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Study on the Change Characteristics of Dust Specific Resistivity and Electrostatic Precipitation Efficiency

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Abstract. Specific resistance is an important factor affecting the performance of ESP. For the dust resistance than the impact of electrostatic dust removal mechanism, the relationship between dust specific resistance and electrostatic dust removal efficiency, high dust specific resistance and low dust specific resistance in the electrostatic dust produced by the adverse effects. The method of controlling the specific resistance of dust is proposed, which reduces the specific resistance of high specific resistance dust by adjusting the flue gas humidity, changing the flue gas temperature and flue gas quenching. The surface modification technology is used to improve the low specific resistance dust. By controlling the dust specific resistance to 104 to 1010 Ω · cm, the electrostatic precipitator is kept at a high dust removal efficiency.

1. Analysis of the mechanism of electrostatic dust removal by dust resistance

In the use of electrostatic dust removal technology in the thermal power plant units, the factors that affect the electrostatic dust removal, smoke and dust gas humidity, smoke and gas flow, smoke and gas flow and flow rate, dust concentration, dust collector structure[1]. In order to further improve the performance of electrostatic dust, this paper focuses on the study of the effect of dust resistance on electrostatic precipitator, and then puts forward a reasonable method to control the specific resistance of dust [2].

1.1. The nature of coal dust

The dust particles of coal dust itself have their severity (or true weight), and as aggregates, the severity of the accumulation is called heavy (or bulk). Severe on the gravity, inertia, centrifugal dust collector dust removal rate is very large, and the accumulation of heavy dust and storage equipment and dust and then the problem of re-flying.

Dust particles generated by the high temperature, dust particles on the surface of the charge, Brownian motion and acoustic vibration and magnetic force, the dust particles can cause mutual impact and cohesion. This feature on the dust removal principle and dust removal efficiency plays a role cannot be ignored.

Dust particles can be wetted by water (or other liquids), with wetting properties. All dust can be divided into hydrophobic dust and hydrophilic dust according to the degree of water wetting. But the wettability also decreases with decreasing particle size and increasing temperature.

Dust in the process of production, due to the intense impact of materials, dust particles or between the dust and material friction, radiation and corona discharge and other acts of charge, its physical properties will change, such as cohesion and the adhesion is enhanced and the stability of the dust particles in the gas is affected. The type of dust, temperature and humidity affect the charge of dust particles.

1.2. Relationship between Dust Specific Resistivity and Electrostatic Precipitation Efficiency

The specific resistance of dust, marking the conductivity of dust, it has a great impact on the performance of electrostatic precipitator [3].

Dust is to rely on dust between the dust particles and dust between the surface adhesion and electrical adhesion, and accumulation in the dust pole. The larger the diameter of the dust particles, the smaller the surface adhesion, easy to produce re-scattering. The electrical adhesion is determined by the Coulomb force generated by the contact between the dust particles and between the dust particles and the dust pole. Electrical adhesion is approximately

$$\mathrm{fe} = d^2(k_2 Ei\rho - E^2/32) \quad (1)$$

In the formula: k_2- Experimental constant

ρ - The specific resistance of dust

The first item is the Coulomb force, the second is the repulsive force.

Conductive through the dust inside the body of the internal electrons or ions, known as the body conduction, the corresponding dust specific resistance, said volume resistivity, mainly depends on the chemical composition of dust [4]. Conductive dust particles along the adsorption of water or surface chemical film, called the surface conduction, the corresponding dust than the resistance is called the specific resistance of the surface. The specific resistance of small dust charged and loss of power are relatively fast, so unstable, and vice versa is more stable; the temperature increases the charge capacity, humidity increases the charge capacity to reduce [5].

Specific resistance of 104 ~ 1010Ω · cm in the dust, is suitable for ordinary electrostatic precipitator the best dust. It is characterized by when the charged dust particles reach the electrode, the charge of the neutralization properly, the resulting adhesion is appropriate and does not cause anti-corona. In other conditions the same circumstances, with high dust removal efficiency, and almost no change in the region than the resistance of the impact. The following figure is the same electrostatic precipitator in other conditions the same circumstances, the relationship between the resistance value and dust removal efficiency [6].

