A LOW COST AND HIGH EFFICIENCT FACILITY FOR REMOVAL OF SO_2 AND NO_x IN THE FLUE GAS FROM COAL FIRE POWER PLANT

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Abstract

The emission of toxic gas, sulfur oxides and nitrogen oxides has become serious issue in the world. A review of EB method to remove the SO_x and NO_x in flue gas from coal-fired power plants was described in this paper. A design of an electron curtain accelerator of 600 keV was given, and a facility for purification of flue gas from coal combustion power plant of 10MW was described here.

1 INTRODUCTION

Air quality is affected by pollutants such as smog, which come from the combustion of fossil flues in vehicles, power plants, smelters, and other industrial plants. Research and measure indicated that smog has become a common term for urban air pollution. Smog can affect our health by irritating the eyes, nose, and throat, reducing lung capacity, and aggravating respiratory or cardiac diseases. Especially vulnerable are elderly, children, and those with heart or lung disease. In 1997 a report said that in China 850,000 persons per year were died caused by environment pollution, about 10 millions person suffered from respiratory or cardiac diseases too.

The emission of toxic gas, sulfur oxides and nitrogen oxides from industrial plants has become serious problem in China. Energy source in China was 1,134TWh in 1997, and 81% of them was from coal-fired power plants. So the total emission of SO_2 amounts to 23 million tons, emission of NO_x was 15 million tons. The SO_x and NO_x are known to be converted to "acid rain" in the atmosphere and cause the environmental pollution. The acid rain can result in acidification of lakes, rivers, and streams, can cause metals to leach from surrounding soils into the water system. Both acidification and metal leaching can seriously impair the ability of water bodies to support aquatic life; The acid deposition causes forest soils to lose valuable nutrients, contributing to declining growth rates in trees; Acid rain has been linked to increased rates of deterioration of structure containing cement, limestone, or sandstone. It will decrease lung function or increased cardiorespiratory mortality.

In order to control and reduce the emission of toxic gas, in the passed thirty years many scientists and engineers dedicated to R & D on de- SO_x and de- NO_x, and have got some way to de-SO_2 and de-NO_x. The main methods are as following:

1) Conventional technology (FGD + SCR), wet limestone and selective catalytic reduction method, which have been common for flue gas cleaning. But the method needs intricate equipment and system to treat the waste water produced by the method, and expensive catalyst that to be exchanged periodically[1].

2) EB method

The results of research and test on a few pilot plants show that the EB method presents many advantages comparing with conventional method: simultaneous removal of SO_x and NO_x"; dry process without waste water; by-product can be used as fertilizer; no need of catalyst; low capital and operating costs (see Fig. 1)[2].

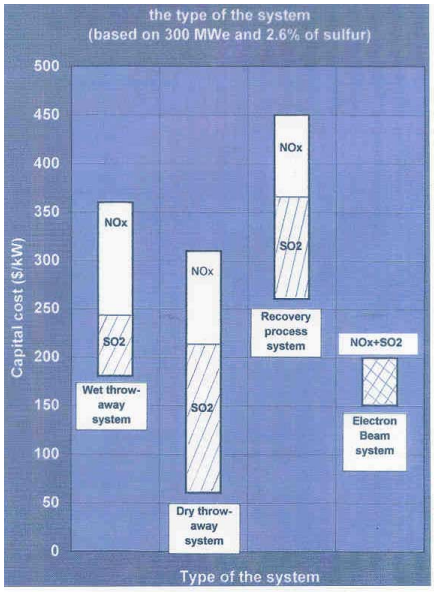

Fig.1 Capital cost of different way

3) Pulsed corona method (non-thermal plasma discharge) which is under way[3].

As mentioned above, EB method is a good way to remove the SO_2 and NO_x. Since 1970's EB facility in Japan was setup and tested, and got some exciting results for removal of SO_2 and NO_x. . After that there were some pilot plants to be constructed in Japan, USA, Poland, and Germany etc.[1,4,5,6,7,8]. Recently a few full-scale facilities for power plants of 200MW-300Mw are

constructing or start to run. In China, some institutes such as Institute of Engineering Physics, USTC (Univ. of Science & Technology of China) have done R & D on EB method[9,10]. The pilot plant to use EB method will be successful in two years.

