Advanced Air Pollution control

Prof. Maie El-Gammal

Environmental Science Dep.

Course : Air and noise pollution control

Control of NOx

DURING STATIONARY COMBUSTION

Nitrogen oxides (NOx) & sulfur oxides (SOx) emissions are primary contributors to acid rain ، causes acidification of lakes & streams, accelerated corrosion of buildings, and visibility impairment .

NOx emitted from stationary combustion; nitrogen oxide (NO،(nitrous oxide (N2O), & nitrogen dioxide (NO_2 (are stable, and NO predominates

NOx and volatile organic compounds (VOCs) react in atmosphere to form ozone, a photochemical oxidant and a major component of smog.

Atmospheric ozone can cause respiratory problems by damaging lung tissue and reducing lung function.

- Oxidation of nitrogen in the air at high temperature is a primary source of NOx, or the “thermal” NOx .

$$N_2 + O \leftrightarrow NO + N$$

- Collisions of hydrocarbon radicals and molecular nitrogen in fuel-rich region of flames consist third major NOx formation pathway

$$CH + N_2 \longrightarrow HCN + N$$
$$C + N_2 \longrightarrow CN + N$$

NOx Control Technologies

- Minimizing NOx formation via combustion modification, such as optimizing burner design for best aerodynamic distribution of air and fuel (low_NOx burner),
- Controlling flame stoichiometry by regulating overall fuel/air ratio supplied (low excess air)

1.In Furnace NOx Control

1.1. Low-NOx Burner

- Low NOx burners control both stoichiometric and temperature histories of fuel and air
- Control achieved through design features that regulate aerodynamic distribution and mixing of fuel and air.
- It include 2 types: staged-air burners and staged- fuel burners

1.2. Other In-Furnace NOx Control Techniques

- Reduce NOx formation during combustion .
- In low excess air (LEA) approach, thus reducing flame temperature and formation of thermal NOx. Fuel NOx is reduced in starved-air flame zone.
- The over fire air (OFA) system uses conventional burners to introduce the fuel and substoichiometric quantities of combustion air (primary air).

- Burners out of service (BOOS)
- Flue gas recirculation (FGR) is based on recycling a portion of cooled flue gas back to the primary combustion zone.
- Reburn, is in-furnace NOx reduction or staged-fuel injection, is only NOx control approach implemented in the furnace zone

2.3 Reburning

2.3.1.Homogeneous Chemistry

- Reburning is a three-stage combustion technology designed for reduction of NO by introducing a small amount of reburning fuel
- volatile fuels were considered primary candidates as reburning fuels .

$$NO + C \longrightarrow CN$$
$$CN + H_2 \longrightarrow HCN + H$$
$$HCN + O \longrightarrow NCO + H$$
$$NCO + H \longrightarrow NH + CO$$
$$NH + H \longrightarrow N + H_2$$
$$N + NO \longrightarrow N_2 + O$$

nitrogen radicals may recycle back to NO through reactions with oxidants, such as OH and O_2

or to HCN through the reducing agent CH

$$N + CH_3 \longrightarrow H_2CN + H$$
$$H_2CN \longrightarrow HCN + H$$

2.3.2. Heterogeneous Chemistry

When these carbonaceous materials were tested in laboratory reactors free from secondary reactions between char and product gas, rates of NO and chars were usually low and seem to be less effective than natural gas in reburning .

2.3.3. Reburning Technologies

- Reburning is attractive to utilities and industries because of its ability to retrofit old boilers at low costs, such as selective catalytic reduction.
- Energy and Environmental Research Corporation's natural gas reburning and sorbent injection (GR-SI) technology. A calcium compound (sorbent) is injected above reburning zone for sulfur removal; hydrated lime [Ca(OH)

- Babcock and Wilcox's coal reburning system. Both bituminous coal and subbituminous coal were used as reburning fuels .
- Energy and Environmental Research Corporation's natural gas reburning (GR(
- Foster Wheeler Energy Corporation's low NOx burner (LNB) technology have been demonstrated.
- D.B. Riley's MPS mill and Fuller's MicroMill™ technology for producing
- micronized coal Low volatile Pittsburgh seam bituminous coal was fired at both test sites .

2.3.4. Altered Reburning Processes

A modified gas reburning process, was designed specifically for destruction of nitrogen oxides in high concentration from industrial waste gas streams. Methane gas was injected into a combustor with a waste gas stream containing a high concentration of NOx.

Combustor could be a furnace designed just for purpose of NOx destruction or an industrial boiler could be utilized for this auxiliary application without affecting normal boiler operation.

