

Webinar – FCC coke combustion kinetics and afterburn control (Q&A)

Q 01. What are the disadvantages to pre-blending CO Promoter?

A 01. If the CO promoter is pre-blended with the catalyst, the control available to the operator to optimize actual CO promoter requirement is very limited. When pre-blending, you assume a fixed proportion based on fresh catalyst makeup rate. If you needed more promoter, you would be adding more catalyst which could make the problem worse by increasing activity. If you don't need as much, then it takes time to adjust the blend in your fresh catalyst and may be months before you are able to see the change hit the unit. In addition, CO-promoters contain expensive metals (Pt or Pd) and can increase NOx so their usage rate should be minimized to only that required for controlling afterburning. Lastly, can you be sure of the homogeneity of the mixture with the catalyst? it is surprisingly difficult to mix two powders when one is a minor component (the CO-promoter) and the other vastly dominant (the FCC catalyst).

Q 02. Can promoter improve FCC yields?

A 02. CO Promoter does not directly impact yields. However, lowering afterburn allows operation at a higher bed temperature. This demands more coke, which in turn allows flexibility to run heavier feeds or operate at higher severity.

Q 03. Q: Does anything poison CO promoter?

A 03. Yes, antimony that is used for Nickel passivation is a poison that can reduce CO promotion by up to 50%. Also, less commonly today lead (that can come in with the feed) is poisonous to CO promoter.

Q 04. We had a temperature excursion around our cyclones, do we need to shutdown to inspect?

A 04. No, but we would recommend inspection at the next turnaround. Elevated Temperatures and Repeated temperature excursions can shorten the span of the cyclones and cause damage to downstream equipment. Look for signs of catalyst losses, such as increased opacity, decreases in ecat 0-40 micron range, changes in downstream units wet gas scrubber fines or fourth stage cyclone fines hopper build-rate, changes in catalyst addition/withdrawal rates or bed levels.

Q 05. How does a cat cooler affect afterburn?

A 05. Having a cat cooler doesn't usually affect afterburn. However, afterburn is more likely to increase when the dense bed temperature is lower due to poorer burn kinetics. A minor benefit can come if maldistribution is a problem where the catalyst re-entering the regenerator from the cat cooler helps with catalyst/air mixing.

Q 06. Which is better for controlling afterburn: platinum or palladium?

A 06. Both! Platinum promoter has been used for many years, but in the last ten years palladium has become more common especially in the US. JM has developed additive technology for non-platinum promoter. The performance for reducing afterburn and CO is equivalent to platinum performance. Pt is usually a little cheaper today because of the higher price of Pd vs. Pt, however Pd offers the advantage of lower NOx where that is also required.

Q 07. Q: We found that we could decrease CO Promoter usage when we were using a SOx control additive, is this normal? – if we were pre-blending we might not have noticed.

A 07. Yes, this is often seen with the use of Full Burn SOx Additives. SOx Additives contain an oxidation package to convert SO₂ to SO₃ which also converts CO to CO₂, so less CO Promoter may be required. Special SOx oxidation systems are required to avoid problems that could be caused by this under Partial Burn conditions where excessive CO oxidation can drive up CRC.

Q 08. What is the economic case for adding CO Promoter using a loader rather than pre-blending and using a simple shot-pot for topping up when needed? Is it really worth-while installing a loader for such a small amount of additions?

A 08. Spreading CO promoter additions throughout the day will give better control of CO emissions and afterburn while reducing NOx emissions. Economically, addition rate is typically decreased by 15-20% or more when using a dedicated loader providing cost savings. Control and flexibility will be better because you can add when needed and increase or decrease as conditions change. The past year of pandemic is a perfect example of conditions changing. Having a dedicated loader during this time allows you to capitalize on rate decreases and also increase rate as needed to prevent FCC feed rate reductions due to high afterburn.

Q 09. Why would my FCC use a mixture of palladium and platinum pre-blended promoter?

A 09. Some palladium promoters have poor combustion promotion function, so some vendors pre-blend some platinum promoter to manage the impact of a poorly performing palladium promoter. This will help resolve the afterburn control issue but pushes the unit closer to a NOx limit. We would propose a trial with 100% JM non-platinum promoter to explore the benefit of separate addition and better additive efficiency in controlling afterburn.

Q 10. Can you discuss again what sets the regenerator bed level?

