Integrated Clarification Technology for De-dusting, Desulfurization and Odor Elimination Preposed-spraying-screen Static Electrical Soot Remover

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Abstract: Based on the truth that traditional ESP is unable to capture the fine dust of low specific resistance efficiently, the paper introduced a self-determination developed technology known as "an oily fine soot dust removal equipment". This technology, also known as the "preposed-spraying-screen static electrical soot remover", has awarded the invention patent certificate issued by the National Patent Bureau. With this new technology, ESP can capture fine dust of low specific resistance efficiently (such as soot and black carbon), therefore breakthrough the specific resistance lower limit law for traditional ESP. Besides, the lower limit range of specific resistance for ESP's high efficiency dust capture is largely expanded; and high efficiency desulfurization can be approached simultaneously, thereby largely expanded the technological field of the combination of ESP and desulfurization equipment. With the adoption of using simplified agent plus water spray as deashing method, the new technology has overcome the problem of secondary dust emission during the vibration deashing in traditional ESP and oily soil. As "Preposed-Spraying-Screen Static Electrical Soot Remover" has reformed the traditional ESP from the above three aspects, the traditional ESP technology is glowed up with strong vitality.

Keywords: water medium, screen, static-electrical field, fine dust of low specific resistance, lower limit of specific resistance, simultaneous desulfurization, deodorization

1 FORMATION CAUSE AND CHARACTERISTIC OF FINE DUST OF LOW SPECIFIC RESISTANCE

1-1 Fine dust of low specific resistance: Usually are dust with specific resistance≤10^3 Ω·cm. Soot, and carbon black are the typical examples.

1-2 Formation of fine dust of low specific resistance:

According to research, When the combustion of hydrocarbon occurred, due to the congruence and production of arene during the dehydrogenation and cracking process, substance of highly contain carbon (that is black smoke or soot) will emerge. This phenomenon is known as condensation. Condensation and dehydrogenation are production causes of black smoke (or soot).

In practice, smoke of low specific resistance mainly response to the black soot caused during the combustion of fuel products, rubber and cotton wool products.

1-3 Characteristic of fine dust of low specific resistance

1-3-1 The dust composition is mainly soot and carbon black, with low specific resistance, usually ≤10^3 Ω·cm;

1-3-2 Fine dust particles: basically the dimension of particles is between 0.01 μm -0.1 μm, as for those are >1.0 μm or <0.01μm, belongs to the fine-super fine particles; and the bulk density r is between 0.025 g/cm³-0.25 g/cm³. They behave as dust particles float in the air easily, which neither can be easily separated by gravity, centrifugal force, coulomb force and other external force, nor can be capture efficiently.

1-3-3 Because of the large amount of oil residues in dust composition, soot has the characteristics of oiliness and hydrophobic.

1-3-4 Consists of corrosive gases like SO_2 and NO_x;

1-3-5 High flue gas temperature: normally of 223-300℃, sometimes reaches 500℃.

2 ANALYSIS OF CAUSES: LOW EFFICIENCY OF TRADITIONAL ESP AND OTHER DUST REMOVAL PROCESS WHEN DEALING WITH LOW SPECIFIC RESISTANCE DUST

2-1 Traditional ESP: With soot and carbon black as the typical examples of low specific resistance dust, due to its specific resistance≤10^3 Ω·cm, they can be easily dense in the electrical field again and again. During that process, the phenomena of "electrical charge-release-recharge-release again" occurred, causing highly difficulties of effective attachment to the dust collection panel, nor to effective capture. In the end, the dust floated in airflow and escaped. Therefore, traditional ESP is unable to capture low specific resistance dust with highly efficiency.

2-2 Cyclone and water-spray dust collector: Due to the fine particles, low specific weight, oily and hydrophobic features of dust particles, cyclone and water-spray dust collector show low efficiency in the capture of fine dust of low specific resistance.

2-3 Bag filter: Due to integrate elements like high flue gas temperature, oily features , containing corrosive gases like SO_2 and fine particles , not only the construction cost of bag filter is expensive, but also the bag filter is not suitable for treatment of oily and high temperature super-fine dust of black smoke. Besides, simultaneous desulfurization is impossible too. Therefore, bag filter can only shown high

efficiency in the removal of low specific resistance fine dust of less oily feature, lower flue gas temperature and larger particle ($d \geq 0.5$ μm).

From the above we can see that due to the special features of low specific resistance dust, except for bag filter can be used as high efficiency dust collector in some situation for low specific resistance fine dust, almost no other traditional dust collectors can capture fine dust of low specific resistance with highly efficiency.

