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The Analysis of Using MGGH in Flue Gas Desulphurization (FGD) System in Cement Plant

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Abstract

The paper first introduces the background and the mechanism of secondary pollution from desulfurization in cement plant. Then, take plant A as an example, using MGGH (media gas-gas heater) to control "white smoke". MGGH uses heat medium water to heat transfer between the original flue gas and the clean flue gas, without additional heat source, and has obvious economic benefits, which is the inevitable development direction of desulfurization reform of cement kiln system in the future.

Keywords

MGGH, Cement Plant, Flue Gas Desulphurization, "White Smoke"

1. Introduction

According to the National Standard GB4915-2013 (Air Pollutant Emission Standard for Cement Industry) of the People's Republic of China, since July 1, 2015, the SO_2 emission limit of new cement kiln production line is 200 mg/m^3 in China, and the SO_2 emission limit of new cement kiln production line in key areas is 100 mg/m^3. Using flue gas desulphurization (FGD) to decrease SO_2 emission may cause "white smoke", which is because the steam in worm flue gas turns to water drops when it meets cold air outside. The refraction and scattering of light by small droplets make the flue gas become gray and white at the chimney exit, which results in visual pollution. In addition to condensate water, there are many impurities such as sulfate and dust in small droplets, which cause certain pollution to the environment (Zhang & Yang, 2018).

2. The Mechanism of "White Smoke"

According to **Figure 1**, when the temperature of the smoke reduces from A to C, the area between the line of ADFC and the line of AC means the appearance of "white smoke". If the temperature of the flue gas first increases from A to B, and then decrease from B to C, there is no "white-smoke-area".

There are two reasons to create "white smoke". The first is the temperature of the flue gas, and the second is the pressure. There is little difference between flue gas pressure in the desulfurization tower and ambient pressure, which does not affect the generation of white smoke. When the wet flue gas is discharged from the chimney and mixed with air, the saturation of water vapor in the flue gas decreases with the decrease of the temperature of flue gas, resulting in a large number of small droplets and the formation of "white smoke".

According to **Figure 1**, the mechanism of reducing "white smoke" is to increase the temperature of the flue gas, thereby increasing the unsaturation of wet flue gas at the desulfurization outlet, so that in the process of cooling, wet flue gas is always unsaturated, that is, no "white smoke" is produced (Deng, 2018).

3. Project Background

The flue gas volume of a cement production line in plant A is 800,000 Nm^3/h. After flue gas desulfurization (FGD) modification, the temperature of flue gas at the outlet of the desulfurization tower is 50˚C. When the flue gas discharges from the direct chimney, the "white smoke" appears and accompanied by "gypsum rain". A set of MGGH system has been developed to alleviate or even eliminate the phenomenon of "white smoke" and "gypsum rain".

4. Project Design

The flue gas temperature at the outlet of the desulfurization tower is 50˚C. According to the empirical algorithm, the temperature of the flue gas at the outlet of the chimney is as below

$$T_s = T_b - \frac{H}{10} = 50 - \frac{100-30}{10} = 43℃$$

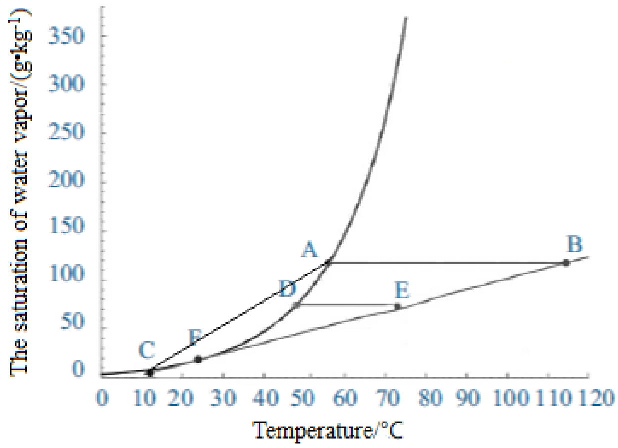

Figure 1. The relationship of the temperature and the saturation of water vapor of the flue gas.