2 EB METHOD FOR REMOVAL OF SO_2, NO_X

2.1Principle of the EB method

The principle of the electron beam irradiation process is shown below.

i Generation of active species

By collision of electron with molecules of SO_2, NO_x, water and carbon dioxide in flue gas, some active species such as O,OH,HO_2 and others are generated continuously. For example

$$O_2, H_2O \xrightarrow{e^-} O, OH, HO_2$$

ii Oxidation reaction of SO_2 and NO_x

SO_2 and NO_x are oxidized and converted into nitric and sulfuric acid respectively, by these active species generated by electron beam irradiation of flue gas in the presence of water vapor.

$$SO_2 \xrightarrow{O,OH,HO_2} H_2SO_4$$

$$NO_x \xrightarrow{O,OH,HO_2} HNO_3$$

iii Neutralization reaction

Nitric acid and sulfuric acid produced by the oxidation reaction react with ammonia injected into the reactor and produce an agricultural fertilizer and so on.

$$HNO_3 + NH_3 \rightarrow NH_4NO_3$$

$$H_2SO_4 + 2NH_3 \rightarrow (NH_4)SO_4$$

2.2 General schematic

The technological process is as following:

Collection the dust in the flue gas use an ESP (Electrostatic Precipitator)→spray the water to cool the flue gas in the cooling tower → inject the ammonia into a reactor vessel → separate and collect the byproducts → exhaust the flue gas cleaned.

A layout of the facility is shown in Fig.2.

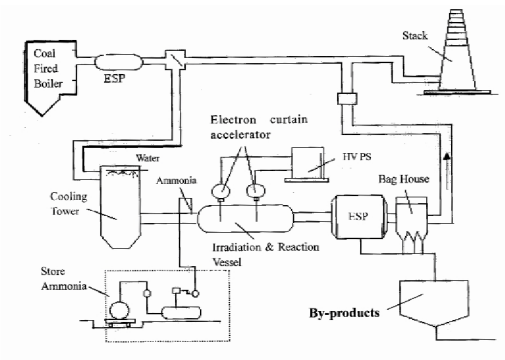

Fig.2 Scheme of facility with two stage irradiation

2.3 Main research results

As mentioned above, many research results have got that they are benefit of designing and constructing the facility for de-SO_2 and de-NO_x[1,4,6].

1) Relation between removal of SO_2 , NO_x and irradiation dose is shown in Fig.3.

2) The efficiency of removal of SO_2 is depend on the flue gas temperature, the relation is shown in Fig.4.

3) Multi-stage irradiation will increase the efficiency of de-SO_2 and de-NO_x.(see Fig.5).

4) Two side irradiation will increase the efficiency of the de-SO_2 and de-NO_x too, which is shown in Fig.6.

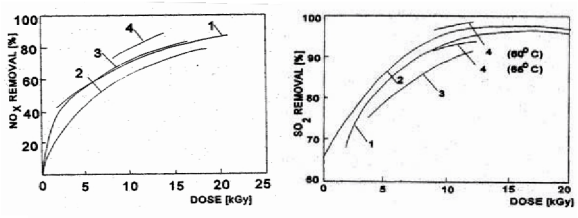

Fig.3 Removal of NO_x, SO_2 vs irradiation dose

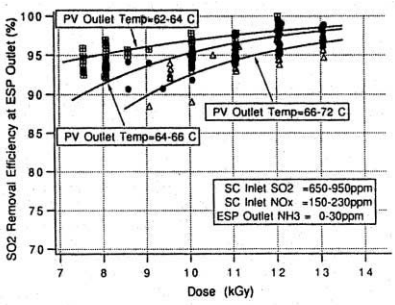

Fig. 4. Dose dependence of SO_2 removal efficiency at different gas temperatures.

