Counter Measures Against the Air Pollutions

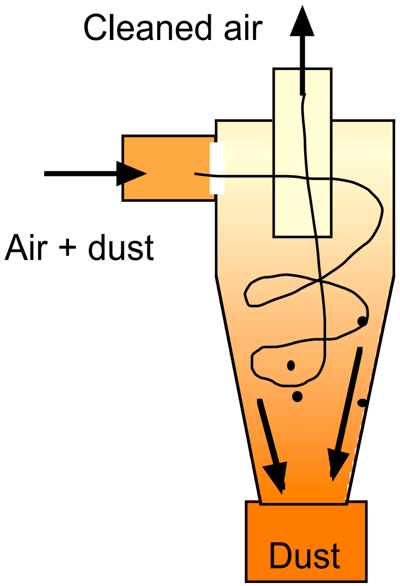
1. Dust Collector

The dust collectors are classified by the usage of water spray as:

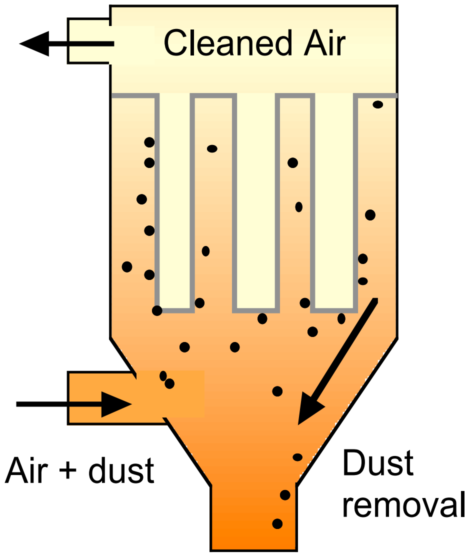
- wet type dust collector: contacting the gas to the water and scrubbing out the dusts
- dry type dust collector

Commonly used dust collection equipments are:

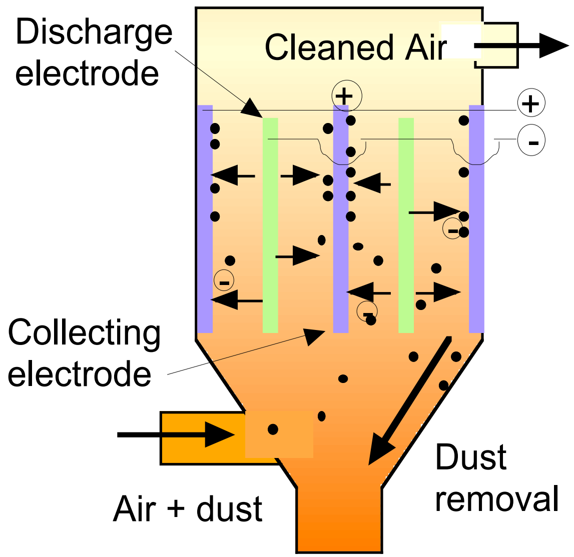
- **cyclone** dust collector: separating the dust by the centrifugal force given by the rotation air flow
- **multi-cyclone** dust collector: equipment using parallely arranged small cyclones, because a cyclone equipped small cross section inlet can collect smaller particles (a few micro-meters).
- **bag-filtering** dust collector: filtering the dust with the bag-like cloth, which has the mesh size larger the dust size, however, the initially precipitated dusts become the filter itself to collect small particles (> 0.1 micro -meters).
- **electrostatic precipitator** (EP): charging the dusts by the discharge electrodes to minus electricity and precipitating particles (> 0.05 micro-meters) onto the collecting electrodes which have plus electricity.



Cyclone dust collector



Bag filter



Electric precipitator

NOTE: EP uses corona discharge to electrify the dust particles.

