## The Lecture Contains:



Previous Next

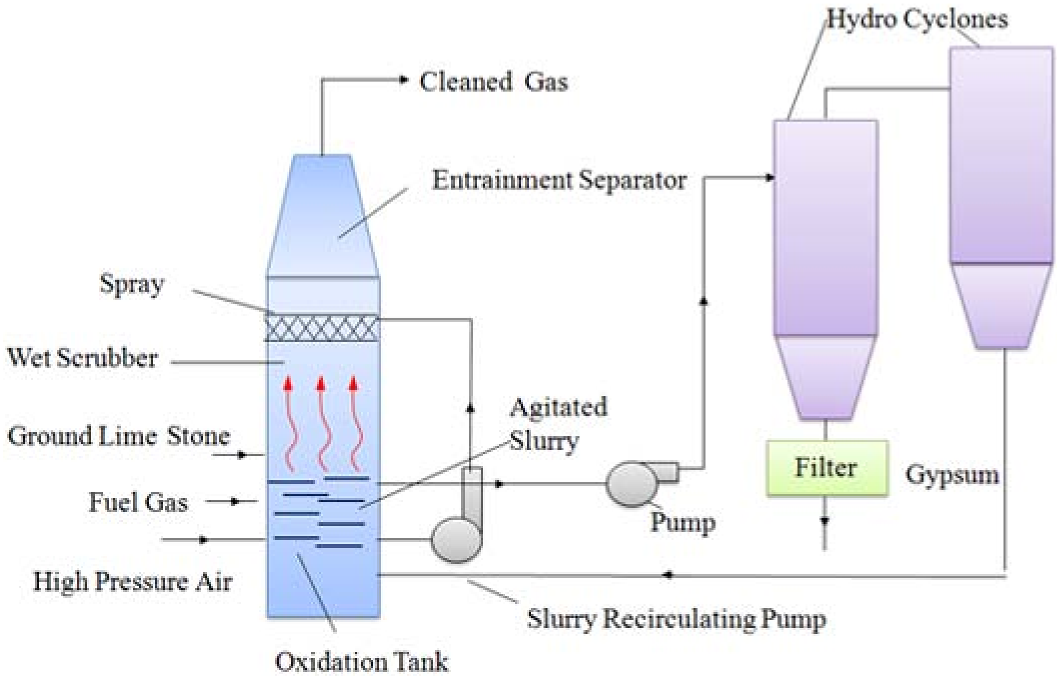
## $SO_x$ Emission and Its Control

### Gasification method

- Sulphur dioxide emission due to burning of coal or fuel oil can be minimized by gasifying them.
- During gasification, coal undergoes partial oxidation resulting in CO and $H_2$. $C + H_2O \rightarrow CO + H_2$
- Sometimes, $CH_4$, $CO_2$ and other gases can also be produced during gasification of coal.
- In this case, sulphur content gets converted into hydrogen sulphide , which can be removed by absorption or adsorption method..
- In absorption method, gases are scrubbed with alkaline reagent such as sodium carbonate or ethylamine.
- Subsequently elemental sulphur is produced.
- In adsorption method, ferric oxide is used to adsorb hydrogen sulphide using fluidized bed around 400°C.

Previous Next

## Forced Oxidation Limestone Wet Scrubber




(Figure 39.1)

Previous Next

## $NO_X$ Emission and Its Control

- Nitrogen in atmosphere forms 8 different oxides during combustion.
- The important oxides are NO, $NO_2$,$N_2O$.
- Is NO harmful to health than $NO_2$ ?
- *NO!* $NO_2$ is more harmful as compared to NO. By what reaction NO and $NO_2$ are formed ?
  $N_2 + O_2 \Leftrightarrow 2NO$
  $2NO + O_2 \Leftrightarrow 2NO_2$
- For any chemical reaction, Gibbs free energy $G_T^O$ attains a minimum value for a particular temperature and pressure

$$lnK_P = -\frac{\Delta G_T^o}{R_u T}$$

$K_P =$ Equilibrium constant

$\Delta G_T^o =$ Standard Gibbs free energy change

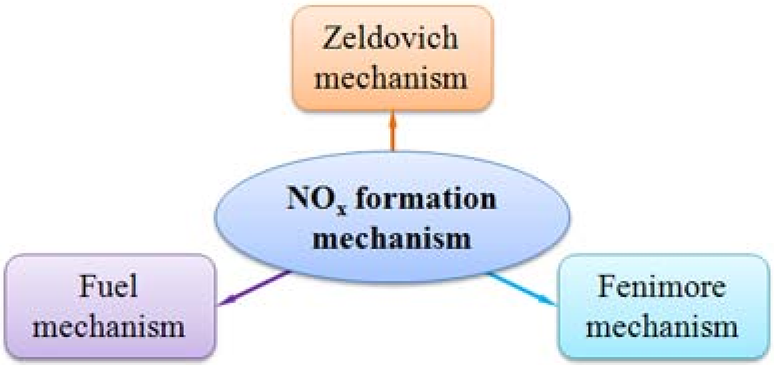
**Table:** Equilibrium concentration of NO and $NO_2$

