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Investigation and research on seawater FGD technology

Haijie Wang*

Department of Environmental Science and Engineering, North China Electric Power University(Baoding), Hebei,071003, PR China

1547567275@qq.com

Abstract

In order to control the worsening atmospheric environment, it is imperative to control the emission of SO_2. China has carried out a variety of desulfurization technology research and application. Coal desulfurization can be divided into three categories according to specific conditions: desulfurization before combustion, desulfurization during combustion and desulfurization after combustion.Flue Gas Desulfurization (FGD) is the most popular SO_2 emission control method in the world today. Flue gas desulphurization refers to the removal of SO_2 pollutants from the flue gas discharged from the boiler. This desulphurization method does not affect the combustion and heat exchange in the furnace. According to the material form of reaction products (liquid and solid), there are three kinds of flue gas desulfurization (Wet, semi-dry and dry FGD). The picture shows the possible flue gas desulfurization scheme when desulfurizer is added in the furnace and flue of coal-fired boiler at different temperatures. Wet flue gas desulfurization technology accounted for about 85%, among which limestone gypsum method accounted for about 36.7%, other wet desulfurization technology accounted for about 48.3%, spray drying desulfurization technology accounted for about 8.4%. Absorbent regeneration desulfurization accounted for about 3.41%; About 1.9% of desulphurization technology is injected absorbent and tail humidification activation. Other technologies include circulating fluidized bed flue gas desulfurization, electron beam desulfurization, activated carbon adsorption desulfurization, seawater desulfurization, copper oxide, catalytic oxidation and reduction desulfurization, etc.Seawater flue gas desulfurization technology is the use of seawater to remove sulfur dioxide in flue gas technology.After a series of investigations and studies on this technology, I wrote this research report.

Keywords

SO_2,Seawater flue gas desulfurization technology,FGD.

1. Introduction

SO_2 emissions from coal-fired power plants in China account for about 50% of the country's total emissions, and are a key area of air pollution control.[1]Seawater flue gas desulfurization technology is the use of seawater to remove sulfur dioxide in flue gas technology, its principle lies in the use of seawater basicity, namely calcium bicarbonate and magnesium bicarbonate, and acid gas in flue gas - fuel combustion sulfur dioxide neutralization reaction, so as to achieve the desulfurization effect of desulfurization technology. Seawater is alkaline, with a general pH value of 7.5-8.5 and a basicity of 1.2-2.5mg/ L. It has strong neutralization ability to acidic gases such as SO_2 in flue gas.

Within this process is the main process of coal-fired flue gas SO_2 with acidic gas into the desulfurization absorption tower, such as large amounts of water in spray washing these coal-fired flue gas desulfurization absorption tower, made the sulfur dioxide in flue gas is absorbed

by water to remove, after purification of the flue gas by demister mist and discharged after flue gas heat exchanger. At the same time, the seawater after absorbing sulfur dioxide is mixed with a large number of undesulfurized seawater, and the SO_3^{2-} is oxidized into stable SO_4^{2-} after aeration treatment in the aeration tank, and the pH value and COD of seawater are adjusted to reach the discharge standard and discharged back to the sea.

And the scope of application of the process is generally applicable to the seaside, diffusion conditions are good, with seawater as cooling water, burning low-sulfur coal power plants. Because of its proximity to the sea, where the water can be harvested locally and the treated water can be easily discharged, the process has been widely used and studied in Norway, which is known as the "Land of Thousand Islands" and has a long coastline, so there is plenty of water to develop the technology.

At present, the problem of this process is the possible heavy metal deposition after flue gas desulfurization and its impact on the Marine environment, which has not been determined. Therefore, when choosing desulfurization technology in areas with high environmental requirements and sensitive environmental quality, it is necessary to carefully choose seawater desulfurization technology.

2. Development history and process classification

2.1. Development History

In the 1960s, the University of California Berkeley studied the principle of seawater desulfurization process. On the basis of Berkeley's research, Norway's ABB-FlAkt and Norsk-Hydro jointly developed the FlAkt-HYDRO process, which is also a seawater desulfurization technology using only seawater as the absorption solution without adding other chemicals. Bechtel developed the desulfurization process by adding lime slurry. This process, which has been demonstrated in the United States but has not been widely used, requires the addition of lime slurry as a way to adjust the alkalinity and increase the desulfurization effect.

2.2. Process Classification

The first category is the process using pure seawater as the absorption solution without adding any chemicals, represented by the FlAkt-HYDRO process developed by ABB Norway. Unit 4 (300NV) of West Power Plant of Shenzhen Energy Group has successfully introduced a set of pure seawater desulfurization system from ABB of Norway, which was completed at the end of 1998 and successfully passed the continuous operation for 72 hours on March 8, 1999. In addition, the 6×6O0NW seawater FCD system of Fujian Zhangzhou Houshi Power Plant was put into operation together with the unit, among which the #1 and #2FCD systems were put into operation in November 1999 and June 2000 respectively. The Houshi power plant is invested by Formosa Plastics USA and constructed and operated by Huayang Electric Co., LTD.

