The Fouling Characteristics and Comparative Analysis of Cleaning Technology of SCR

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Abstract: The paper mainly discussed the related issues of fouling and blowing problem of power plant de-nitrification systems. The fouling mechanism and the harm of fouling problem in SCR were pointed out. Then the paper compared the characteristics of the acoustic soot blower and steam soot blower. The advantage of acoustic soot blower was also analyzed here. At last, the paper concluded the future research direction.

Keywords: SCR, fouling characteristics, acoustic soot blower

1 INTRODUCTION

Selective catalytic reduction of NO_x (SCR) is the technology of controlling the NO_x emission and is widely used in coal-fired power plant. The reaction mechanism is that injecting [1] NH_3 into the rear boiler flue, and the NO_x in the flue gas will be quickly reduced to the N_2 and H_2O when going through the catalyst layer. Because of the use of the catalyst, the reaction can be effectively achieved under the temperature about 370℃. In order to maintain the denitrification efficiency, the catalyst activity must be guaranteed.

As is shown in Fig. 1, the SCR systems are usually installed between the economizer and the air pre-heater .The ash content in flue gas is high [5]. The ash will become fouling and seriously affect the catalytic activity. So the utilization of steam or acoustic soot blowers to remove the ash on catalyst surface is considered. This paper compared the two ways of soot-blowing, and used the finite element method to simulated sound field.

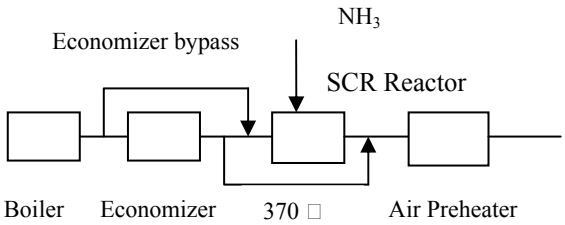

Fig.1 SCR arrangement of the high-ash

2 FOULING PROPERTIES

Generally, the flue gas temperature in SCR is between 300 ℃–400 ℃. At this temperature the fouling is loose because the condensation of alkali metal salts steam has ended.

There are several reasons for the formation of fouling in SCR. First of all, the ash that produced during combustion, will float to the catalyst surface with flue gas. The small gray tablets will gather in the laminar state and fall to the catalyst surface, finally format bypass or blockage in catalyst as shown in Fig. 2.

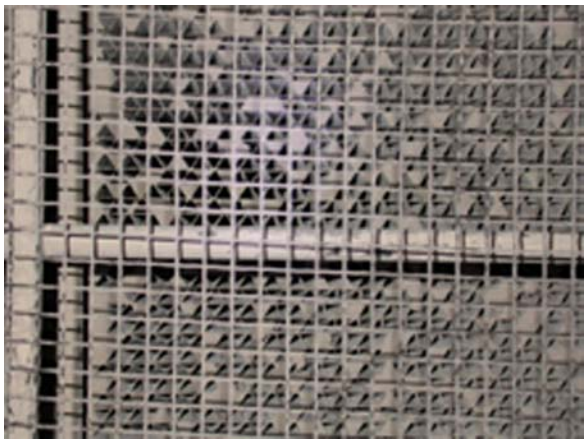

Fig. 2 The fouling on the catalyst surface

The other reason is CaO which contained in the ash. When the CaO attach to the catalyst surface, SO_3 in flue gas will bond with CaO and then generate $CaSO_4$. Another kind of fouling is generated because the acid steam and water steam in the flue gas condensate on the support structure, and cohere with the gray tablets as can be seen in the Fig. 3.

Fig.3 Fouling on the support structure

Analyze the deposited ash that on the surface of first layer of catalyst in SCR reactor, and the following chart gives the size distribution of ash. The diameter of the most gray tablets is smaller than 100 μm. The gray tablets that smaller than 40 μm account for the majority part of deposited ash.

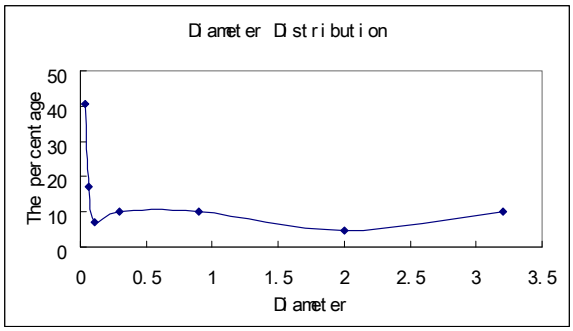

Fig. 4 Diameter Distribution of ash

3 THE IMPACT ON CATALYST

The alkali metal in ash such as sodium and potassium, can directly react with the active component of catalyst and make them lose their activity. And the fly ash in flue gas will wear the windward side of catalyst and even the inside wall, which will reduce the surface area of catalyst and influence the catalytic activity. The bypass or blockage in catalyst will plug the access to the active site, and reduce the effectively size of catalyst, which would lead to serious activity losses.