| $Temperature(K)$ | $K_p$ | | $NO(ppm)$ at 79% $N_2$, 21% $O_2$ | $NO_2(ppm)$ |
|---|---|---|---|---|
| | $NO$ | $NO_2$ | | |
| 300 | $7 \times 10^{-31}$ | $1.4 \times 10^{6}$ | $3.4 \times 10^{-10}$ | $2 \times 10^{-4}$ |
| 500 | $2.7 \times 10^{-18}$ | 130 | $7 \times 10^{-4}$ | 0.04 |
| 1000 | $7.5 \times 10^{-9}$ | 0.11 | 35 | 1.9 |
| 1500 | $1.07 \times 10^{-5}$ | 0.011 | 1320 | 6.8 |
| 2000 | 0.0004 | 0.0035 | 8100 | 13.2 |
| 2500 | 0.0035 | 0.0018 | 24000 | 20.0 |

Previous Next

## Zeldovich Mechanism

- From the above table it is clear that $NO_x$ emission can be reduced by decreasing the temperature.




**(Figure 39.2)**

- Thermal $NO_x$ are formed by simple heating of oxygen and nitrogen.
- The radical ‘N' can react with $O_2$ to form NO.
- Thermal NO contribution is low till 1300 K and beyond which it increases rapidly.
- The thermal mechanism consists of the following two chain reactions.

$$O + N_2 \Leftrightarrow NO + N \qquad \text{--------(1)}$$

$$N + O_2 \Leftrightarrow NO + N \qquad \text{--------(2)}$$

$$N + OH \Leftrightarrow NO + H \qquad \text{--------(3)}$$

Previous Next

## Fenimore (Prompt) Mechanism

- Prompt mechanism refers to the $NO_x$ which are formed very quickly by interaction of active hydrocarbon species derived from fuel with nitrogen and oxygen.
- They are generally not observed in flames of non-hydrocarbon flames.
- They cannot be formed by just heating nitrogen with oxygen.
- During initial phase of combustion, the radials with carbon atom react with $N_2$ to produce N.

$$CH + N_2 \Leftrightarrow HCN + N \qquad \text{--------(4)}$$

- This reaction is the main path which dictates the rate at which radical 'N' is formed.
- The radical 'N' can also be formed by the following reaction.

$$C + N_2 \Leftrightarrow CN + N \qquad \text{--------(5)}$$

- When the equivalence ratio is less than 1.2, HCN can be converted to NO as follows,

$$HCN + O \Leftrightarrow NCO + N \qquad \text{--------(6)}$$

$$NCO + H \Leftrightarrow NH + CO \qquad \text{--------(7)}$$

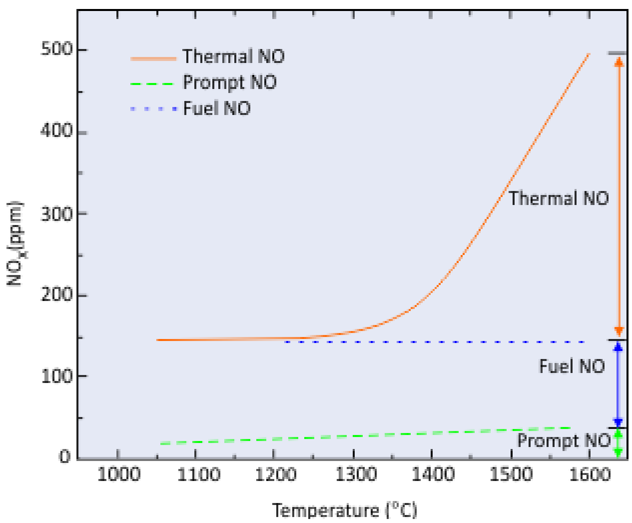
$$NH + H \Leftrightarrow N + H_2 \qquad \text{--------(8)}$$

$$N + OH \Leftrightarrow NO + H \qquad \text{--------(9)}$$

Previous Next

## Fuel ($N_2O$ – Intermediate) Mechanism

- Thermal NO is quite small below 1300°C
- Thermal NO rises sharply with temperature
- Both fuel NO & prompt NO do not vary with temperature
- But prompt NO increases marginally with temperature.




$N_2O$ intermediate mechanism plays a very important role for NO control in lean premixed combustion.

Three steps of $N_2O$ intermediate mechanism are given below;

$$O + N_2 + M \rightleftharpoons N_2O + M$$

$$H + N_2O \rightleftharpoons NO + NH$$

$$O + N_2O \rightleftharpoons NO + NO$$

**(Figure 39.3)**

Several techniques are devised to control $NO_x$ in combustion as described in next section.

Previous Next