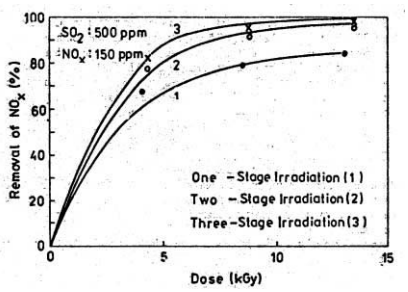

Fig.5 Model curves for single and multi-stage irradiatior

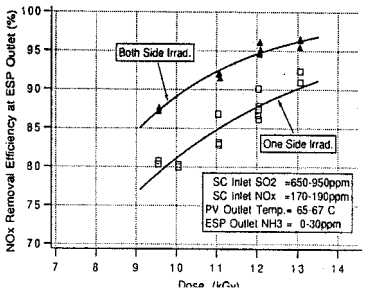

Fig.6 Efficiency of removal of NO_x in one and two side irradiation

3 SCHMEMATIC OF THE FACILITY FOR REMOVAL OF SO_2 AND NO_X

It is difficult to utilize widely existing a facility for removal of SO_2 and NO_x in the fuel gas from coal-combustion power plant developed by a few companies abroad, because the facility are high cost, high operating fee and equipment lifetime is not long enough, and so on.

According to economic status in China, reduce the cost is very important and is a key point to utilize widely the facility in China and world. According to some R & D achievements on the facility recent years, we will develop a facility with low cost, high efficiency, long lifetime and reliability. Its goal is as following:

(1) It will be used for purification the flue gas from a 100MW ~ 300MW power plants using coal combustion boiler.

(2) Efficiency of removal of SO_2 and NO_x is more than 90% and 80% respectively;

(3) Total power for running the facility needed is less than 1.5% of the power plant;

(4) Available operating time a year is more than 7500 hrs;

(5) Low cost (the cost is about 30-40% of other facilities).

In order to reduce the cost and operating fee, enhance the reliability, according to existing achievements and experiences at home and abroad, we will adopt the following measures:

- Multi electrodes electron curtain accelerators as the pulse EB sources, which don't need beam scanning. The cross section of the accelerator with two intermediate electrodes is shown as Fig.7. Its main parameters are:

  Energy 500keV ~700keV
  Current 500mA ~1000mA
  Beam size 15× 1000 mm/mm
  Pulse width of the current 0.1~10μs (adjustable)
  Repeating frequency 50~1kHz (adjustable)
  Energy stability $\Delta E/E$ ≤ 2%
  Homogeneity of the irradiation dose ≤ 3%

- Two stage and two side irradiation will be adopted that will save energy of 20%~30%.

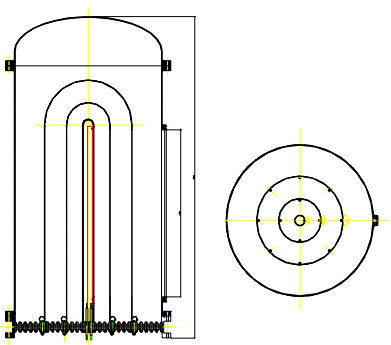

Fig.7 Cross section of accelerator with two intermediate electrodes

- FEA Cathode with grid control electrode as gun's cathode, which will be of long lifetime (lifetime ≥ 8000hrs)
- Window material will be thin enough (30μm) to reduce the energy loss in it;
- Small size pump with high deposition performance;
- High efficient, pulse power electrostatic precipitator. This is a patent technology.

4 STATUS OF THE PROJECT

Now we have completed the design of the facility for removal of SO_2 and NO_x of a small coal-fired power plant of 10 MW in Hefei. Some key equipment is developing, and a test facility in laboratory will be finished soon.

A test facility in a thermal coal-fired power plant of 10 MW will be established next year in Hefei.

A pilot plant in a 100MW power plant for removal of SO_2 and NO_x will be constructed next year.

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