2. Desulfurization of the Combustion Gas

The desulfurization methods for the combustion gas are classified by the usage of water as:

- **wet type desulfurization** method: desulfurizing the gas using wet absorbent
- **dry type desulfurization** method: desulfurizing the gas by the dry process such as the usage of the activated carbon

a. Wet lime-gypsum method

The combustion gas after the dust collecting and cooling process is desulfurized in the **absorbing tower** by splaying the lime stone **slurry**. The primary process is,

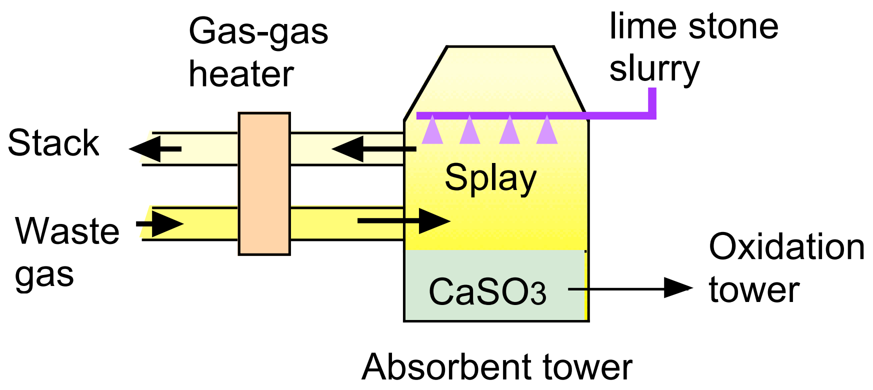
$CaCO_3 + SO_2 + 1/2\ H_2O \rightarrow CaSO_3 \cdot 1/2H_2O + CO_2$,

and the produced $CaSO_3$ is oxidized (partially by the oxygen in the combustion gas, and) by the next process in the **oxidation tower** as,

$CaSO_3 \cdot 1/2H_2O + 1/2O_2 + 3/2\ H_2O \rightarrow CaSO_4 \cdot 2H_2O$.

The SOx removal efficiency is greater than 90 %.

NOTE: The gas-gas heater is a heat exchanger to cool the waste gas to be injected into the absorbent tower, and to heat up the cleaned gas to 90 ~ 100 degrees C. The heating of the stack gas is aiming to de-water-saturate the gas preventing the condensation in stack, and improving the effective stack height.



