

# Research on energy saving improvement of ammonia desulphurization tower

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**Abstract.** All Coking chemical industry (also known as coking chemical industry) is a major component of the traditional coal chemical industry in China. In its production process will produce a large number of smokes containing SO<sub>2</sub>. In view of the above problems, the design of ammonia desulfurization tower has been improved in this paper. The pre-treatment step in the industry is completed in the desulfurization tower, and the baffle area is designed to separate the different reactions and collected the spray liquid, and a drainage plate is added at the flue gas inlet. The improved desulfurization tower can ensure the uniform distribution of flue gas inlet, but also can improve the absorption efficiency and increase the recycling of reagents.

## 1. Flue gas desulphurization in coking enterprises

Coking chemical industry (also known as coking chemical industry) is a major component of China's traditional coal chemical industry, but also an important pillar industry of the national economy. Coking and chemical industry, also known as coal high-temperature retorting, refers to the coal under the condition of air insulation, heating to 950 ~ 1050°C, after drying, pyrolysis, dissolution, bonding, solidification, shrinkage, molding and other physical and chemical stages, and obtain the final coke, gas, tar and other chemical products.

Coking enterprise is a heavy pollution unit. In coking, the heat needed for dry distillation is supplied by return gas. There are 80 billion m<sup>3</sup> ~ 3 coke oven gas used as the heat source of coking every year in our country, and the flue gas with SO<sub>2</sub>, NOX has to be discharged about 672 billion m<sup>3</sup> ~ 3. For this reason, the emission standard of pollutants for GB16171-2012 coking chemical industry has been issued by our country.

## 2. Advantages and development of ammonia desulphurization

With the development of desulfurization technology, the disadvantages of limestone process become increasingly prominent. The development of ammonia process will bring more dawn to the desulfurization industry: ammonium sulfate chemical solution can avoid any internal fouling. Compared with the limestone desulfurization tower, it can reduce the defects of absorption tower scaling. Compared with limestone, ammonia has higher reactivity. Under different sulfur content, the removal rate of SO<sub>2</sub> can reach more than 90%. Ammonia desulfurization tower can produce high value by-products, rather than low value calcium sulfate and sulfite sludge. Under high sulfur conditions, the amount of reagent (limestone) is large and the cost is high. Compared with limestone, ammonia desulfurization tower has higher flexibility in operation, especially in the case of high sulfur content.



Compared with limestone, the operation of ammonia desulphurization tower has high reliability and effectiveness.

### 3. Analysis of wet ammonia desulphurization process

The wet ammonia desulfurization process uses mother liquor (ammonium sulfate and ammonia mixed solution) as absorbent and ammonium sulfate fertilizer as by-product. The flue gas discharged from the boiler is washed into the pre-scrubber to remove HCl and HF and cooled to 90~100 C. After washing, the flue gas is removed by the droplet separator to enter the pre-scrubber. In the front washer, ammonia water is washed from the top of the tower to wash the flue gas, and the SO<sub>2</sub> in the flue gas is washed and absorbed and removed. After washing the flue gas discharged, the droplet carried by the droplet separator is removed. The flue gas is further washed in the scrubber, and mist droplets are removed through the mist eliminator at the top of the washing tower. The flue gas enters the desulfurization scrubber and is heated by the flue gas heat exchanger and discharged through the chimney. Ammonium sulfate solution of about 30% concentration in the washing process is discharged from the washing tower. It can be sent to a fertilizer plant for further treatment or sold directly as a liquid nitrogen fertilizer, or it can be further concentrated, evaporated and dried to produce fertilizer for sale.

Ammonia desulfurization means that ammonia water contacts flue gas through spraying. Sulfur dioxide in flue gas is absorbed. Finally ammonium sulfite is produced. The reaction formula is as follows:



Because the flue gas contains high oxygen content, the following oxidation reactions will occur:



## 4. Improvement of desulphurization tower

### 4.1. Improvement of desulfurization tower structure

First of all, we put the pretreatment in the desulfurization tower, which saves space and reduces the operating resistance of flue gas. In this way, the desulfurization tower can be divided into three parts: the pre-washing section, the absorption section and the ammonia removal section.

