5B2. NOx Reduction Technology

Technology overview

1. Background

Nitrogen oxide emissions are regulated, with acceptable concentration levels set according to the type of fuel and the size of the boiler. However, with the recent stiffening of regulations, some regions are subject to a "total amount control," which provides for a region-wide overall emissions level as is the case with sulfur oxide emissions. To comply with these regulations, flue gas denitration equipment was commercialized in 1977, and ongoing efforts have been made to improve the durability of DeNOx catalysts as well as to reduce costs. The Selective Catalytic Reduction (SCR) process is used to decompose nitrogen oxides, mainly through the use of ammonia.

2. Technology

(1) Selective catalytic reduction process

Research and development: Mitsubishi Heavy Industries, Ltd.; Ishikawajima-Harima Heavy Industries Co., Ltd.; Babcock Hitachi K.K.

Overview

In this process, ammonia (NH_3) is blown into exhaust gas, allowing the ammonia (NH_3) to selectively react with nitrogen oxides NOx (NO, NO_2), and decompose them into water (H_2O) and Nitrogen (N_2). In the DeNOx reactor, since soot and dust are present in the exhaust gas, a grid- or plate-like catalyst is mainly used, as shown in Figure 1. The catalysts, as shown in Photo 1 and Photo 2, are installed in the reactor to react with the NH_3 blown into the catalyst layer from its inlet, allowing NOx (NO, NO_2) to breakdown into water vapor (H_2O) and nitrogen (N_2). The catalyst is mainly composed of TiO_2, to which vanadium (V), tungsten (W), and the like are added as active ingredients.

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

The temperature at which the catalyst attains optimal performance is 350°C. At a temperature lower than this, SO_3 in the exhaust gas reacts with NH_3, producing ammonium hydrogen sulfate (NH_4HSO_4) that covers the surface of the catalyst, thereby reducing the ability to remove NOx. At a temperature higher than 350°C, the NH_4HSO_4 decomposes, improving the removal of NOx regardless of the SO_3 concentration. At a temperature above 400°C, NH_3 is oxidized and its volume decreases, thereby reducing its ability to remove NOx. The process is also designed to limit NH_3 leaks from the reactor to 5ppm or less. If a significant quantity should leak, it will react with the SO_3 in the exhaust gas, producing NH_4HSO_4, which clogs the piping when separated out by an air pre-heater.

The NOx removal efficiency is around 80-90% for pulverized coal-fired thermal power plants. On the other hand, measures to equally disperse and mix the NH_3 with the exhaust gas as well as to create greater uniformity of the exhaust gas flows to cope with growing boiler sizes have been developed. These include placing a current plate, called a "guide vane" at the gas inlet, or dividing the gas inlet into grids, each to be equipped with an NH_3 injection nozzle.