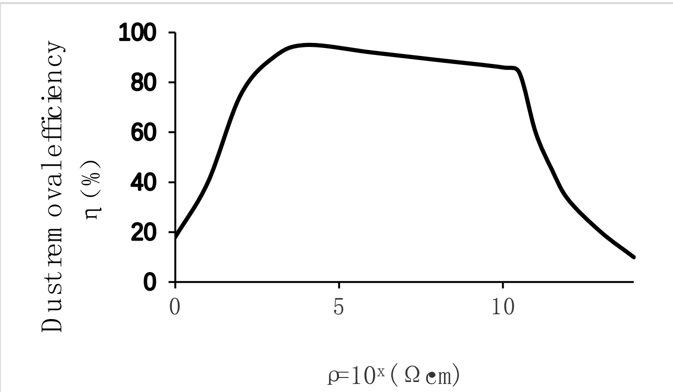

Figure 1. The relationship between dust resistance and dust removal efficiency of the same electrostatic precipitator under the same conditions.

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1.3. Effect of Low Specific Resistivity on Electrostatic Precipitation
Dusts with a resistance less than 104Ω · cm are called low resistance or strong conductive dust. Its characteristics are due to dust conductivity is good, when the charged dust particles to reach the electrode, the immediate loss of charge. Due to loss of charge at the same time, but also lost dust particles in the semi-free electron (at the same time around two or more nuclear rotation of the electrons), at this point the electrical adhesion in the Coulomb force disappeared, dust particles were detached from the dust pole, the formation of dust and then fly. Scattered dust collides with the ions in the air to regain the negative charge, moving to the anode plate under the action of the electric field force, forming a jump between the anode plates, causing the dust to be taken out by the electrostatic precipitator. With electrostatic dust treatment of a variety of metal dust and graphite dust, carbon black dust can see this phenomenon. Jump as shown in the figure [7], making the low specific resistance dust in the ordinary dust collector cannot achieve the effect of dust, electrostatic precipitator dust removal efficiency.

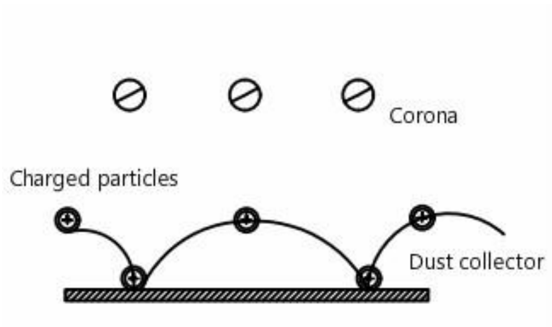

Figure 2. Low specific resistance dust jump phenomenon

1.4. Effect of high dust specific resistance on electrostatic dust removal
A specific resistance value greater than 104Ω · cm is called high resistance dust [2]. As the electrical adhesion, so that dust particles in the dust on the accumulation of dust layer. At this point, the corona current through this high-resistance dust layer, in some areas of the current density and resistance value of the opportunity may be much more than enough to cause the dust layer breakdown of the electric field strength. Due to the local high current density formed by this breakdown, the corona current is converged to the breakdown point, resulting in a large amount of ion activity. In the effective dust removal space, there are positive, negative ions, positive ions and negatively charged dust particles, the dust layer can be seen on the surface of the spark, so that the dust charge greatly deteriorated. At the same time in the corona pole on the dust adhesion is particularly strong, it is easy to vibration, the formation of corona pole thick. The result of corona discharge causes the space near the dust collector to produce a large amount of positive ions, partially or totally neutralizing the negative charge carried by the particles, and the dust removal efficiency is greatly reduced.

2. Method of controlling the specific resistance of dust

2.1. Factors that affect the specific resistance of dust
In addition to the type of dust, the temperature, humidity and chemical composition in the flue gas will affect the specific resistance of dust particles.

