FCC Catalyst Technical Report- Sample:41011056

Sample Overview

Item	Detail
Unit ID	313
Sample ID	41011056
Sampling Date	2024-10-28 00:00:00
Received Date	2024-10-30 00:00:00
Unit Name	CITGO - CORPUS CHRISTI (NEW), TX, US
Lab Code	C
Anomalous Parameters	Al_2O_3 (wt%), Co (ppm), Fe (wt%), MgO (ppm), Pb (ppm), RE_2O_3 (wt%), Sb/Ni Ratio (nan), Gas Factor (nan), Coke Factor (nan), ABD (g/cc), Pore Volume (cc/g), Zeolite Surface Area (m²/g), Total Surface Area (m²/g), Z/M Ratio (nan)

Key Observations

- Severe catalyst deactivation is indicated by Zeolite Surface Area, Total Surface Area, and Z/M Ratio significantly below their lower acceptable limits, leading to expected losses in conversion and gasoline yield.
- The Sb/Ni Ratio is zero, indicating a complete absence or severe insufficiency of nickel passivation, which will exacerbate coke and hydrogen production.
- Catalyst selectivity shows an undesirable trend with the Gas Factor below the lower limit and the Coke Factor flagged as above the operational target, pointing to inefficient cracking performance.
- Physical properties such as Apparent Bulk Density (ABD) and Pore Volume are outside limits, suggesting potential changes in catalyst morphology, particle size distribution, or fresh catalyst characteristics.

Parameter-by-Parameter Interpretation

Parameter	Status	Diagnostic Summary
Al_2O_3 (wt%)	Exceeds Limit	The Al_2O_3 value is significantly above the upper limit, suggesting a higher alumina content in the Ecat. This could stem from an increased fresh catalyst makeup rate or a change to a fresh catalyst with higher alumina, impacting overall catalyst activity, selectivity, and hydrothermal stability.
CaO (wt%)	Within Limit	The CaO concentration is within acceptable limits. Maintaining CaO at this level is crucial as it's an undesirable contaminant that neutralizes acidic sites, preserving catalyst activity and preventing excessive coke formation.

Parameter	Status	Diagnostic Summary
Co (ppm)	Exceeds Limit	Cobalt concentration is below the lower acceptable limit, indicating a significant deviation from expected equilibrium. This might suggest a cleaner feed source or dilution due to a higher fresh catalyst makeup rate, impacting contaminant management strategy.
Cu (ppm)	Within Limit	The Cu concentration is within acceptable limits. Copper is a feed contaminant that can promote dehydrogenation; keeping it within range helps control coke and hydrogen production, preserving unit profitability.
Fe (wt%)	Exceeds Limit	Iron concentration is below the lower acceptable limit, indicating a notable shift from equilibrium. This could be due to reduced corrosion, cleaner feedstock, or a high fresh catalyst makeup rate, influencing the unit's metal balance strategy.
K_2O (wt%)	Within Limit	The K_2O concentration is within acceptable limits. Potassium is a contaminant that can permanently deactivate zeolite sites, so maintaining it within range is essential for preserving catalyst activity and stable conversion.
MgO (ppm)	Exceeds Limit	MgO concentration is flagged as below the established operational target. This deviation might suggest a change in the fresh catalyst's composition profile or more effective removal, subtly impacting catalyst activity and hydrothermal stability.
Mn (ppm)	Within Limit	The Mn concentration is within acceptable limits. Manganese is a feed contaminant that can contribute to coke and hydrogen formation at higher levels, but the current value poses no immediate concern.
Mo (ppm)	Within Limit	The Mo concentration is within acceptable limits. Molybdenum is a feed contaminant that can act as a mild dehydrogenation catalyst, and current levels are stable, indicating controlled impact on product selectivity.
Ni (ppm)	Within Limit	The Ni concentration is within acceptable limits. Nickel is a critical feed contaminant promoting dehydrogenation, leading to high coke and hydrogen. Current levels are effectively controlled, crucial for optimal product slate.
Ni/V Ratio (nan)	Within Limit	The Ni/V Ratio is within acceptable limits. This ratio is important for managing the combined impact of nickel and vanadium contaminants, and a stable ratio indicates balanced contaminant management strategies.
P_2O_5 (wt%)	Within Limit	The P_2O_5 concentration is within acceptable limits. Phosphorus can be a contaminant or a promoter, and its stable content ensures no adverse impacts on catalyst activity or stability.
Pb (ppm)	Exceeds Limit	Lead concentration is below the lower acceptable limit, indicating a departure from the typical equilibrium range. This could be due to cleaner feedstock or increased fresh catalyst makeup, altering the overall contaminant balance.
RE_2O_3 (wt%)	Exceeds Limit	Rare Earth Oxides concentration is above the upper acceptable limit, suggesting a higher rare earth content in the Ecat. This could be from an increased fresh catalyst makeup rate or a catalyst formulation switch, potentially increasing activity but also dry gas yields.
Sb/Ni Ratio (nan)	Exceeds Limit	The Sb/Ni ratio is 0.0, indicating a complete absence or severe insufficiency of antimony passivation for nickel. This will lead to uncontrolled nickel activity, resulting in elevated coke/hydrogen production, reduced gasoline yield, and potential regenerator temperature issues.