Desulfurization equipment

b. Coal ash utilizing method

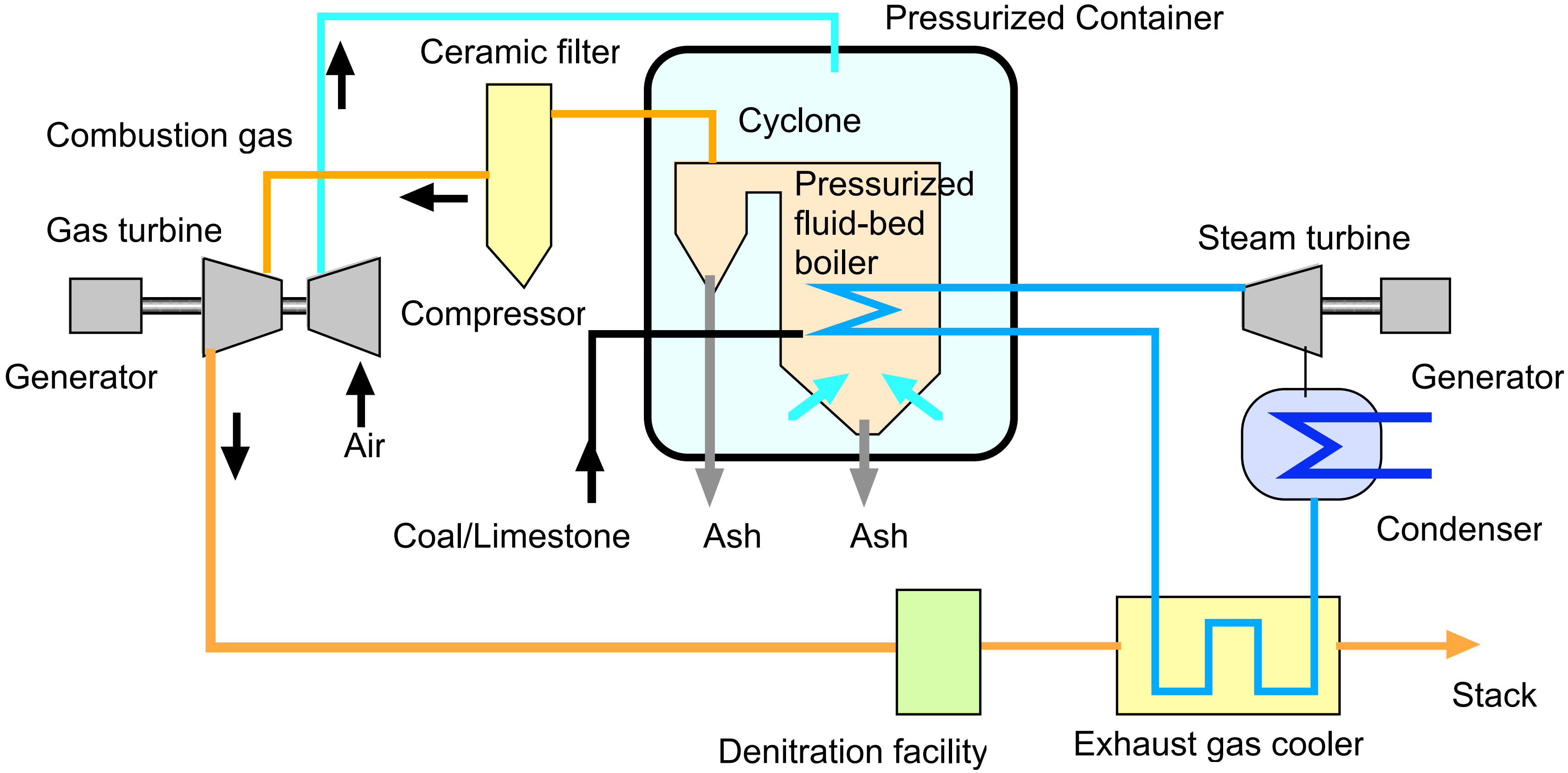
The coal combustion power plant discharges a lot of ash. This method desulfurize the gas in the **absorbing tower** filled with the ash, slaked lime, and gypsum. The **process is dry**, and the components of the ash, such as alumina and silica, improve the SO_2 absorption ratio as,

$Ca(OH)_2 + SO_2 + 1/2O_2 \rightarrow CaSO_4 + H_2O$.

However the method is simple and is completed in dry process, the SOx removal efficiency is greater than 90 %.

c. Pressurized Fluid-bed Combustion Combined Cycle Generation System (PFBC)

PFBC power generation system uses **in-boiler-desulfurization,** and can eliminate a wet and large desulfulization facility. Relatively low combustion temperature **suppresses the NOx generation** in lower level comparing pulverized coal combustion plant.