The specific resistance of the dust layer increases significantly as the temperature increases due to the reduced ability of the dust particles to adsorb moisture or dust in the dust. And because the body of electronic heat generated by the volume of conduction is very weak, so the dust at this time the specific resistance to reach the maximum. The size of the maximum value varies with the nature of the dust. The greater the humidity of the same dust is, the smaller the maximum resistance is, and the maximum value moves to the low temperature with decreasing humidity [8] (Figure 3).

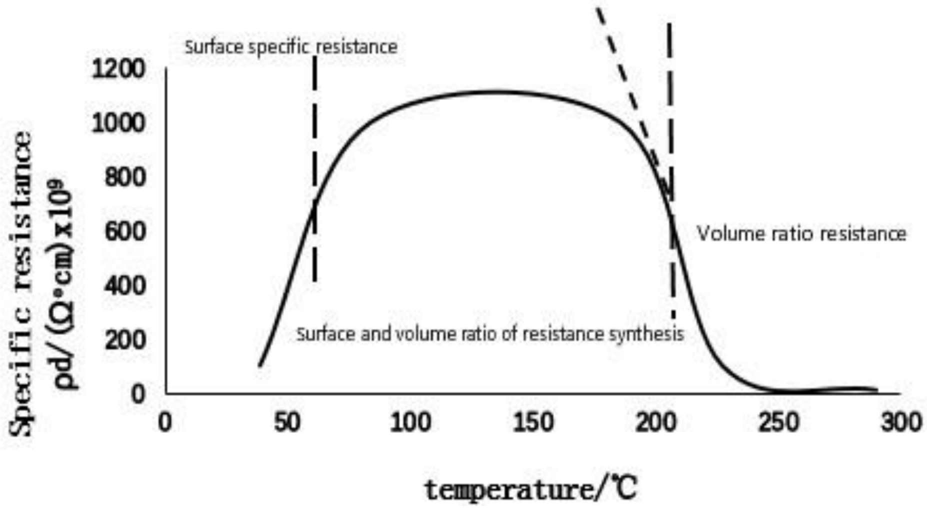

Figure 3. The relationship between temperature and specific resistance

In the case of the same humidity, the relationship between the temperature and specific resistance of different gases (Figure 4).

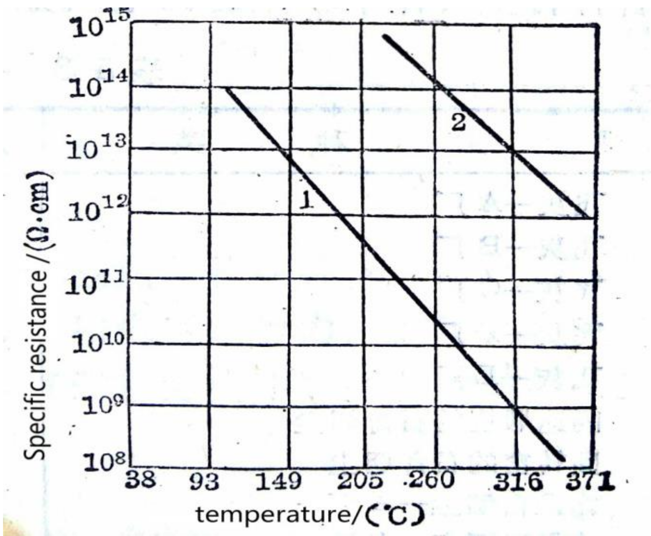

Figure 4. The relationship between temperature and specific resistance 1-Cement kiln dust 2- Calcium oxide dust.

In the case of constant gas composition, the relationship between temperature and specific resistance of different humidity (Figure 5, 6).

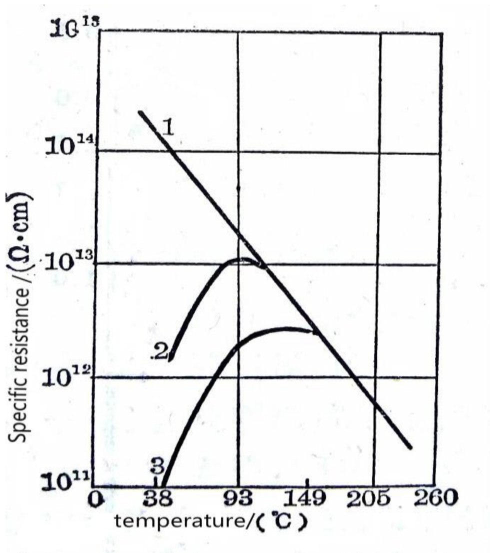

Figure 5. The relationship between temperature and specific resistance Dry air 2-1%H20 3-3%H_2O.