Parameter	Status	Diagnostic Summary
V (ppm)	Within Limit	The V concentration is within acceptable limits. Vanadium is a detrimental contaminant causing severe zeolite deactivation. Maintaining it within range is critical for preserving catalyst activity and minimizing regenerator metallurgy impact.
ZnO (ppm)	Within Limit	The ZnO concentration is within acceptable limits. Zinc oxide ensures that any beneficial effects are realized or contaminating effects minimized, supporting stable catalyst performance.
0–40 (µ)	Within Limit	The 0-40µ particle size fraction is within acceptable limits, indicating good control over fines generation and retention. This is crucial for fluidization quality and minimizing stack emissions.
0–60 (µ)	Within Limit	The 0-60µ particle size fraction is within acceptable limits, reflecting satisfactory particle size distribution. This is vital for stable catalyst circulation and minimizing erosion.
0–80 (µ)	Within Limit	The 0-80µ particle size fraction is within acceptable limits, supporting overall unit stability through proper fluidization behavior and efficient stripping.
Gas Factor (nan)	Exceeds Limit	The Gas Factor is below the lower acceptable limit, indicating the catalyst is less active in producing light gases. While potentially favorable for liquid yields, it deviates from the expected operational range, possibly due to lower catalyst activity or a cleaner feedstock.
Coke Factor (nan)	Exceeds Limit	The Coke Factor is flagged as above the established operational target, implying increased coke make. This directly impacts regenerator heat balance and air blower capacity, potentially limiting throughput or conversion due to increased contaminant metals or catalyst aging.
H_2 Yield (SCFB)	Within Limit	The H_2 Yield is within acceptable limits, indicating controlled metals activity and efficient operation regarding hydrogen production.
ABD (g/cc)	Exceeds Limit	The Apparent Bulk Density (ABD) is above the upper acceptable limit, suggesting a denser catalyst. This can impact catalyst holdup, stripping efficiency, and regenerator operation, potentially due to loss of fines or changes in fresh catalyst characteristics.
APS (µm)	Within Limit	The Average Particle Size (APS) is within acceptable limits, indicating good particle size management. This is fundamental for stable and efficient FCC unit operation, influencing catalyst circulation and bed expansion.
Pore Volume (cc/g)	Exceeds Limit	The Pore Volume is above the upper acceptable limit, indicating a change in catalyst morphology or a more open structure. This can influence reactant residence time, potentially affecting conversion, selectivity, and coke burning efficiency.
Zeolite Surface Area (m^2/g)	Exceeds Limit	The Zeolite Surface Area is significantly below the lower acceptable limit, indicating substantial deactivation of active sites. This will result in a significant loss of conversion, reduced gasoline yield, and a shift towards less valuable products.
Total Surface Area (m^2/g)	Exceeds Limit	The Total Surface Area is significantly below the lower acceptable limit, reflecting extensive deactivation of both zeolite and matrix active sites and pore structure. This will lead to a substantial reduction in overall catalyst activity and lower conversion.

Parameter	Status	Diagnostic Summary
Matrix Surface Area (m^2/g)	Within Limit	The Matrix Surface Area is within acceptable limits, indicating a healthy macroporous structure. This ensures efficient diffusion of large feedstock molecules and supports overall catalyst activity.
Umb/Umf (nan)	Within Limit	The Umb/Umf ratio is within acceptable limits, indicating satisfactory fluidization properties. This ensures smooth fluidization, efficient stripping, and regeneration.
Z/M Ratio (nan)	Exceeds Limit	The Zeolite to Matrix (Z/M) Ratio is significantly below the lower acceptable limit, indicating a proportionally much lower zeolite content relative to the matrix. This implies a significant reduction in catalyst activity and gasoline selectivity, shifting product distribution towards heavier ends.

