Question 63: What are your current methods used for regenerator cyclone temperature control? Do you use water sprays or steam injection?

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In the early days of FCC, the normal bed and dilute-phase operating temperatures –being less than 1100°F –did not support CO combustion. These units operated with high levels of carbon on catalyst and about 10 vol% CO in the flue gas with almost no excess oxygen in the flue gas. However, all it took was an accumulation of oxygen and an occurrence of a point of ignition above 1150°F in the regenerator dilute phase to spark runaway temperatures in the regenerator dilute phase and flue gas system as high as 1800°F.

Because of the potential for temperature runaways, steam and water connections were installed throughout the regenerator and flue gas systems in the early FCCU installations to control temperatures in the event of temperature runaways. Water sprays were often included in the dense bed, lower dilute phase, upper dilute phase, primary cyclone outlets, cyclone plenum, regenerator overhead line, flue gas cooler outlet, and ESP outlet. The primary cyclone outlets also included steam connections, in addition to water.

As regenerator temperatures increased to above 1200°Fwith advances in catalyst stability and cyclone metallurgy, some burning of carbon monoxide in the regenerator dilute phase, referred to as 'afterburning', became normal. CO combustion and cyclone temperatures in these operations could be managed by control of the combustion air rate. Especially after widespread adoption of complete CO combustion and mechanical design for 1400°F operation, water sprays were removed from FCC units as they were found to do more damage than good to the equipment.3

Today, the means of controlling regenerator cyclone temperatures and afterburning are primarily related to control of flue gas oxygen concentration, regenerator bed temperature, and CO promoter additions.

Cyclone steam connections are still useful in mitigating high temperatures due to afterburning in individual cyclones, but this utility is typically not provided in modern FCC unit designs. However, where the cyclone steam connections exist, they are useful as a secondary means of controlling temperatures in individual cyclones.

Answers to Question 10 from the 1996 NPRA Technology Q&A provide a rich discussion of controlling partial-burn regenerators with respect to the interrelated variables of bed temperature, CO_2/CO ratio, CO promoter use, and carbon on regenerated catalyst. More Q&A on this topic are available in transcripts for years 1975 through 1982. In 1976, NPRA Q&A transcripts reached a zenith of 13 pages of discussion related to just the control and benefits of different modes of CO combustion.

In oxygen-lean or partial-CO combustion, localized areas of oxygen breakthrough from the bed lead to afterburning. Typically, in these operations, the afterburning in the dilute phase and cyclones can be controlled with flue gas oxygen concentrations of about 0.2 vol % or less. The degree of afterburning is limited by the available oxygen, and FCC units operating in partial combustion are often fitted with instrumentation to directly control the degree of afterburn by regulating the regenerator air flowrate.

In complete CO combustion, localized areas of carbon monoxide breakthrough from the bed leads to afterburning. Typically, CO combustion in the dilute phase and cyclones can be controlled by sustaining flue gas oxygen concentrations of about 1.5 vol% or more. In addition, maintaining a regenerator bed temperature of 1300°F or more will improve combustion kinetics and will, therefore,reduce afterburning.Lastly, to further stimulate combustion kinetics, CO combustion promoter can be used as needed. Even if CO promoter is not normally utilized, it is prudent to always have CO promoter available for immediate useto provide almost instantaneous mitigation of afterburning in FCC unit upsets where regenerator temperatures or flue gas oxygen fall to less than normal levels.4Platinum-based CO promoters are very effective for controlling CO emissions in complete CO combustion operations,and they also can play a role in managing partial-burn FCC operations. It has been well documented that platinum COpromoters increase NOx emissions,which is an important consideration that can lead to careful control of promoter additions and use of non-platinum-based promoter.It is noted that CO promoters introduce significant completion with carbon in the dense bed for utilizing the available combustion air and may significantly increase carbon on regenerated catalyst.

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