T_s is the temperature of the flue gas at the outlet of the chimney. T_b is the temperature of the outlet of the desulfurization tower. H is the height of the desulfurization tower.

In this project, chimney is on the top of the desulfurization tower. The height of the desulfurization tower is 30 meters, and the height of the chimney is 100 meters.

According to **Figure 2**, in summer, the outside temperature of chimney outlet is about 20˚C (point A). The flue gas is heated from point C (43˚C) to point D (about 60˚C), then cooled to point A (20˚C). When the flue gas temperature passes through the line CDBA in turn, no "white plume" will be produced.

The formula for heat transfer during flue gas heating is as follows:

$$Q_1 = c_1 m_1 \Delta t_1 = c_1 \cdot \rho_1 V \cdot \Delta t_1$$

c_1 is the specific heat capacity of flue gas when the temperature is below 100˚C, which is 1.3811 KJ/m^3. ρ_1 is the flue gas density at 50˚C, which is 1.097 kg/m^3. V is standard flue gas volume, which is 800,000 Nm^3/h. Q_1 is the heat energy needed to be absorbed When flue gas is heated from 43˚C to 60˚C per hour. Δt_1 is the Temperature difference from 43˚C to 60˚C. By calculation, according to the formula, the value of Q_1 is 2.06*10^7 KJ/h.

According to **Figure 3**, in winter, the outside temperature of chimney outlet is about 0˚C (point A). The flue gas is heated from point B (43˚C) to point C (about 80˚C) and then cooled to point A (0˚C). When the flue gas temperature passes through BCA in turn, no "white smoke" will be produced.

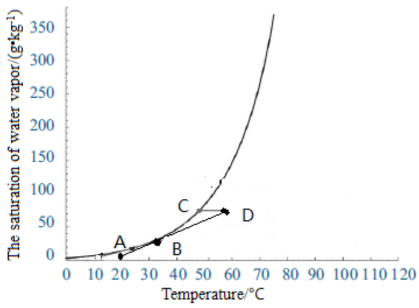

Figure 2. The relationship of the temperature and the saturation of water vapor of the flue gas in Plant A in summer.

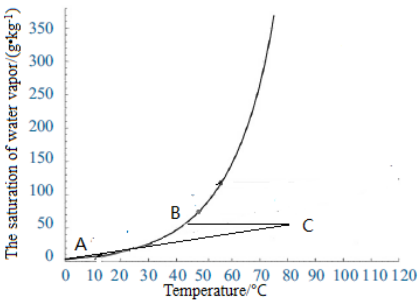

Figure 3. The relationship of the temperature and the saturation of water vapor of the flue gas in Plant A in winter.

The formula for heat transfer during flue gas heating is as follows:

$$Q_2 = c_1 m_1 \Delta t_2 = c_1 \cdot \rho_1 V \cdot \Delta t_2$$

Δt_2 is the Temperature difference from 43˚C to 80˚C. By calculation, according to the formula, the value of Q_2 is $4.48*10^7$ KJ/h.

MGGH is used in this project to decrease the "the white smoke". The heat medium water in the heat exchanger is heated by the original flue gas in front of the desulfurization absorption tower, and then the heat medium water is sent to the heating heat exchanger after the desulfurization absorption tower to increase the temperature of the clean flue gas. Circulating Pump is used to transport the heat medium water. Considering the expansion of heat medium water when it is heated, an expansion tank is set up in the circulating pipeline. The structure of MGGH is as follows (**Figure 4**).

The difference between MGGH and traditional GGH is that MGGH uses heat medium water to transfer heat. The cooling side of flue gas is completely separated from the heating side of flue gas. There is no interaction caused by the leakage of flue gas. The SO_2 and fly ash in the original flue gas will not leak into the clean flue gas after the desulfurization absorption tower, due to the sealing problem of the equipment. MGGH does not use additional heat sources to heat the flue gas, so it has good economy. Heat can be controlled by the rate of circulating heat medium water flow to keep the different temperatures in summer and in winter. It is also can keep flue temperature higher than dew point temperature to prevent SO_2 corrosion.