Most dust-laden gases contain different concentrations of sulfur dioxide, at 600 ℃ or more, due to the role of metal oxide catalyst, a part of sulfur dioxide can be converted to sulfur trioxide. When the temperature is below the dew point, the adsorption speed of the dust surface is accelerated. However, in most cases, even if the temperature is much higher than the dew point, the adsorbed matter will be deposited on the surface of the dust to form the surface conduction channel. Boiler emissions of flue gas will be about 0.5% of the sulfur dioxide into sulfur trioxide.

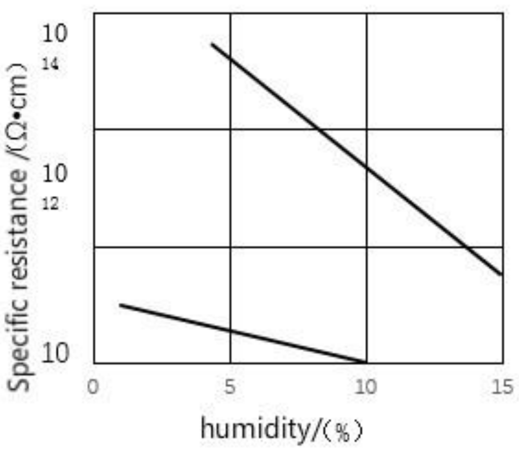

Figure 6. The relationship between SO_3 and H_2O and specific resistance

2.2. Reduce the specific resistance of high specific resistance dust
For high specific resistance dust, the specific resistance can be reduced from the following aspects.

2.2.1. Adjust the flue gas humidity. Flue gas humidity can change the specific resistance of dust, in the same temperature conditions, the greater the moisture contained in the flue gas, the smaller the resistance. Dust particles adsorb water molecules, and the conductivity of the dust layer increases. As the humidity increases, the breakdown voltage increases, the breakdown voltage and air moisture content as shown in Figure 7.

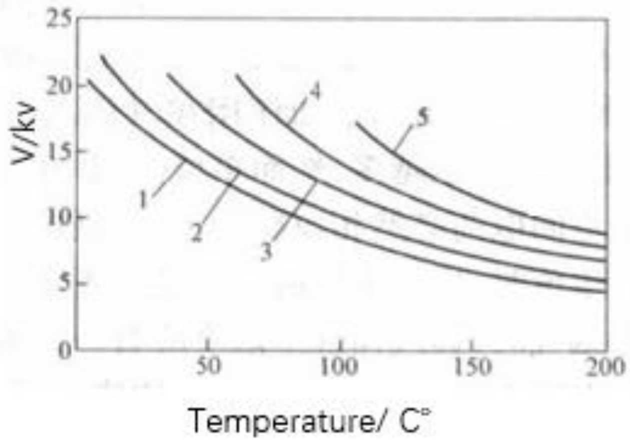

Figure 7. The relationship between the air temperature, humidity, and breakdown voltage 1- Humidity is 1%;2- Humidity is 5%; 3-Humidity is 10% ;4-Humidity is 15%; Humidity is 20%.

It can be seen that as the moisture content in the air increases, the power plant breakdown voltage increases accordingly, the spark discharge is more difficult to occur. This effect is of great value to the electrostatic precipitator, which allows the precipitator to operate stably under elevated voltage conditions. Increased strength of the power plant will significantly improve the dust removal effect.

2.2.2. Change the flue gas temperature. Many industrial dust in the 423-427K temperature range than the higher resistance, but if the flue gas temperature dropped to 403K below, or rose to 623K or more, the dust can have sufficient conductivity.

Therefore, by studying the change of the specific resistance of the dust with temperature, it can be seen that the position of the dust resistance on the curve is determined, and the flue gas temperature is reduced or the flue gas temperature is reduced, so that the specific resistance of the dust is reduced.

