Controlling Emissions of SOx and NOx from power plants

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Main Control Technologies for SOx

- Remove the sulfur from the fuel before it is burned
- Remove the SO_2 from the exhaust gases

Sulfur Removal

- Sulfur is removed from crude oil by the catalytic reaction:

$$R\text{-}S + H_2 \rightarrow H_2S + R$$

- Until the mid 1970’s the H_2S was mixed back into the fuel gas.
- The problem with this is that the H_2S is burned in fuel producing SO_2, but at a different stage

Claus Process

$$R\text{-}S + H_2 \rightarrow H_2S + R$$

$$H_2S + 3/2\ O_2 \rightarrow H_2O + SO_2$$

$$2\ H_2S + SO_2 \rightarrow 2\ H_2O + 3\ S$$

- The elemental sulfur is then sold and the emissions of SO_2 and H_2S are reduced drastically

Limestone Scrubbing

- Most widely used because it is very cost effective
- Current efficiency of 98 - 99% removal of SO_2 compared to 88 - 90% in the 1980's

Limestone Scrubbing Chem

$$CaCO_3 + 2\ SO_2 + H_2O \rightarrow Ca^{+2} + 2\ HSO_3^- + CO_2$$

$$CaCO_3 + 2\ HSO_3^- + Ca^{+2} \rightarrow 2\ CaSO_3 + CO_2 + H_2O$$

$$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$$

- This is a two step process including the scrubber and the effluent hold tank.
- $CaSO_4$ (gypsum) is also formed by the oxidation of $CaSO_3$

- The first reaction occurs in the scrubber and if there is an excess of $CaSO_3$ or $CaSO_4$ it will precipitate and cause scaling in the scrubbing tower.

- Therefore, there must be a second process to ensure that the precipitation occurs in a different chamber.

- The second chamber is called the effluent hold tank (EHT) where more $CaCO_3$ is added in order to precipitate the $CaSO_3$ and $CaSO_4$

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Main Control Technologies for NOx

- Combustion Modification
- Flue Gas treatment

Combustion Modifications

- “1. Reduce peak temperatures of the flame zone

- 2. Reduce the gas residence time in the flame zone

- 3. Reduce the oxygen concentration in the flame zone”

Alley, F.C., and C. David Cooper. *Air Pollution Control: A Design Approach*. 3rd ed. New York, NY: Waveland Pr Inc, 2002

Flue Gas Treatment

- Selective Catalytic Reduction (SCR)

$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$$

$$2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$$

- SCR's are usually 80% efficient in reducing NOx
- Operates at temperatures from 300 to 400 C

Flue Gas Treatment Contd.

Selective Noncatalytic Reduction (SNR)

- Operates at 900 to 1000 C
- NH_3 at this high temperature will reduce the Nox into N_2 without a catalyst
- Only around 40 - 60% reduction in Nox
- More cost effective than SCR's if only 40 to 60% reduction is needed

Questions?