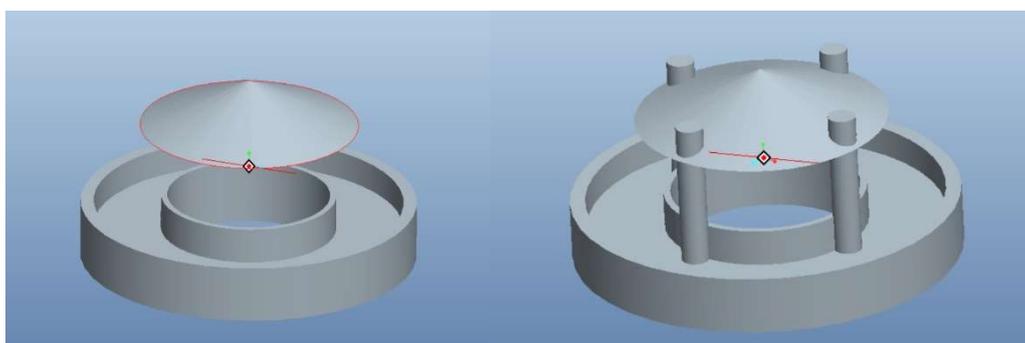
For direct washing section, we use direct spray mother liquor. After denitration, the flue gas is sent to the washing section of the desulfurization tower. It reacts with the upper spray of ammonium sulfite solution and the flue gas is cooled by adiabatic evaporation. By spraying and washing with ammonium sulfite solution, the heat of flue gas makes part of the water in ammonium sulfite solution evaporate and part concentrate. The flue gas is washed through the washing section, and the temperature is cooled down and cooled into the absorption section of the desulfurization tower. The main purpose of such pre-washing is to cool down the flue gas. Therefore, a certain amount of water in the mother liquor is evaporated by spraying, and the concentration of ammonia sulfate in the mother liquor is bound to increase. This is conducive to the subsequent formation of ammonium sulfate solid. This method can also reduce the problem of flue gas, and use this part of heat to concentrate the mother liquor preliminarily.

The absorption section mainly realizes the process of absorbing sulfur dioxide by ammonia. Sulfur dioxide is removed by spraying 10% dilute ammonia water and process water in the absorption section of flue gas after cooling in the washing section. Through consulting the data, adding 10% ammonia water to the reflux place instead of spraying directly on the top of the main absorption area of  $\text{SO}_2$  can effectively prevent ammonia escape and control the concentration of  $\text{NH}_3$  in the outlet flue gas below 60 ppm, which meets the industrial environmental protection standards. Instead of spraying the mixture of ammonia and ammonia sulfate directly from the bottom of the absorption tower with a pump, we used a dilute ammonia water spray with a concentration of 10% to remove sulfur dioxide.

In the ammonia removal section, wet electric dedusting technology is currently used directly, and we use sprinkling clean water. The principle is to use ammonia to dissolve water easily to absorb excess ammonia in the flue gas. We use water to absorb ammonia and use our unique baffle technology to collect the ammonia from the absorbed ammonia and recycle it.

In response to the different reactions in different regions above, we are bound to separate the different processes. Because each spray uses different types and concentrations of liquids, non-separation can also result in low-impact partial spraying of the upper solution, and we need to collect the sprayed liquids.

Based on the life phenomenon of umbrella in the rain, I designed the following middle baffle layer, the structure is shown below.



**Figure 1.** Sketch map of partition board

Because the smoke rises from below to the top of the tower, we must first have enough space on the partition to ensure that the smoke passes smoothly, so we have a certain number of round holes in the middle of the partition. And we need to make a groove shape to ensure that the second layer of spray liquid cannot flow through the gap to the first layer of spray section, that is, use the groove to collect the basin after the liquid.

The structure we designed can solve the above problems well. We have designed holes in the baffle according to the amount of flue gas, and there is a certain height of cylindrical pipes around the holes. There is also an umbrella-shaped structure above the cylindrical pipe to ensure that the liquid does not fall to the bottom after the upper spray.

#### *4.2. Improvement of flue gas inlet*

The current desulfurization tower mainly adopts the form of unilateral inlet, which will inevitably lead to uneven distribution of flue gas. The non-uniform distribution of gas flow is a major factor affecting the desulfurization efficiency. Excessive local velocity of flue gas will reduce the gas-liquid contact time, thus reducing the absorption efficiency and seriously affecting the normal operation of the desulfurization tower.

At present, for the problem of uneven distribution of flue gas, a better treatment is double inlet desulphurization tower. The cost of flue layout of double inlet absorption tower is equivalent to that of single inlet tower, but the floor area is reduced, the elbow is reduced, the total pressure drop of flue is reduced, and the energy consumption is saved. The double inlet absorber also eliminates the solid

deposition at the inlet. It is also conducive to the long-term stable operation of the desulfurization system, and the flow field uniformity is better than that of the traditional absorber.

## 5. Innovation points of the project

This project mainly optimizes the structure of the flue gas ammonia desulfurization tower in coking enterprises, which helps to improve the absorption efficiency and ensure the more stable operation of the desulfurization tower.

### 5.1. The redesign of desulfurization tower

The pretreatment part is placed inside the desulfurization tower. The desulfurization tower is divided into three parts: pre-washing section, absorption section and ammonia removal section, which is helpful to reduce the floor area and flue gas flow resistance.

### 5.2. Design of clapboard

Using the basic model of umbrella in life, the designed baffle layer can ensure that the spraying liquid does not affect the reaction in part while passing through the flue gas, and can store and collect the spraying liquid to increase the recycling of chemical reagents for desulfurization reaction.

### 5.3. Design of flue gas inlet

In view of the uneven distribution of flue gas at the entrance of the original desulfurization tower, and considering the influence of site construction and other factors, the drainage plate was designed, and the results were verified by fluent simulation.

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