# 5B3. Simultaneous De-SOx and De-NOx Technology

## Technology overview

### 1. Background

The technology behind the wet desulfurization process has also matured but requires a significant amount of service water as well as advanced wastewater treatment measures. Meanwhile, an already commercialized ammonia-based selective catalytic reduction (SCR) process requires not only long-term control of expensive DeNOx catalysts but also measures to prevent ammonia leaks. Development efforts are, therefore, underway for a dry combined desulfurization DeNOx method to remove NOx and SOx simultaneously without requiring any service water, wastewater treatment, or a DeNOx catalyst.

### 2. Technology

(1) Active carbon adsorption method

Research and development: J-POWER; Sumitomo Heavy Industries, Ltd.; Mitsui Mining Co., Ltd.
Project type: Voluntary support project for coal utilization promotion

**Overview**

The active carbon adsorption method causes a reaction between $SO_2$ in exhaust gas and injected $NH_3$ on active carbon at 120-150°C, thereby converting $SO_2$ into ammonium hydrogen sulfate ($NH_4HSO_4$) and ammonium sulfate ($(NH_4)_2SO_4$) for adsorption/removal while decomposing NOx into nitrogen and water as does the SCR process. Figure 1 shows the process. The moving-bed adsorption tower (desulfurization tower) removes $SO_2$ in the first-stage and, in the second stage (denitration tower), NOx is decomposed. This method first removes SOx and then NOx since, as shown in the figure, the presence of high-concentration $SO_2$ tends to decrease the effectiveness of NOx removal.

Active carbon that has absorbed $NH_4HSO_4$ is heated to 350°C or higher in the desorption tower to desorb $NH_4HSO_4$ after decomposing it into $NH_3$ and $SO_2$, while the active carbon is regenerated. $SO_2$ can be adsorbed and removed in the form of sulfuric acid ($H_2SO_4$) even if $NH_3$ is not injected in the desulfurization tower. However, since the following reaction with carbon occurs during desorption, consuming active carbon, $NH_3$ is added at the time of desulfurization to prevent such active carbon consumption.

$H_2SO_4 \rightarrow SO_3+H_2O$

$SO_3+0.5C \rightarrow SO_2+CO_2$

Coal is used to reduce desorbed $SO_2$ into elemental sulfur at 900°C for recovery. There is another method that oxidizes $SO_2$ into $SO_3$ to recover it as sulfuric acid.

During the development of this technology, carried out at J-POWER's Matsushima thermal power plant, first, an active-carbon desulfurization method (with an adsorption tower) that can treat 300Km$^3$N/h (90MW-equivalent) of gas was subjected to verification tests (1983-1986), obtaining removal efficiency of 98% for SOx and 30% for NOx. To improve the DeNOx removal efficiency, a combined desulfurization DeNOx pilot plant that can treat 3,000m$^3$N/h of gas with two towers was tested (1984-1986). SOx was almost completely removed by the desulfurization tower in the first stage, while 80% of NOx was removed. This technology, verified after being up-scaled to a capacity of 150Km$^3$N/h, was introduced in 1995 to the DeNOx unit of the No. 2 unit of the Takehara coal thermal power plant's normal-pressure fluidized-bed boiler (350MW), and is currently in operation. This technology was also installed as a desulfurizer in 2002 at J-POWER's Isogo thermal power plant's No. 1 new unit (600MW) (Photo 1). Although this technology is currently in operation, there are no cases of it being used as a combined desulfurization-denitration system.