However, from the dust resistance curve, the impact of high flue gas temperature on the electrostatic precipitator is mostly negative, if possible, or to make the electrostatic precipitator at a lower temperature to run better.

2.3. Improve the specific resistance of low specific resistance dust

2.3.1. Surface modification technology. Surface modification technology refers to the use of a certain resistance value of the conductive coating covering the dust collection board, increasing the resistance between the particles and the dust collector, balancing the high conductivity of particulate matter [10]. Increase the charge time of the particles, so that it can be more long time attached to the dust board, enough to wait for the cleaning device to clean it [9], as shown in Figure 8.

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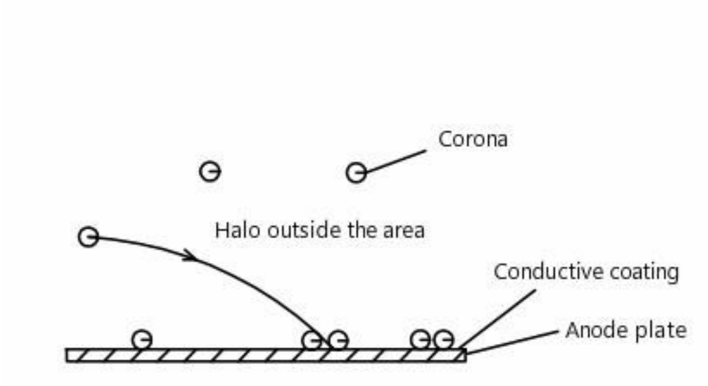

Figure 8. The Movement Characteristics of Particles in the Electrode Coating.

3. Conclusion

Low dust specific resistance due to easy to live, but also easy to lose electrons, likely to cause jumping phenomenon, so that the efficiency of the precipitator. High specific resistance dust is neither easy to charge, it is not easy to discharge, likely to cause the phenomenon of anti-corona, will also reduce the efficiency of the precipitator.

For high specific resistance dust, by adjusting the flue gas humidity, change the flue gas temperature, flue gas quenching and other methods to reduce its specific resistance to 104 ~ 1010Ω · cm, so that the efficiency of ESP. For low specific resistance dust, through the surface modification technology, particle mixing quality, etc., to increase its specific resistance to 104 ~ 1010Ω · cm range, thereby improving efficiency.

References

[1] Donglin Chen,Kang Wu,Xi Zeng, Review on technology for dust removal from flue gas of coal-fired boilers[J],Environmental engineering,2014,32(09):70-73+162.
[2] Peng Chen, Present situation and prospect of electrostatic precipitation technology development[N], China metallurgical news, 2016-06-23(008).
[3] Keping Yan,Shuran Li,Qinzhen Zheng,Jingxin Zhou,Yifan Huang,Zhen Liu,Development and application of electrostatic precipitation technology[J/OL],High voltage engineering, 2017, 43(02): 476-486.
[4] Shumin Ma,Jianwen Su, Analysis of specific resistance of coal ash[J], Metallurgical safety, 1981, (01):21-23.
[5] Minkang Tang,Study on dust accumulation and its specific resistance[J],Jiangxi nonferrous metals,1991,(04):235-238.
[6] Qinglin Zhang,The main controlling factor of ESP[J],Heilongjiang paper making,1998,(02):31-32.
[7] Bowen Luo,Shibin Geng,Improvement measures of electrostatic precipitation technology for different specific resistivity particles[J],Clean and air conditioning technology,2016,(04):91-94.
[8] Xianghua Zhang,The main factors that affect the specific resistance of dust[J],Industrial safety and environmental protection,2011,37(06):34-35.
[9] Wenge Hao,Liyan Dai,Xiaomin Hu,Xueling Wei,Collecting low-resistivity dust with electrostatic precipitator[J],Journal of northeastern university(natural science), 2007, (03): 426-429.
[10] WeiZhuo Zhu,Experimental study on collection of low resistivity fly ash in a high temperature electrostatic precipitator[D],Zhejiang university,2016.