Therefore, collection of low specific resistance fine dust effectively is still an unsolved problem to the traditional dust collector.

3 INTRODUCTION OF PREPOSED-SPRAYING SCREEN-ELECTROSTATIC SOOT REMOVER (SOOT REMOVER FOR SHORT IN THE FOLLOWING) PROCESS

3-1 Brief introduction of technology

Referring to Fig. 1, the soot dust remover comprises a wet-type dust removal- desulfurization device (3), an electrostatic de-dusting body (15) and a tank (10). The tank (10) is divided into clear water tank and waste water tank by a partition board (7) located at the center of the tank (10), the lower part of the partition board (7) is installed with a filter screen (9), which enabling the waste water being filtered before flowing into the clear water tank (10).

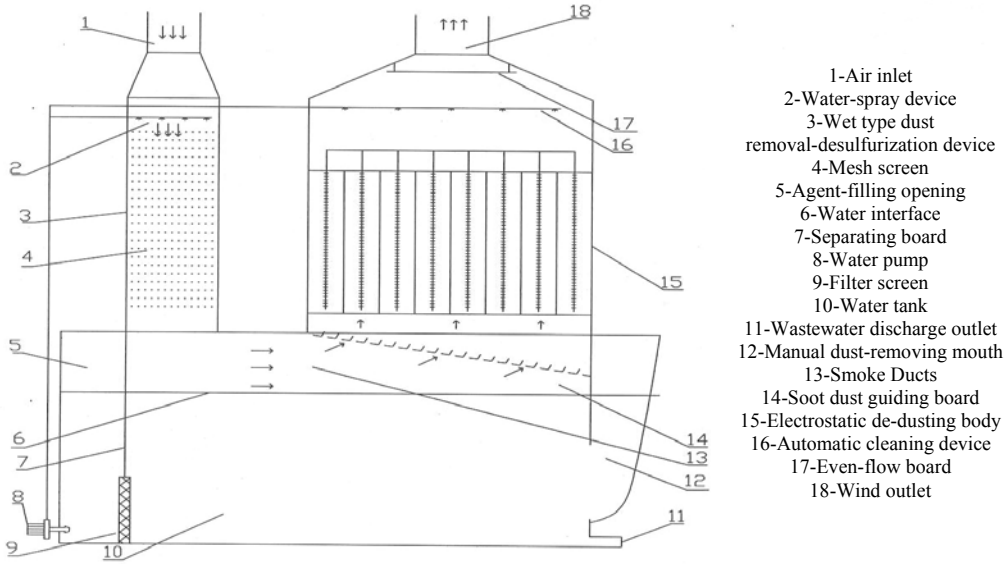

Fig 1 Preposed-spraying screen-electrostatic soot remover

On one side of the tank (10), a manual dust-removing mouth (12) is designed under the water interface (6), while a wastewater discharge outlet (11) is set at the lower part of the tank (10). On the other side of the tank (10), an agent-filling opening (5) is designed above the water interface (6). The wet type dust removal-desulfurization device (3) and electro-static de-dusting body (15) are connected to the upper part of the tank (10). Thus the wet type dust removal–desulfurization device (3), the electrostatic de-dusting body (15) and the water interface (6) formed a closed body. A smoke duct (13) is located above the water interface (6) of the tank (10). Different numbers of layers of mesh screen (4) is installed in the wet type dust removal-desulfurization device (3), and the mesh screen 4 is tangent to the direction of smoke flow at 10°-90°. A wind inlet (1) is designed in the upper part of the wet type dust removal-desulfurization device (3), and a water-spray device (2) is installed on the top of the wet type dust removal-desulfurization device (3), so that the flow direction of the smoke is the same as that of the spraying water from top to bottom. A soot dust guiding board (14) is mounted on the lower part of electrostatic de-dusting body (15) that enables the smoke dust to enter the electrostatic de-dusting body (15) evenly. An automatic cleaning device (16) is mounted on the upper part of electrostatic de-dusting body (15), and an even-flow board (17) and a wind outlet 20 is located on the top of electrostatic de-dusting body (15). Via a water pump (8), the water pipe in the clear water tank of the tank (10) is connected to the water spraying device (2) of the wet type dust removal- desulfurization device (3) and the automatic cleaning device (16) of the electrostatic dust removal -desulfurization device (15).