Consolidated Issue Summary

Issues	Evidence	Impact
Al_2O_3 (wt%)	Captured value 52.40013 wt% significantly above Y_Max: 44.50726 wt%.	Higher content of alumina component, potentially indicating increased catalyst matrix content or change in fresh catalyst makeup, impacting overall catalyst activity, selectivity, and hydrothermal stability.
Co (ppm)	Captured value 21.34817 ppm below Y_Min: 27.76159 ppm.	Significant deviation from expected equilibrium levels, potentially indicating a cleaner feed source or higher catalyst makeup rate, which could alter contaminant management strategy.
Fe (wt%)	Captured value 0.35731 wt% below Y_Min: 0.42 wt%.	Notable shift from equilibrium, possibly implying cleaner feed, effective corrosion control, or high fresh catalyst makeup rate, influencing contaminant balance and unit's operational strategy for metals.
MgO (ppm)	Captured value 28882.69 ppm flagged outside limits with negative deviation from target.	Deviation below target might suggest a change in catalyst's composition profile or more effective removal mechanism, subtly impacting catalyst activity and hydrothermal stability.
Pb (ppm)	Captured value 16.74595 ppm below Y_Min: 19.07916 ppm.	Departure from typical equilibrium range, potentially due to a cleaner feedstock or increased fresh catalyst makeup, altering the overall contaminant balance.
RE_2O_3 (wt%)	Captured value 3.14486 wt% above Y_Max: 2.329 wt%.	Higher concentration of rare earth elements, potentially from increased fresh catalyst makeup rate or a switch to a higher RE catalyst, leading to increased catalyst activity but potentially higher dry gas yields and cost implications.

Issues	Evidence	Impact
Sb/Ni Ratio (nan)	Captured value 0.0, flagged outside limits despite being at Y_Min: 0.0.	Absence of antimony or severely insufficient concentration relative to nickel, leading to uncontrolled nickel activity, elevated coke and hydrogen production, reduced gasoline yield, and potentially higher regenerator temperatures.
Gas Factor (nan)	Captured value 1.84077506 below Y_Min: 2.25227568.	Catalyst is less active in producing light gases, potentially favorable for liquid yields but deviates from expected operational range due to lower catalyst activity or cleaner feedstock.
Coke Factor (nan)	Captured value 1.41615277 flagged outside limits with positive deviation from operational target.	Increased coke make, directly impacting the regenerator's heat balance, air blower capacity, and overall unit conversion efficiency; potentially limiting throughput or conversion.
ABD (g/cc)	Captured value 0.8379999999999999 g/cc above Y_Max: 0.822 g/cc.	Denser catalyst, potentially due to a shift in particle size distribution or a change in physical properties, impacting catalyst holdup, stripping efficiency, and regenerator operation.
Pore Volume (cc/g)	Captured value 0.4 cc/g above Y_Max: 0.39 cc/g.	Elevated internal void space, potentially indicating a change in catalyst morphology or a shift towards a more open structure, influencing reactant residence time, conversion, selectivity, and coke burning efficiency.
Zeolite Surface Area (m^2/g)	Captured value 56.09581882 m^2/g significantly below Y_Min: 121.62252874 m^2/g.	Substantial deactivation of active sites, resulting in significant loss of conversion, reduced gasoline yield, and a shift towards lighter, less valuable products or heavier residue. Critical for unit performance.
Total Surface Area (m^2/g)	Captured value 137.97648084 m^2/g significantly below Y_Min: 162.4662069 m^2/g.	Extensive deactivation of the catalyst's active sites and pore structure, leading to a substantial reduction in overall catalyst activity, lower conversion, and diminished ability to process heavy feed components efficiently.
Z/M Ratio (nan)	Captured value 0.6850923946645441 significantly below Y_Min: 1.4158027756465823.	Proportionally much lower zeolite content relative to matrix, implying a significant reduction in catalyst activity and gasoline selectivity, shifting product distribution towards heavier ends or increasing bottoms yield.