Postcombustion NOx Control

Hybrid Control Systems

Simultaneous SO2 and NOx Control

Dry Processes

Wet Scrubbing Processes

RESULTS OF RECENT DEMONSTRATION PLANTS ON NOx CONTROL

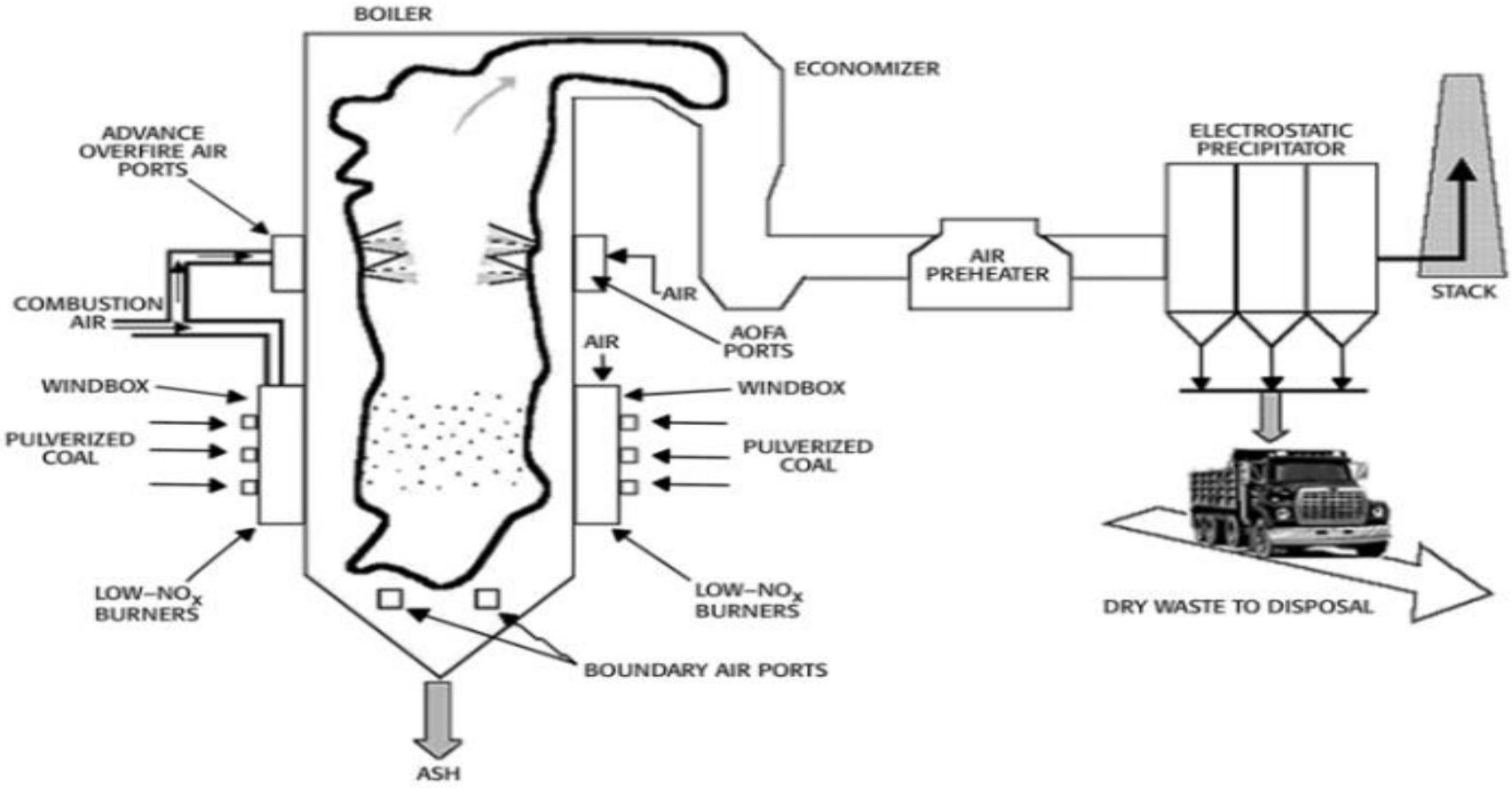

Fig. 1. Foster Wheeler's low-NO_x burner with AOFA.