3-2 Analyze of basic principle

3-2-1 When the soot dust (black smoke) enters the wet type dust removal-desulfurization device (3), with the combination function of both water gravity and fan draft, the soot dust (black smoke) must passes through the holes of the mesh screen (4) together with water fog. Due to the above movement, the soot, black smoke and water fog are fully connected with compulsory, until it is entirely or partly affinitive with water molecule or surrounded by water

molecule in one hand, on the other hand, particles are enlarged or coarsen by it self-extrusion and collision.

When soot, and black smoke are affinitive with water, water has a larger specific resistance and specific weight, which changed water into a resistance additive, weight additive and adhesive, therefore overcome the disadvantages of soot and black smoke, including low specific resistance, hydrophobic, fine particles and low specific weight. With the help of water, the specific resistance of soot and black smoke reach the range for high efficiency dust removal by ESP, which is 10^4-5×10^{10} Ω·cm.

So, when the hydrophilic smoke soot and black carbon of the smoke dust enters the electrostatic de-dusting body (15) via the smoke duct (13) for the second-stage dust removal-desulfurization treatment, the black smoke (soot and black carbon) can be separated by static Coulomb force easily, and will not returned to the airflow. Furthermore, the black smoke (soot and black carbon) can be washed away to the tank (10) via the automatic cleaning device (16) thus reaching the purpose of removing the smoke dust (black smoke) efficiently.

3-2-2 As the above illustration, when flue gas flow into the wet-dust removal-desulfurization device (3), with the combination function of both water gravity and fan draft, the flue gas must go through the tiny holes of the mesh screen (4) together with water, in order to have thorough mixing contact. Multi-layer of screens can repeat the mixing contact for several times, so as to have more thorough effects. Therefore, the desulphurizer in the water media, which is NaOH, will has a thorough absorption reactions, having the reaction equations showed followed, will succeed simultaneous desulfurization of high efficiency.

$$2NaOH+SO_2=Na_2SO_3+H_2O$$
$$Na_2SO_3+SO_2+H_2O=2NaHSO_3$$
$$NaHSO_3+NaOH=Na_2SO_3+H_2O$$
$$Na_2SO_3+1/2O_2=Na_2SO_4$$

In the above 4 reaction, Na_2SO_3 has the ability of absorbing SO_2, while $NaHSO_3$ and Na_2SO_4 don't. Therefore, Na_2SO_3 is treated as the actual absorbent in the recycling process.

The traditional wet-sodium hydroxide absorption-desulfurization process has a desulfurization rate of no less than 90%, therefore it is a desulfurization process of high efficiency.

The cooling function of water media, can also improve the efficiency of desulfurization.

3-3 Function of mesh screen

3-3-1 By forcing the soot and black smoke to be affinitive with water media, that is to have succee in having water covering dust—saying that having water molecule surrounded the surface of both soot and black smoke particles. This help to change the specific resistance of soot and black smoke from the lower dimensional specific resistance to the higher surface specific resistance, which is well prepared for the high efficient ESP operation.

3-3-2 By forcing the SO_2 gas to mix thoroughly with NaOH, which is the desulphurizer in the water media, so as to have efficient absorption reactions occurred.。

3-4 Function of water media

3-4-1 With the help of screen, soot, and black smoke are affinitive with water, water becomes a resistance additive, weight additive and adhesive to both soot and black smoke. These not only change the specific resistance of soot and black smoke rather thoroughly from the lower dimensional specific resistance to the higher surface specific resistance caused by surface water molecule, but also succeed in ESP capturing low specific resistance dust in a high efficiency.

3-4-2 The water molecule on the surface of soot and black smoke has become the adhesive of the soot and black smoke that is located on the electrode panel of ESP, therefore can overcome the problem of soot and black smoke returning back to the air flow, and stable the high dust removal efficiency of electrostatic field.

3-4-3 With the help of screen and the function of desulphurizer NaOH, absorption reactions is completed, having a high efficiency of simultaneous desulfurization fulfilled.

3-4-4 Being the effective cooling agent of fuel gas, it has overcome the problem of high fuel gas temperature.

3-4-5 Being the cleaning media for black soot on the electrode, with the help of the NaOH agent, can overcome the problem of highly oily dust in flue gas cohered with the electrode panel, therefore it can clean the electrode and electrode panel in the electrostatic field.

3-4-6 Being a media that can be recycling used, it can reduce the running cost effectively.

3-5 Function of electrostatic field

3-5-1 Can effectively capture the low specific resistance dust of which surface specific resistance has been changed by the water media.

3-5-2 The high concentration of ozone (O_3) can help to eliminate the odor gases effectively, so as to fulfill the aim of odor elimination.

3-6 Treatments of the produced wasted water

3-6-1 Make the best of the internal water media filtration system in the equipment. The effective way of reducing wastewater is the recycling of water media.