4 THE COMPARISON OF THE TWO SOOTBLOWERS

According to gas composition and the characteristics of catalyst, steam soot blowers and acoustic soot blowers are now universal applied in SCR.

Then compare the characteristics of two soot blowers.

The utilization status

Steam soot blowers are traditional blowers, and are used more widely than other blowers. The acoustic soot blower technology [2] is the emerging technologies in the cleaning field. This technology was introduced in domestic in the late 1980 s and early 1990 s.

Mechanism

The mechanism of Steam soot blowers is to emit a certain pressure and dry degree steam in high-speed, to purge the fouling surface, and to remove the fouling. The cleaning efficiency is determined by the pressure of soot-blowing steam.

The mechanism of acoustic soot blowers is using metal patch to produce a certain pressure and frequency sound waves under compressed air. Then the wave can be transmitted by the air to clean the corresponding fouling.

The effect of blowing

Steam soot blowers use steam to purge the fouling directly, so it can clean the strong viscous fouling effectively; the soot-blowing intensity of acoustic soot blowers is lower than the intensity of steam, and has less impact on the strong viscous fouling.

They have different effective range because the different mode of energy transmission. As the acoustics soot blowers transfer energy by less energy dissipation, they have larger effective range [3].

As catalyst channels are tiny and have irregular structure, steam can't be full of the whole reactor, which will result in "dead ends" of blowing. But the acoustic soot blowers don't have such problems because of the reflection, transmission and diffraction effect of sound wave. Therefore, acoustic soot blowers can clean the reactor in higher efficiency [4].

Capital investment

Initial investment

The acoustics soot blowing system needs a compressor to produce compressed air which leads to the larger initial investment.

The operation and maintenance cost

The operating cost of acoustic soot blower is about 10% to 20% of the steam soot blowers'. The only part that easy to wear of acoustic soot blower is the patch of generator which can generally maintain for more than two years. Therefore, the maintenance cost of acoustic soot blowers is lower compared with the steam soot blowers.

The others

The steam soot blowers emit steam into the reactor which will increase the humidity of flue gas. The dew point will increase and the steam will wear the catalytic surface. Acoustic soot blowing will not cause the similar effects because it just emits air into reactor.

5 ACOUSTIC RESEARCH METHODS

Assumed that there is a intermittent sound field, the sound pressure is P, the fouling area is S, its force can be used under the terms of:

$$F = P \times S \times \cos(\omega t + \psi) \quad (1)$$

When the value of $\cos(\omega t + \psi)$ is 1, F is the max and when the value of $\cos(\omega t + \psi)$ is -1, F is the minimum, and the margin of the force is $2\ P \times S$. So the fouling will be impacted by the forced alternating from zero to $2P \times S$. According to this principle of cleaning, utility of the finite element method to simulate the internal sound field of SCR is feasible.

The acoustic finite element method is first to establish finite element model of sound field, and then to solve the corresponding FEM equation to get the acoustic transfer function, on the basis of which make further analysis of acoustic characteristics.

It is assumed that there is a sound source in a closed space which provides the medium quality of $\rho_0 q(r,t)$ to the unit volume in unit time. According to the law of conservation

of the quality, the continuity equation of sound waves is as following [6]:

Continuous equation:

$$\frac{\partial \rho'}{\partial t} = -\rho_0 \nabla . v(r,t) + \rho_0 q(r,t) \quad (2)$$

Movement Equation:

$$\text{grad}(p(r,t)) = -\rho_0 \frac{\partial v(r,t)}{\partial t} \quad (3)$$

Equation of state:

$$p(r,t) = c_0^2 \rho' \quad (4)$$

where: ρ' —medium density incremental

ρ_0 —Static medium density

$v(r,t)$ —Medium speed particle

6 CONCLUSIONS

The fouling on the SCR catalyst will reduce the catalytic activity. So it's necessary to use soot blowers to clean the fouling on the catalyst surface to ensure the catalytic activity.

Comparing the characteristics of two soot blowers, considering of the security, reliability and economic, acoustic soot blowers are very suitable for the SCR system.

Using finite element method to simulate sound field, researching the cleaning effect by sound wave, and analyzing the various factors that impact the cleaning, is all further research directors which will be helpful to the utilization of acoustic soot blowers.

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