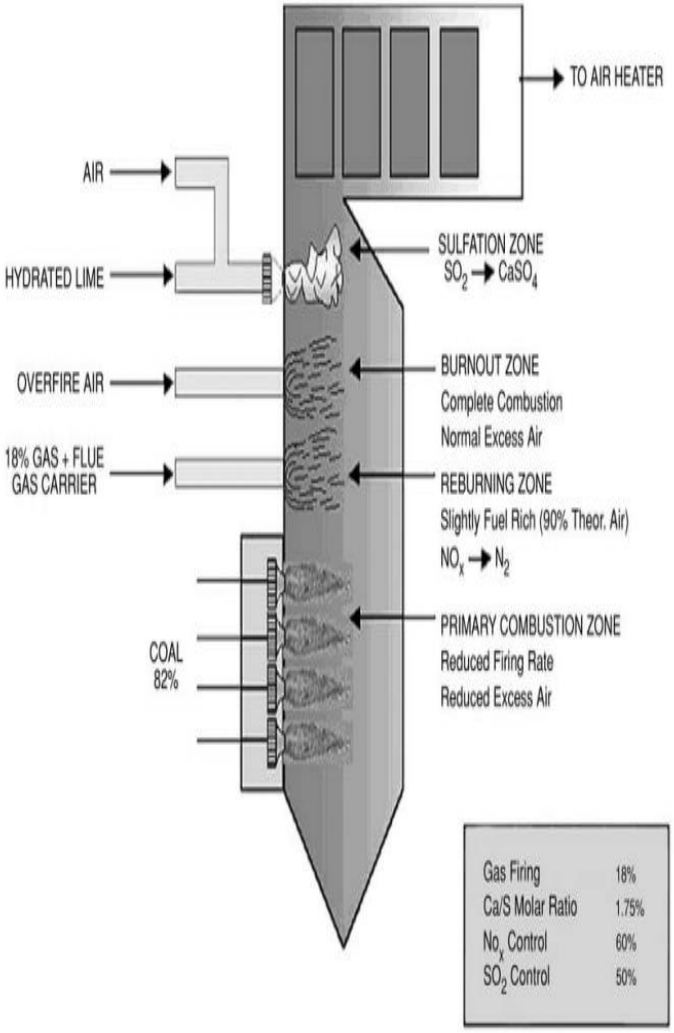

Fig. 3. Schematic of reburner technology.

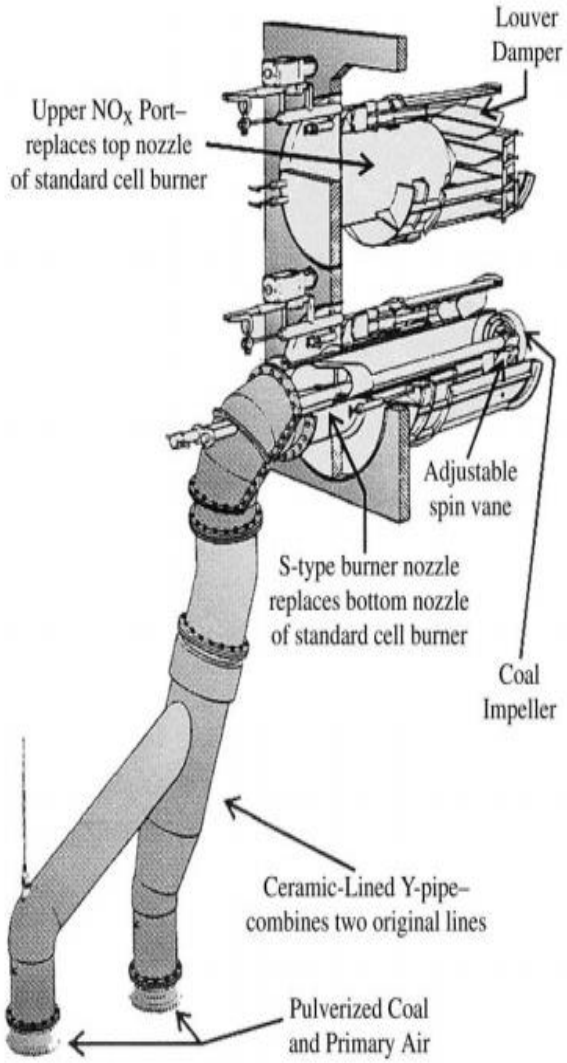

Fig. 2. Low-NO_x cell burner (B&W).

FUTURE REGULATION CONSIDERATIONS

- One potentially important development in near future is growing interest in developing three-pollutant (SO2 ،NOx, and toxics [e.g., mercury)

.***Future Technology Developments in Multipollutant Control***