Similarly, according to above formula, the temperature of flue gas at the cooled heat exchanger can be calculated. At the same time, due to heat loss, the coefficient of 1.1 times can be considered. The original flue gas passes through a

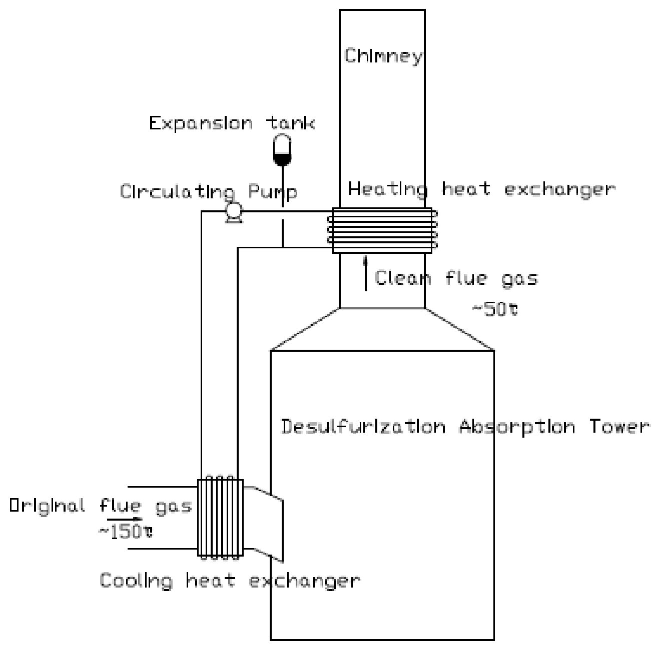

Figure 4. The system of MGGH.

cooling heat exchanger, and the temperature drops from 150˚C to 130˚C in summer, and 150˚C to 110˚C in winter.

The formula for calculating acid dew point of flue gas is as follows:

$$t_{aid} = 20\lg V_{SO3} + \alpha - 80$$

V_{SO3} is volume fraction of SO_3 in flue gas. α is moisture constant. When volume fraction of moisture in flue gas is 5%, 10% and 15%, moisture constant is 184, 194 and 201 respectively (Li & Tong, 2009). According to the calculation, SO_3 content in the tail gas of cement kiln is very low, and the acid dew point of the original flue gas is less than 100˚C, so the temperature of original flue gas is higher than the acid dew point.

When designing MGGH, the following aspects should be considered:

1) Considering the dust content in flue gas, anti-wear devices should be installed on the windward side of MGGH heat exchanger tubes.

2) In order to improve the heat transfer rate, MGGH heat exchanger tube adopts fin structure.

3) In order to avoid the accumulation of ash in MGGH, it is necessary to install auxiliary means to clean ash. Sound soot blower is used in this project.

4) Medium-thick wall and No. 20 steel can be selected for heat exchanger tubes in high temperature section, and ND steel and other high-quality corrosion resistant materials can be selected for heat exchanger tubes in low temperature section to improve corrosion resistance (Chen, 2014).

While using MGGH technology to decrease the amount of "white smoke", it also has the following functions:

1) Reduce the corrosion of tail flue and chimney. When the temperature of the clean flue gas is heated above the dew point, the dew attachment of moisture in the chimney is reduced and the formation of dilute sulfuric acid is prevented.

2) Increase the elevation of the flue gas and reduce landing concentration of pollutants.

3) The temperature of the original flue gas entering the desulfurization tower decreases, so that the evaporation of water in the absorption tower is reduced, and the water consumption of desulfurization is reduced (Li et al., 2017).

5. Conclusion

The installation of MGGH in flue gas desulfurization system can effectively control the generation of "white smoke" and "gypsum rain". Compared with GGH, MGGH has no air leakage, corrosion and blockage. At the same time, MGGH uses heat medium water to heat transfer between the original flue gas and the clean flue gas. MGGH uses no additional heat source, which has obvious economic benefits, which is the inevitable development direction of desulfurization reform of cement kiln system in the future.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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