Pressurized Fluid-bed Combustion Combined Cycle Generation System

3. NOx Suppression and Removal of the Combustion Gas

a. NOx suppressing Combustion method

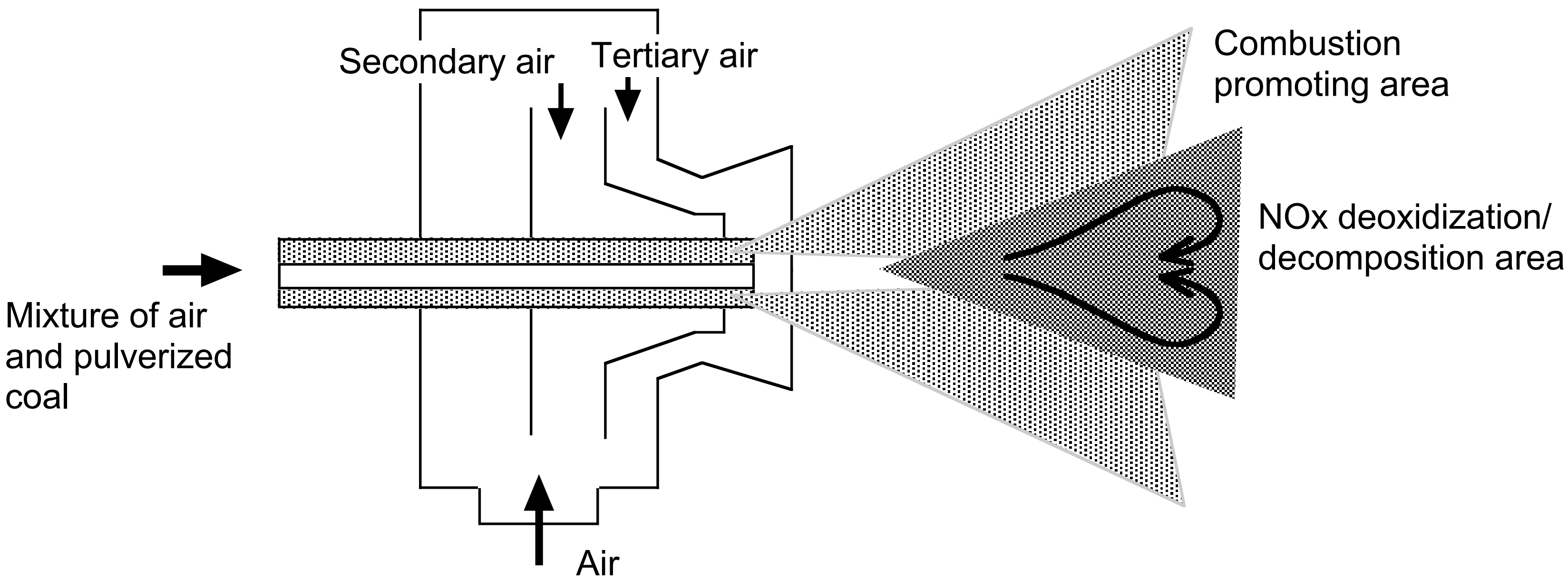
- **NOx suppression combustion condition**
  Changing the combustion condition such as the decreasing air supply to the boiler can suppress the thermal NOx and the fuel NOx, however, it increases the dust in the combustion gas.

- **Two staged combustion**
  The method is the supplying air with two stages. At the first stage, the combustion was performed at 0.85 ~ 0.9 **excess air ratio**, then at the second stage, the perfect combustion is attained complementing the insufficient air (0.1 ~ 0.15 of excess air ratio). Decreasing the oxygen density and the lowering the temperature of the flame at the first stage suppress the thermal and the fuel NOx generation.

- **Gas mixing combustion**
  The mixing the combustion gas to the fresh air for fuel combustion can suppress the thermal NOx generation by the decreased oxygen and lowered combustion temperature.

b. Low NOx burner

The usage of the burner which has the function of the two staged combustion or gas mixing combustion can reduce the generation of NOx.

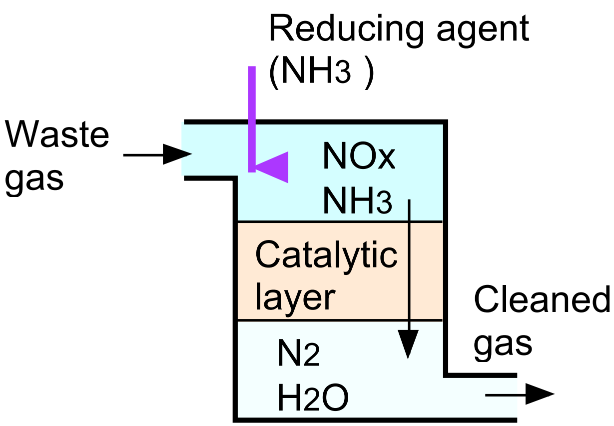


Ultra low Nox pulverized coal burner

c. NOx removal equipment

- **Selective catalytic reduction process (SCR)**
  Under the catalyzer, the NOx is reduced to N_2 using the reducing agent usually NH_3 or H_2S. The ammonia SCR is a dry, simple, no-byproduct, and high NOx removal ratio (> 80 %) process.

