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Application Of SCR Denitration In Treatments Of Nitrogen Oxides In The Air

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Abstract. This article mainly introduces the background of nitrogen oxides in air pollution and SCR technology in detail. SCR has become a very wide range of pollution control technology in recent years, because it saves energy, produces no pollution, and is easy to operate. The article clearly lists the reaction mechanism, reaction materials and matters needing attention when SCR is applied. As a problem that has plagued people for several years, air pollution has always existed in our daily life. If SCR technology is well applied, air pollution will be effectively controlled in the near future.

Keywords: Selective catalytic reduction, Nitrogen oxides, Air pollution, Catalyst, SCR Denitration.

1. Introduction

Outdoor air pollution is a major environmental health problem affecting eve- ryone in low, middle and high income countries of the world [1]. Nitrogen Oxides are the main contaminants in the air, and it is also the main component of the precursors of PM2.5. Nitrogen dioxide and nitrogen monoxide are the most important nitrogen oxides in the air, and they are mainly derived from fuel combustion [2]. The beneficial role of nitric oxide (NO) and as well as other nitrogen oxides are their circulatory effects, which can be reused and generate valuable resources that may benefit mankind [3]. However, the contamination of nitrogen oxides has always been neglected, so it is crucial to ponder on the treatments of nitrogen oxides contaminants in the air. Air pollution in urban centers has increased rapidly due to dense populations, increasing numbers of various vehicles, fuel combustion, fragile transportation systems and ineffective environmental regulations [4].

There are several treatment methods of nitrogen oxides nowadays, such as combustion, and activated carbon adsorption. However, some remnants of combustion are toxic and hard to recycle, which will contaminate the environment once again. Activated carbon adsorption is slightly more efficient than combustion, but it can be used only when the concentration of the contaminants are very low. Based on the circumstances above, an efficient yet inexpensive method shall be used.

Denitration is a rising nitrogen oxides treatment technology in recent years. Using specially designed apparatuses, denitration can convert nitrogen oxides into clean gases and will cause no contamination. There are few denitration methods that had been developed lately. For example, Mo et al. had found radical reduced denitration, a robust dearomative denitration of nitroarene derivatives induced by a radical ipso-cyclization process [5]. Zhuang and others had found that a strain of Ensifer sp. 22–1 that

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was capable of degrading both 2,6-DCNP and 2C4NP was isolated from a halogenated aromatic-contaminated soil sample [6]. Denitration is efficient and environmental- friendly, and the products are also clean and even useful in other fields.

This paper expounds the generation of nitrogen oxides in air pollution through literature review, and introduces a widely used pollution control technology, SCR technology. Effective methods for air pollution control mainly focus on SCR technology. With the research and update of technology, air pollution can be reduced and controlled in the near future.

2. Selective Catalytic Reduction

2.1. Mechanism

Selective catalytic reduction (SCR), is injecting nitrogen containing compounds, such as ammonia or urea, into the nitrogen oxides exhaust gas to convert nitrogen oxides into nitrogen and water under moderate temperatures.

The main reactions are[7]:

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

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

With no catalyst present, the above reactions can only happen in a small range of temperatures. SCR aims to let NH3 to first react with NOx, but not oxygen in the air.

2.2. Influence factors

2.2.1. Temperature Generally speaking, the higher the reaction temperature, the faster the reaction speed and the higher the activity of the catalyst, so that the reaction space required for a unit reaction is smaller and the reactor volume is smaller.

Temperature is the most important and limiting factor in selective catalytic reduction. Many times different instruments or devices such as gas turbines, automobiles, or diesel engines are reserved or allowed a period of time (in minutes or even hours, depending on the scale or other factors) during the Start-Up phase to allow the exhaust temperature to rise sufficiently to achieve the desired temperature for the occurrence of selective catalytic reduction reactions. The ideal temperature for selective catalytic reduction is 630 to 720 K, but it can also be operated at 500 to 720 K to obtain longer residence times. The minimum allowable operating temperature depends on fuel type, gas composition and catalyst geometry. Other options include the reducing agents cyanourate and ammonium sulfate.

2.2.2. The smoke flow pattern The application effect of the catalyst is determined by the reasonable smoke flow pattern, which can not only fully benefit the catalyst, but also reduce the flue gas resistance along the path. In the reduction process, the ammonia injection point shall have turbulent conditions to achieve the best mixing with the flue gas, forming a well-defined homogeneous flow area.

2.2.3. Spacial velocity Spatial velocity is a critical parameter in the SCR method. It is the spatial scale at which the standard wet flue gas stays in the catalyst volume. It determines whether or not the reactants can react completely. If the space velocity is large and the residence time of the flue gas in the reactor is short, the reaction may be incomplete, so that the amount of ammonia leakage will be large.

2.2.4. Catalyst The type, structure and surface area of catalysts are the most critical parts of SCR system. The type, structure and surface area of catalysts have a great influence on the NOx removal efficiency

[8]. If well controlled, SCR denitration will be a great saving of time compared to other ordinary denitration methods.

2.3. Cautions

To ensure that SCR is effective and harmless, the following points must be met.

(1) NH_3 must be fully mixed with nitrogen oxides.

If NH_3 is not fully reacted, excess NH3 will flow out and react with oxygen in the air to form sulfur dioxide and sulfur trioxide when the catalyst is present.

(2) The injection amount of NH3 shall be strictly controlled according to the concentration and removal rate of NOx entering the reaction zone.

If there is excess NH_3, there will be some waste products, such as $(NH_4)_2SO_4$, and will form deposit, thus cause damage to the equipment. After the denitration process, the equipment must be cleaned cautiously in order to avoid further damages to the apparatus.

3. Application

Due to its high denitrification efficiency, SCR technology has been gradually applied to power plant boilers since the 1980s, especially in those countries with strict requirements on nitrogen dioxide emissions, such as Japan, Germany, the United States and some countries in Northern Europe. At present, the maximum capacity of the retrofitted power plant boiler using this technology is 750 MW, and the maximum capacity of the newly built boiler is 1,000 MW.

In Japan, SCR is widely used in gas-fired, oil-fired and coal-fired power plant boilers. SCR accounts for 93% of flue gas denitration units in the electric power industry. There are about 170 SCR systems operating on generating units with nearly 100,000 MW installed capacity. SCR technology has been introduced in some European countries since 1985, with an estimated installed capacity of over 60 000 MW applied. In Germany, boilers with an installed capacity of more than 23,000 MW by 1990 using SCR, and these power stations burn low-sulfur coal [9].

4. Conclusion

SCR technology for boiler flue gas NOx control effect is very significant, the technology is relatively mature, has become the world's most used, the most effective flue gas denitrification technology. Under reasonable arrangement and temperature range, the removal rate of 80~90% can be achieved. The control of air pollution is a problem that people are committed to solving in recent years. SCR technology can make people realize significant reduction of air pollution as soon as possible, and also bring a better environment for the whole world. SCR technology should be widely used to combat NOx pollution around the world. However， due to limited time and space, further analysis experiments and more experimental data collection were not carried out in this paper.

SCR catalytic conversion technology has the advantages of good continuity of technology upgrading, short development cycle and cost, good fuel economy, and low requirements on fuel quality. However, there are still many problems, especially in the case of low exhaust temperature, such as poor urea decomposition, formation of crystallization precipitation, low temperature conversion efficiency. Therefore, SCR technology still needs to be further developed.

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