We can see in the picture through the induced draft fan, precooler into the boiler, boiler flue gas and after after the condenser cooling water through the circulating pump into the seawater desulfurization desulfurization absorption tower spray device, sprayed with the SO2 in flue gas neutralization, after absorbing SO_2 of seawater into the aeration tank and mix a lot of water, After aeration, each index reaches the specified value and then the flue gas after desulfurization is discharged into the atmosphere through the chimney.

The second type: add a certain lime in seawater to adjust the alkalinity of the absorption solution, represented by the desulfurization process of Bechtel company in the United States, this process has been built in the United States demonstration project, but has not been promoted and applied.

The system consists of flue gas pre-cooling system, absorption system, recirculation system, electrical and instrument control system, etc.

The main principle of the technology is to take advantage of the magnesium content in seawater, add lime slurry, reaction to produce magnesium hydroxide, magnesium hydroxide can effectively absorb sulfur dioxide.

The process flow is as follows:

Two percent of the total cooling water goes into the absorber, and the rest is used to dissolve gypsum crystals generated from desulfurization. In the regeneration system, the mixture of lime or gypsum is added to improve the alkalinity required for desulphurization. Soluble magnesium and alkali in seawater also produce $Mg(OH)_2$, which can quickly absorb SO_2 in flue gas.[2]

3. Process Characteristics and Influencing Factors

3.1. Process Characteristics

Firstly,Seawater flue gas desulfurization technology, that is to use seawater as the absorption liquid, the process does not add any chemical substances, because it does not involve the preparation of absorbent and subsequent treatment, as well as ash and slag treatment system, so the wage system is simple. The second is that the absorption system will not produce scaling, blocking and other operational problems, the system can be used high, like the previous limestone gypsum wet denitration and LIFAC desulfurization technology, have varying degrees of ash blocking problems, and seawater flue gas desulfurization technology is not involved in this problem. Third, because the reaction products are ions and gases, there is no desulfurization slag generation, and no desulfurization slag treatment facilities are needed. The fourth is high denitration efficiency, can reach more than 90%, very good to complete the denitration task, to meet the discharge requirements, there are obvious environmental benefits. The fifth is an extension of the first feature. Because the system is simple and does not require the addition of chemicals, the investment and operating costs are low, usually one-third lower than the wet limestone gypsum method.

3.2. Influencing Factors

Because we use water as absorbing liquid, and so are the main factors affecting the sea water, sea water alkalinity and the water temperature, sulphur content in flue gas and air, why there are air, because the water after the reaction with SO_2, the seawater into acid, low pH, hydrogen ions and carbonate reaction generates carbon dioxide in the sea water, direct discharge is bad for the environment, Therefore, we need to treat acidic wastewater. This treatment process is achieved through aeration, which removes CO_2 produced by chemical reaction and improves pH value.

1. The higher the sulfur content of flue gas is, the more seawater and aeration is needed. This is easy to understand, the higher the sulfur content of the flue gas, the higher the concentration of reactants, so we need to provide more seawater and aeration to achieve a better removal efficiency.

2. As the seawater can absorb more sulfur dioxide, the Ph of the wastewater is lower. In order to achieve the Ph of the wastewater up to the standard, more aeration is needed to achieve this. Therefore, we can conclude that under the same conditions, the larger the aeration volume, the better the desulfurization effect.

3. As there is a relationship between water temperature and aeration volume, when other conditions are the same, the higher the water temperature, the better the aeration effect and the better the desulfurization effect.

4. The lower the alkalinity of seawater is, the more seawater is needed to meet the requirements of seawater discharge after desulfurization.

5. In winter, the temperature of sea water is low, and the aeration effect is correspondingly poor. In order to achieve the EIA index, more sea water must be used.

4. Application example

4.1. Ship flue gas seawater desulfurization technology

The principle of the seawater desulfurization process is to neutralize the alkaline seawater and filter the SO_2 in the exhaust gas. On ships, the advantage of applying this technology lies in the inexhaustible seawater. Some ocean-going ships such as VLCCs and ten thousand box ships directly use seawater for flue gas desulfurization. However, ships sailing in inland river basins are not dominant. Because the alkalinity of river water is low, close to fresh water, it is necessary to add alkaline chemical additives to meet the requirements of flue gas desulfurization. The additives can choose sodium hydroxide, sodium carbonate etc., increase the alkalinity of the absorbent and further strengthen the desulfurization quality. The desulfurization tower for flue gas desulfurization uses an open structure design. In order to meet the standard of waste gas discharge into the ocean, the seawater with filtered sulfur-containing waste gas must be treated by an aeration system. For the adaptability of the ship, consider designing an aeration tank, which is arranged in the aft peak tank, and part of the tank volume is discarded in exchange for the tank volume. With the overflow displacement method, the fresh seawater and the used seawater are replaced, the latter is diluted and aerated, so that the space on board can be fully utilized, which is very suitable for container ships.[3]Using seawater desulfurization technology on board to control engine emissions, the operation is very reliable and the desulfurization efficiency is high.[4]