- **Activated carbon method**
  Combined process of the desulferization and the NOx removal can be achieved using the activated carbon. The process is composed of two steps. The sulfur oxides are removed by the activated carbon layer in the first process, next, ammonia injected gas is introduced another activated carbon layer and where the NOx are removed. By the combined process, SOx removal efficiency achieved to greater than 95 %, and NOx removal efficiency to greater than 80 %.



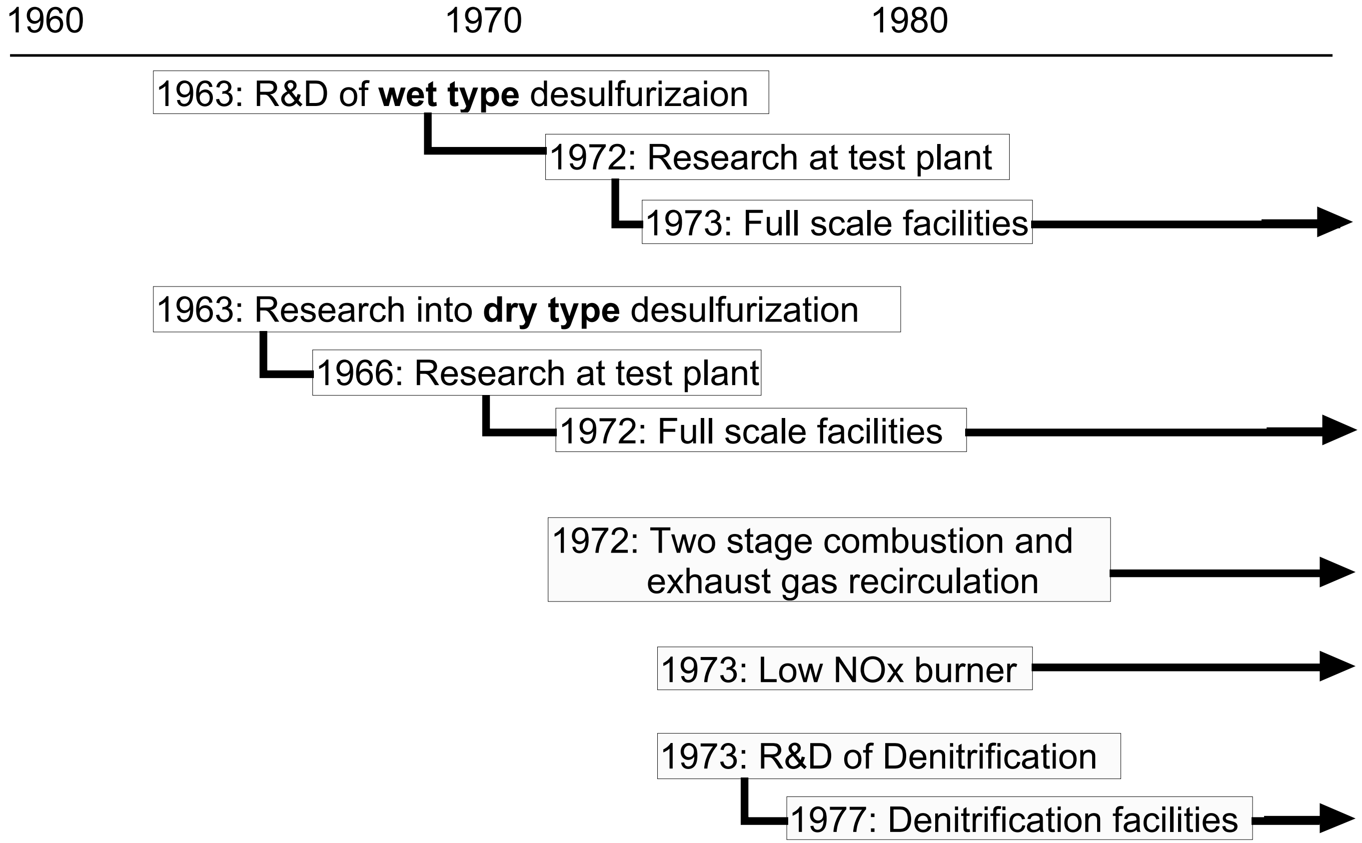
Ammonia SCR

4. Emissions Control Policies