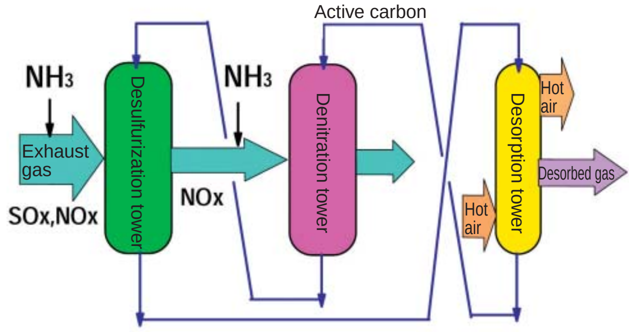


Fig. 1 Active carbon method desulfurization process

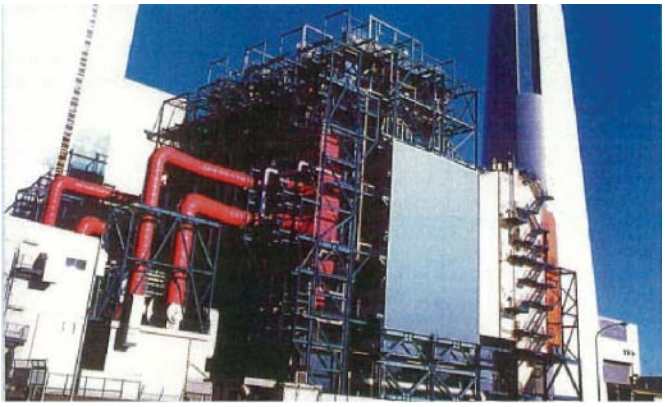

Photo 1 Active carbon method desulfurizer

(2) Electron beam process

Research and development: Ebara Corporation; Chubu Electric Power Co., Inc.; Japan Atomic Energy Research Institute; others
Project type: Voluntary

**Overview**

The electron beam process, as shown in Figure 2, involves using an electron beam to irradiate SOx/NOx in exhaust gas and injected $NH_3$ to cause a reaction for their recovery as ammonium sulfate ($(NH_4)_2SO_4$) or ammonium nitrate ($NH_4NO_3$) in the downstream precipitator. Byproducts: ammonium sulfate and ammonium nitrate, which are used as fertilizers. Removal efficiencies of 98% or more for SOx and 80% for NOx, at an $NH_3$/NO molar ratio of 1, is obtained at 70-120°C. The NOx removal efficiency also characteristically increases with higher $SO_2$ concentrations, though SOx removal efficiency does not affect the concentration of $SO_2$ at the inlet.

For this process, technology development was undertaken by Ebara Corporation and U.S. partners, including DOE, which made joint contributions from 1981-1987. In Japan, based on the development results, a pilot plant that can treat 12,000$m^3$N/h of gas was built at Chubu Electric Power's Shin-Nagoya power plant, where the technology was verified from 1991-1994.
Regarding this technology, a plant that can treat 300K$m^3$N/h (90MW) of gas (Photo 2) was built at Chengdu Heat-Electricity Factory, a co-generation power plant in Sichuan Province, China. It is currently being operated for demonstration and is obtaining a NOx removal efficiency of 80%.

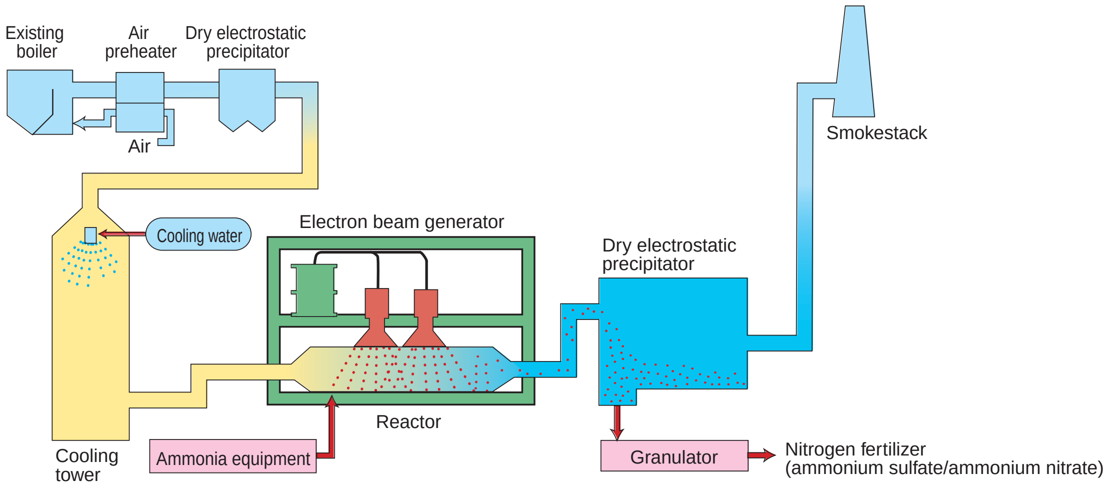


Fig. 2 Process flow for electron beam desulfurization process

Photo 2 Electron beam desulfurizer

References
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2) "Renewing Isogo Thermal Power Plant" pamphlet, J-POWER.
3) Aoki, "Electronic Beam Flue Gas Treatment Technology," Fuel Association Journal, Vol. 69, No. 3, 1990.
4) S. Hirono et al., "Ebara Electro-Beam Simultaneous SOx/NOx Removal," proc 25th Int Tech Conf Util Sys, 2000.