3-6-2 When the internal water media filtration system is no longer effective and influence the dust-removal efficiency, that is to say the wastewater concentration reaches to a certain extend, then should replace with new water media.

4 OPERATION SIGNIFICANCE OF THE SOOT REMOVER TECHNOLOGY

4-1 With the invention of new method to change surface specific resistance of low specific resistance fine dust, the lower limit range of specific resistance for ESP's high efficiency dust capture has been expanded, thereby largely expanded the technological field of the combination of ESP anddesulfurization equipment.

4-2 Having ESP and FGD technology combined together, the ESP can approach simultaneous desulfurization of high

efficiency; thereby can largely expand the technological field of the combination of ESP and desulfurization equipment.

4-3 With the adoption of using simple water spraying + NaOH agent as deashing method, the new technology has overcome the problem of secondary dust emission during the vibration deashing in traditional ESP and oily soil.

5 INTRODUCTION OF PRACTICAL PROJECT

Here is one typical example selected from the large number of practical projects.

Example 1: The treatment project of high concerntration black soot and SO_2, Dongguan Changan JingXia ChangSheng Optical Manufacture Factory.

5-1 Pollution situations: The polluted gases mainly are the high concentration black smoke and SO_2 that formed during the combustion of the diesel oil-stoves in the canteen. The gases emission is about1000 m^3/h -1500 m^3/h, flue gas temperature is≤200℃ , daily operation period≥12 hours. When the stoves are working, the stack emitted high concentration black smoke that just looked like a "black dragon", seriously polluted the ambient environment..

5-2 Treatment effect: The treatment project finished and put into operation on the

20th June 2003, and obtained ideal effects. The cleaned emission showed no sight of black smock and fog from visual observation, having the outlook of normal air.The daily average collection of black soot is about 8 kg-15 kg (in wet state).

In 23rd OCT 2003, being monitored by the Dongguan Environmental Monitoring Station, results showed that the efficiency of dust removal is ≥95.5%, and the efficiency of desulfurization is ≥97.7% (Reference to Table 1). The integrative effects of smoke removal and desulfurization are significance.

5-3 The stability and lifetime of application

The facility has been operated stably till the end of 2006,when the kitchen of client had changed the stove from oil-fuel to gas –fuel. In the 3 years' operation, the integrative effects of smoke removal and desulfurization has been stable and significance.

Table 1 Dongguan Environmental Monitoring Station Monitoring Report [Document (031023) No.1]

Monitoring Spot	Type of fuel	Height of stack	Monitoring Items			
			Particles	SO_2	NO_x	Smoke Blackness
Before treatment	Diesel oil	19m	160	1310	Null	Null
After treatment	Diesel oil	19m	7.2	30	Null	Grade 0.5
Reference: <Emission limit of air pollutants >(DB44/27-2001) First time period Second grade emission limit			120	550	240	Grade 1

Time of monitoring: 23.OCT.2003 Unit: mg/Nm^3

This project has been awarded the "Guangdong Provincial Excellent Environmental Protection Demonstration Project" in year 2004.

6 PROSPECT OF TECHNOLOGY APPLICATION

The technology of soot remover has a vast application market. It is suitable for any dedusting- desulfurization project dealing with fine dust of low specific resistance. The major application regions for treatment can be summarized as follow:

6-1 Soot caused by uncompleted combustion of diesel oil and heavy oil, like kitchen- oven using diesel oil and heavy oil, heating boiler, small generator. Soot is caused because of the uncompleted combustion, due to reason of the facilities itself or the quality of diesel oil and heavy oil.

6-2 Soot caused by the burning of material like rubber, asphalt and plastic, e.g. Black smoke from furnace for medical waste, combustion production places for rubber and asphalt.

6-3 Soot caused by the combustion of wood, and saw dust, e.g. saw dust from wood factory used as boiler fuel, light joss sticks in temples of Buddhism.

6-4 Soot caused by the burning of organic textile like cloth and silk, e.g. black smoke from crematorium incinerator and burning clothes of the death for memorial events.

6-5 Black smoke caused by special process of industry: e.g. soot and black smoke occurred in the quench hardening process using oil as media; black smoke caused by the burning of mould oil during mould casting; residue left on the filtration net will caused black smoke when being burned; soot caused by substance like cut tobacco containing tar when being baked.

6-6 Lots of high concentration carbon barbecue soot and barbecue odor occurred during barbecue.

As the application of this technology is deepen and explored, more new application fields will be developed and explored.

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