To reduce the emissions, the electric power industries can select or combine the counter measures such as:

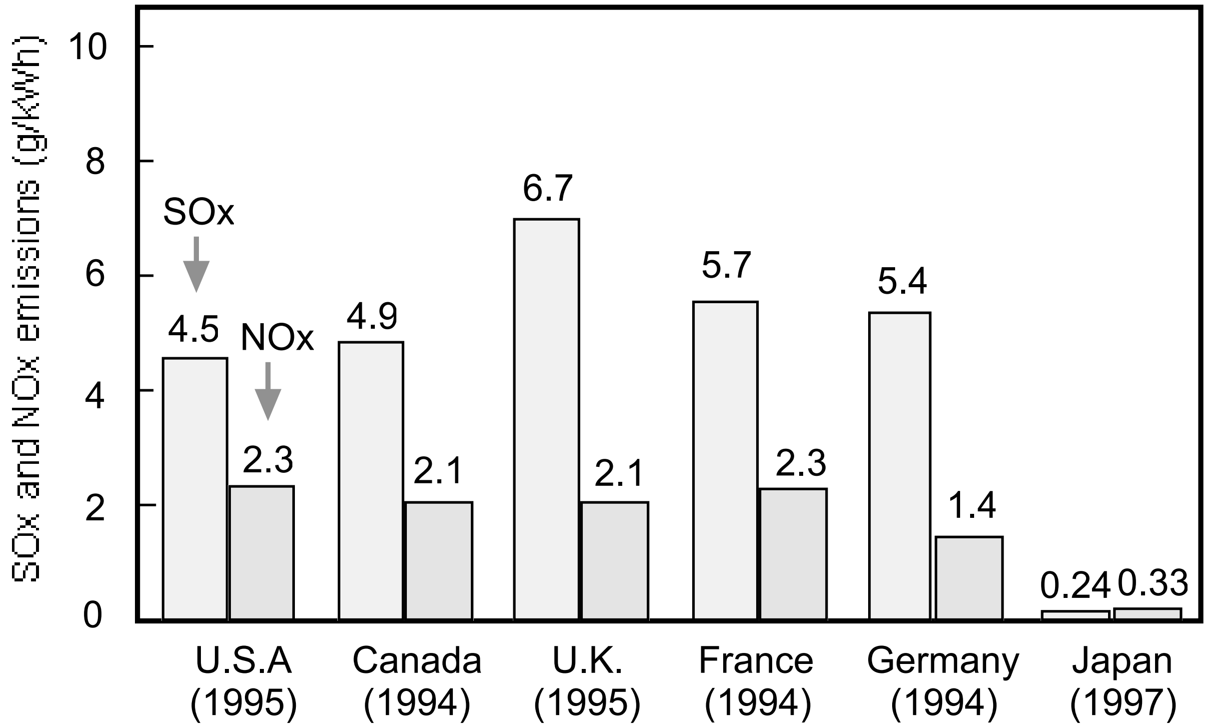
- to use low sulfur and nitrogen oil and/or coal
- to use LNG that contains no sulfur or particles
- to equip desulfurization/denitirfication facilities

a. desulfurization/denitirfication facilities in Japan



Establishment History of Air Pollutants Reduction Facilities in Japan

b. Emissions control policies of each country



Pollutants emissions per unit of electricity generated by thermal power plant