A 10. Regen bed level in slide valve units can be adjusted by adding or decreasing catalyst within certain constraints. The constraints are having the bed level low enough to provide enough Transport Disengaging Height for the catalyst in order to not overload the cyclones, and high enough to keep the seal on the diplegs and have enough level to maintain regen slide valve dP. This all must be balanced. In pressure balance units, changing the catalyst inventory adjusts the level in the stripper, so you can only change the bed level if that is where the levels adjust verse inventory.

Q 11. Can you please explain how the Pt rule of thumb works? Is that similar to Pd?

A 11. Platinum rule of thumb is to target 1 to 2 ppm platinum to begin with when adding CO promoter. So, if your catalyst addition rate is 5,000 kgs, you want to target 2 ppm Platinum to start, and your adding promoter that is 375 ppm platinum, then, the calculation is $(5,000 \text{ kgs} * 2 \text{ ppm}) / 375 \text{ ppm} = 26.6 \text{ kgs per day of COP-375 addition rate}$. For JM, this product is COP-375, we also sell several different grades of platinum. Palladium is calculated based on platinum equivalent. JM's COP-NP has 375 ppm platinum equivalent.

Q 12. What is the best way to add recycles streams for regenerator bed temperature control?

A 12. Recycle streams to the reactor side create heat demand (vaporization, sensible heat and cracking). For injection into the riser, bottoms will make the most coke, but it's very unlikely that it will be fully vaporized if it isn't injected through the feed nozzles or low in the riser. HCO is better than slurry to avoid nozzle erosion due to catalyst fines that may be present (HCO should have little or none there). Injection into the mix zone through a low-tech nozzle is likely better to avoid erosion, but more likely to produce coke in the riser, disengager, and overhead line due to non-vaporized feed. Overall to avoid problems with vaporization, coking, and erosion, using mid riser HCO or LCO recycle injection for the intent to use it as a heat sink and coke producer while making the least dry gas is most effective. Slurry containing fines can be fed back to the riser in doses with mid riser LCO or HCO, but it's not recommended to feed slurry through FCC feed nozzles.

Q 13. The use of portable analysers assumes that you have dedicated sample points for this purpose across the height of the regenerator? How else would you be able to safely sample the hot flue gas/catalyst mixture without a dedicated/properly designed sample point?

A 13. If no other option, the safest most practical option is to use or adapt the existing sample point already used for the online flue gas analyser. Most of the time it is located downstream of the ESP/ heat recovery so it is cold enough. Not all refiners can do this. So, you can alternatively monitor bed temperatures.

The refinery may also consider building a temporary sample cooler as an alternative that could be used at available bleeders on the regen. This must meet refinery safety and environmental emissions standards.

Q 14. Does the oxidation functionality of CO promoter also impact the oxidation of SO₂ to SO₃ in the regenerator?

A 14. Theoretically this is possible. However, if it does have an effect it is very minor and is unlikely to be noticed with reductions in SO_x additive. The half-life of promoter is drastically shorter (hours) compared to SO_x additives (10-20 days), which makes its impact on SO₂ to SO₃ conversion very short and hard to detect. Also, even if the promoter can facilitate the oxidation of SO₂ to SO₃, it happens on the particle surface. The lack of adsorption material on the promoter allows the SO₃ to escape back to gas phase where the SO₂/SO₃ equilibrium is determined by thermodynamic equilibrium and reverts back to SO₂. So, the net effect on SO_x reduction is negligible.

Q 15. In our case we can even operate at regen dense bed temperature of 610DegC. CRC is still good but CO at the regen outlet goes up. how much extra COP we need to dose if we dose 16 Kg/Day in case of 650 DegC dense bed to get desired level?

A 15. Decreasing bed temperature from 650 deg C to 612 deg C you will likely have to increase promoter significantly to help increase the temperature in the dense bed and prevent CO breakthrough. A JM technical service representative can help guide you towards the amount of CO promoter you will need to increase by with more details of your process.

Comment 16: We used to have a CO promoter that had both platinum and palladium as part of its formulation.

A 16. Yes, this is a less common practice that some refineries employ to reduce NOx emissions while controlling CO and afterburn.

Comment 17: Heat supply to the process includes that in the feed in addition to coke combustion

A 17. Yes, that's correct, overall heat balance includes heat with fresh feed and recycle, heat with atomizing steam, and the heat of adsorption of coke on the catalyst which is an exothermic process.

We at JM would like to thank you for participating in this webinar