4.2. Seawater Desulfurization Technology and Its Application in Qinhuangdao Thermal Power Plant

The desulfurization of Unit 3 (300MW) of Qinhuangdao Power Plant is the first flue gas and seawater desulfurization project of Beijing Longyuan Company with independent intellectual property rights. 95%, the outlet flue gas temperature under design conditions is not lower than 70°C, the effluent meets the national Class III seawater standard, DO>3mg/l, COD≤4mg/l, and the system is set to GGH. (the flue gas volume in this paper is the standard state value). This technology optimizes the commonly used square tower structure into a round tower; the spray pipe adopts a ring structure, and the water distribution is more uniform; it is equipped with an energy-saving anti-clogging spray device, which further optimizes the water distribution with a smaller piezoresistive cost; adopts a new research and development The combination of bulk packing and structured packing has better fluid performance and specific surface area, and further improves water distribution, air distribution uniformity and mass transfer efficiency. The project was put into operation in December 2008.Compared with the No. 4 unit (300MW) which adopts foreign technology, the performance indicators are more excellent, the overall performance of the demonstration project technology is excellent, and the adaptability to the changing range of coal quality and seawater quality has been improved.[5]

5. Flue gas system and SO_2 absorption system of seawater FGD system

5.1. Flue gas system

The flue gas system is mainly composed of a dust collector, a booster fan and a gas-gas heat exchanger (GGH). In order to avoid corrosion, the booster fan is generally designed on the original flue gas side, while the GGH needs to be coated with enamel on its heat exchange surface. The function of the flue gas system is to introduce the original flue gas into the absorption tower for desulfurization after being dedusted by the dust collector, boosted by the booster fan, and cooled by the gas-gas heat exchanger.

The gas-to-gas heat exchanger has two functions:

On the one hand, because the lower the flue gas temperature, the higher the SO_2 absorption rate, and the lower flue gas temperature can reduce the requirements for anti-corrosion materials and fillers in the absorption tower, so the flue gas must be cooled before entering the absorption tower, generally to around 80°C.

On the other hand, after the flue gas is absorbed and purified by seawater in the absorption tower, the temperature is further reduced, but when the temperature is lower than the dew point temperature of the acid gas, condensation is likely to occur, causing corrosion of the flue and chimney. Moreover, the low temperature is not conducive to the diffusion and emission of flue gas, which will cause "white smoke" from the chimney. Therefore, after the flue gas is discharged from the absorption tower, it generally needs to be heated by GGH, so that the flue gas is heated to above 70 °C, and then discharged into the atmosphere through the chimney.

5.2. SO_2 absorption system

The main body of the SO_2 absorption system is the absorption tower, where the absorption of SO_2 and the oxidation of some sulfite radicals are completed. The flue gas entering from the lower part contacts and mixes with the seawater drenched from the upper part of the absorption tower, and the chemical reaction between SO_2 and seawater occurs. , generate SO_3^{2-} and H^+, and the pH value of seawater decreases. The flue gas after desulfurization passes through the mist eliminator to remove mist droplets in turn, and the flue gas heat exchanger is heated and heated up and then discharged from the chimney.

There are generally two types of absorption tower designs. One is a packed tower, which is widely used. Multi-layer packing is set in the tower. The mass transfer process mainly occurs in the liquid film on the surface of the packing. Numerous hollow sheet packings ensure that the gas-liquid two-phase fluid has a good mass transfer surface. And by continuously changing the direction of water flow, the retention time of seawater is prolonged and the full combination of flue gas and seawater is promoted. The advantage is that the mixing of seawater and flue gas is uniform and sufficient, and the desulfurization rate is guaranteed; the disadvantage is that the delay resistance is large, and the operation power consumption is high. The other is a spray empty tower. There is no filling component inside the spray tower. Seawater is led to several nozzles on the upper part of the absorption tower through a booster pump. The nozzles are atomized into fine droplets in the absorption tower. The countercurrent flue gas mixing can achieve the purpose of removing SO2. The advantages are that the resistance of the flue gas is small and the maintenance is relatively simple; the disadvantage is that the mixing effect of seawater and flue gas is not as good as that of the packed tower.

6. Conclusion

Seawater desulfurization technology began to appear in the 1970s. It has the advantages of low investment, high desulfurization efficiency, low operating cost and environmental friendliness. It can be widely used in coastal power, chemical, heavy industry and other enterprises.

In countries with long coastlines, such as China and Asia, there are a large number of coastal power plants, the coastal areas are economically developed, densely populated, and have strict environmental protection requirements, but most areas are listed in acid rain control areas and sulfur dioxide control areas. Therefore, it is of great significance to further develop, optimize and promote the application of seawater desulfurization technology in coastal areas to control the air pollution caused by coal-fired units and save freshwater resources.

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