Corrective Actions & Optimization Strategies

Issue	Corrective Action
Al_2O_3 (wt%)	• Review fresh catalyst specifications and current makeup rate to understand the source of elevated alumina.• If a recent fresh catalyst change occurred, evaluate its suitability for the unit's performance objectives.
Co (ppm)	• Investigate recent changes in crude slate or upstream feed processing that could lead to cleaner feedstock.• Monitor fresh catalyst makeup rate to confirm if dilution is contributing to lower contaminant levels.
Fe (wt%)	• Conduct an inspection for potential corrosion sources within the FCC unit and upstream processing equipment.• Review feed quality and treatment processes for reduced iron ingress.
MgO (ppm)	• Re-evaluate fresh catalyst specifications for MgO content.• Monitor fresh catalyst makeup rate and ensure it is consistent with target Ecat composition.
Pb (ppm)	• Investigate changes in crude blend or upstream processing for reduced lead content.• Monitor fresh catalyst makeup rate to assess its diluting effect on lead contaminants.
RE_2O_3 (wt%)	• Review fresh catalyst specifications and current makeup rate, as elevated RE_2O_3 may indicate a recent change in catalyst type or an increased addition rate.• Evaluate the impact on product selectivity, particularly dry gas yields.
Sb/Ni Ratio (nan)	• Immediately inspect and troubleshoot the antimony additive injection system to ensure proper operation and flow.• If no additive system is present, evaluate the need for a fresh catalyst containing an antimony passivation package or the implementation of an external additive program.
Gas Factor (nan)	• Address underlying issues causing low catalyst activity (e.g., zeolite deactivation, metals passivation).• Review feed quality for heavy components that may be under-cracking.
Coke Factor (nan)	• Implement immediate measures to restore nickel passivation (Sb/Ni ratio).• Investigate sources of coke-promoting metals (Ni, V) and optimize metals passivation strategies.• Optimize regenerator conditions to ensure efficient coke burning.
ABD (g/cc)	• Review fresh catalyst specifications for particle density.• Analyze Ecat particle size distribution to identify any shifts towards coarser particles.• Monitor catalyst attrition rates and consider optimizing cyclone efficiency.
Pore Volume (cc/g)	• Review fresh catalyst specifications for pore volume.• Evaluate regenerator and reactor conditions to ensure optimal hydrothermal stability, mitigating pore collapse.
Zeolite Surface Area (m^2/g)	• Intensify monitoring of vanadium contamination and implement strategies to reduce its impact (e.g., feed pretreatment, metals passivation additive).• Optimize regenerator temperature and steam injection to minimize hydrothermal deactivation.• Consider adjusting fresh catalyst type to one with higher hydrothermal stability or metals tolerance, prioritizing root cause mitigation over increasing fresh cat rate.
Total Surface Area (m^2/g)	• Address severe hydrothermal deactivation by optimizing regenerator conditions.• Investigate and mitigate sources of catalyst poisoning metals, particularly vanadium, that impact overall surface area.
Z/M Ratio (nan)	• Address severe zeolite deactivation by focusing on reducing vanadium poisoning and optimizing hydrothermal conditions.• Evaluate if the current fresh catalyst formulation has an appropriate Z/M ratio for desired activity and selectivity.

Final Remarks

- The Ecat exhibits severe deactivation, primarily indicated by critically low Zeolite Surface Area, Total Surface Area, and Z/M Ratio. This substantial loss of activity suggests significant hydrothermal deactivation or severe metals poisoning, particularly from vanadium, affecting the catalyst's cracking capability and gasoline selectivity.
- A critical issue is the complete absence of nickel passivation, evidenced by a zero Sb/Ni ratio. This is a primary driver for the elevated Coke Factor and potentially contributes to the low Gas Factor, leading to inefficient cracking and increased undesirable byproducts.
- While some contaminant metals (Co, Fe, Pb) are below their lower limits, and Al_2O_3 and RE_2O_3 are high, this could indicate an increased fresh catalyst makeup rate or a recent change in fresh catalyst type. However, this increased addition is not effectively mitigating the severe activity loss and poor selectivity.
- If uncorrected, these issues will lead to a sustained reduction in unit conversion, decreased gasoline yield, higher coke and hydrogen production, and potentially unstable regenerator operation due to unpassivated nickel. Continuous monitoring and immediate corrective actions addressing deactivation mechanisms and passivation failure are crucial to restore unit profitability and minimize reliance on simply increasing fresh catalyst addition.