (-0,5 %wt)**	More aromatic feedstock	→ Conversion loss (-5 %wt)	→ If the feedstock is at the cracking limit, there are no operational actions that can be taken
↑ **Viscosity**	Heavier feedstock	→ Poorer dispersion and atomization of the feedstock	→ Increase the preheating temperature of the feedstock

As can be seen in the table presented, different variations in feedstock quality can generate specific impacts on the performance of the FCC unit. The proper interpretation of these changes allows for the identification of possible operational actions that can be implemented by the unit's team to mitigate these effects. In this way, the table can be used as a quick reference guide that facilitates the interpretation of feedstock analyses and supports decision-making in the daily operation of the unit.

4. Conclusion

The quality of the feedstock is one of the most determining factors in the performance of a Fluidized Catalytic Cracking unit. As discussed throughout this technical moment, variations in feed quality can directly influence conversion rates, product yields, and consequently, the profitability of the unit.

The systematic monitoring of feedstock analyses, along with the use of indicators derived from these results, allows for a better understanding of the nature of the feed entering the FCC and anticipating possible changes in the behavior of the process. When this information is interpreted in an integrated manner, it becomes a valuable tool to support operational decision-making and identify optimization opportunities within the unit.

The technical team at FCC S.A. is available to assist its clients in interpreting feedstock quality analyses, evaluating possible operational actions, and identifying optimization opportunities. In the same way, through the use of thermodynamic simulation tools, such as FCC_SIM, and the integrated analysis of operational data, it is possible to deepen the understanding of the unit's behavior and provide greater technical support for decision-making in daily operations, thus contributing to maintaining maximum performance and profitability of the FCC unit.

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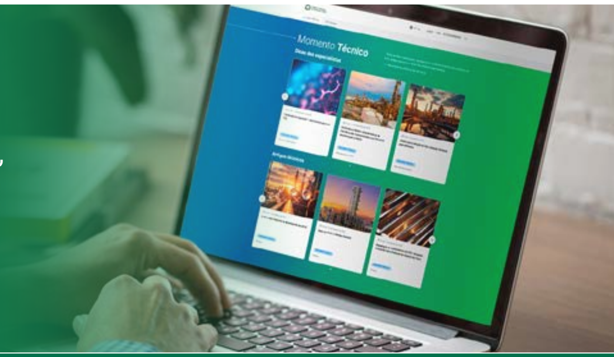

About FCC S.A.

FCC S.A is a leading-edge technology company, with headquarters in Rio de Janeiro, comprising the Petrobras S.A. and Ketjen companies. Being the sole manufacturer of catalytic cracking catalysts and additives for petroleum refining in the South-American market, its consumer customers are the refineries of the Petrobras Systems, as well as the petroleum refineries of South-American countries.

For more information, contact the FCC S.A. Technical Services team

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