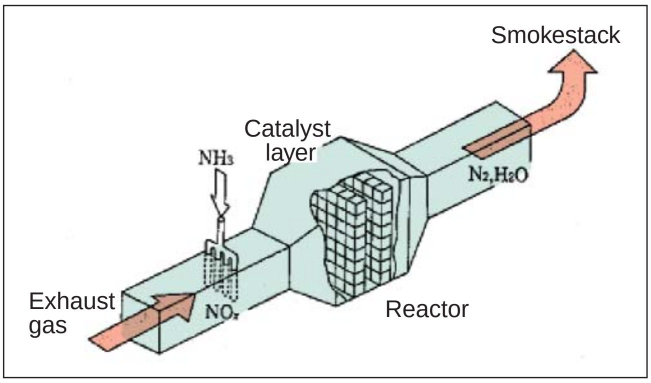

Fig. 1 Selective contact reduction method denitration process

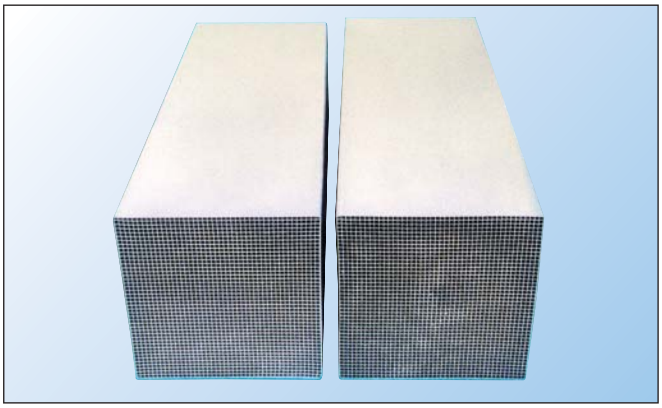

Photo 1 Grid-like catalyst

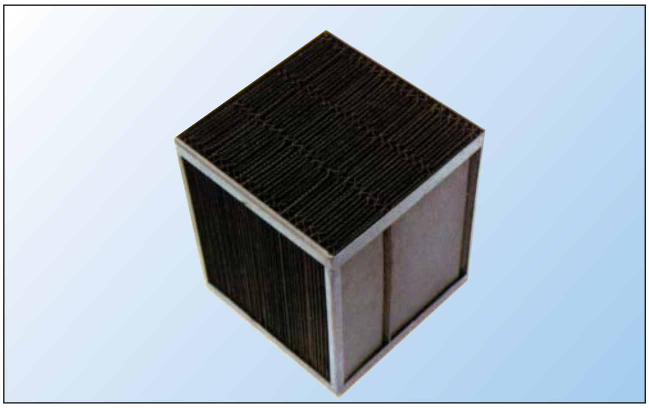

Photo 2 Plate-like catalyst

(2) Selective non-catalytic reduction (SNCR) process

Research and development: Chubu Electric Power Co., Inc.; Mitsubishi Heavy Industries, Ltd.

Project type: Voluntary

Overview

SNCR is a process to, as shown in Figure 2, blow NH_3 into the boiler section where the exhaust gas temperature is 850-950°C and to breakdown NOx into N_2 and H_2O without the use of a catalyst. Despite the advantages of not requiring a catalyst and its lower installation costs, the NOx removal efficiency is as low as 40% at an NH_3/NOx molar ratio of 1.5. Because of this, it is used in regions or equipment where there is no need for a high NOx removal efficiency. More NH_3 is also leaked than with the selective contact reduction method, requiring measures to cope with NH_4HSO_4 precipitation in the event of high SO_3 concentrations in the exhaust gas.

This technology is mainly used at small commercial boilers and refuse incinerators. With respect to thermal power plant applications, this technology has only been installed at Chubu Electric Power's Chita thermal power plant No. 2 unit (375kw), in 1977.

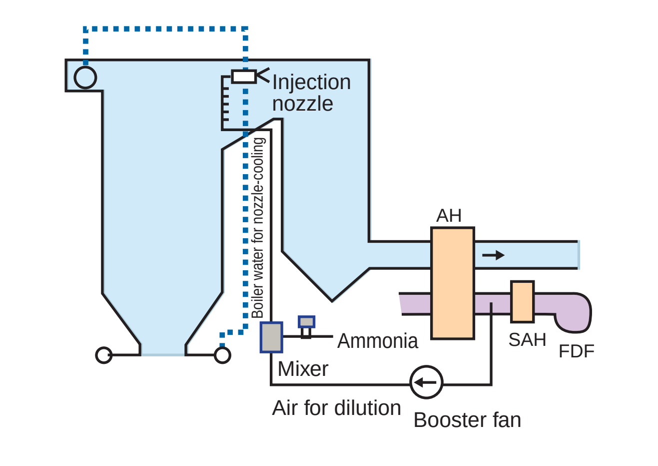

Fig. 2 Selective non-catalytic denitration NOx removal process

(3) Radical injection method

Research and development: Japan Coal Energy Center

Project type: Subsidized coal production/utilization technology promotion

Development period: 1999-2002

Overview

In the radical injection method, as shown in Figure 3, argon plasma is injected into NH_3, generating NH_2 plasma and other plasmas, which are then blown into the boiler to decompose NOx into N_2 and H_2O. The target for this technology is to attain an NOx concentration of 10ppm or less.

At present, basic research is underway at the Japan Coal Energy Center, with commercialization expected around 2010.

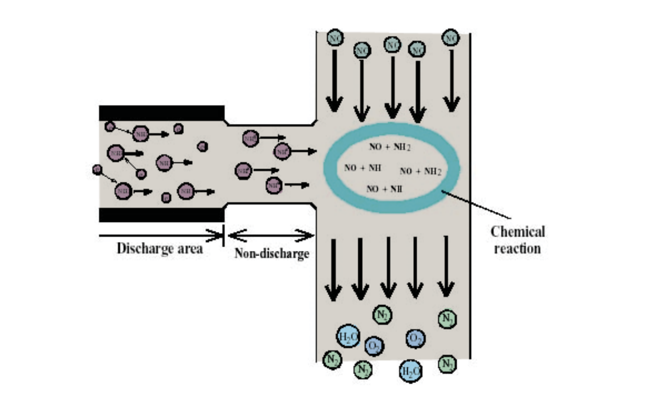

Fig. 3 Overview of radical injection method

References

1) Masahiro Ozawa et al., "Latest Flue Gas Denitrator Technology," Ishikawajima-Harima Technical Journal, Vol. 39, No. 6, 1999.

2) Tadamasa Sengoku et al., "Selective Non-Catalytic Denitration Method for Boilers," Thermal/Nuclear Power Generation, Vol. 29, No. 5, 1978.

3) Coal Utilization Next-Generation Technology Development Survey; Environment-friendly coal combustion technology field (advanced flue gas treatment technology)/NEDO results report, March 2002.

4) Masayuki Hirano, "New Flue Gas Denitrator Technologies for Large Boilers/Gas Turbines," Thermal/Electronic Power Generation, Vol. 50, No. 8, 1999.