Structural Optimization Design of Oil Fume Purification Equipment for Stretching and Shaping Machine

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Abstract—In view of the high temperature exhaust gas containing organic oil, fuel, fuel additives, lubricants, fibre particulate matter and other pollutants produced after heat setting of the stretching and shaping machine, the temperature and electric field which affect the performance of the oil fume purification equipment of the stretching and shaping machine are theoretically analyzed. Finally, the structure of lampblack purification equipment is optimized from three aspects. Practice proves that the improved lampblack purification equipment improves the performance, reduces the cost and energy consumption, and provides a reference for dealing with the exhaust gas of the stretching and shaping machine in the future.

1. Introduction
With the development of economy, people have higher and higher requirements for the quality of living environment. Some industries with environmental pollution are facing important challenges. The waste water and waste gas discharged from textile industry are one of the important sources of environmental pollution. The stenter is the key equipment for finishing after textile printing and dyeing. The high-temperature waste gas discharged by the stenter contains organic oil, fuel, fuel additives, lubricating oil, fiber particles and other pollutants [1-2]. At present, most enterprises use oil fume purification equipment to purify the exhaust gas from the stenter [3-4].

"TLL" stenting and shaping oil smoke purification equipment has been running in textile dyeing and finishing enterprises for more than three years, and the purification effect of tail gas has been recognized by customers. "TLL" equipment has been widely used in the textile industry. However, in recent years, with the enhancement of people's awareness of environmental protection, the country's requirements for environmental protection are more and more strict. The continuous improvement of the exhaust gas purification standard of the stenter makes the textile industry have higher requirements for the fume purification equipment.

2. Structure of oil fume purification equipment
The treatment of high temperature exhaust gas by the oil fume purification equipment of stenting and setting mainly includes two ways: cooling and solidification and electrostatic adsorption. At present, there are three parts in the market: cooling part, electrostatic field and exhaust fan. The structural
diagram of oil fume purification equipment is shown in Figure 1. After the exhaust gas generated by the stenter is cooled by filtration, it enters the static field of the tower body from the middle part. Due to the sealing of the upper layer of the tower body, the exhaust gas is buffered in the tower body once, and then enters the evenly arranged circular pipe electric field from the lower partition plate of the tower body. After the treatment of the electric field, the tail gas is discharged into the atmosphere through the exhaust fan.

3. Structure optimization design of oil fume purification equipment
Through the repeated experiments and verification of technicians, as well as the valuable opinions of customers on "sky blue", combined with the new exhaust emission standards, the structure of the fume purification equipment has been optimized and improved in three aspects. The optimized structure diagram is shown in Figure 2.
3.1. Spray lint removal device
The stenter is mainly used to dry and finalize the cloth through the hot air in the drying room, and the inevitably entrained wool in the high-temperature exhaust gas is discharged. At present, the wool entrained in the exhaust gas by the oil fume purification equipment is mainly filtered and removed through the filter screen of the cooling part. The oil fume purification equipment needs to be shut down and maintained regularly, and the accumulated wool inside the filter screen is cleaned, which costs a lot of labor and work. The environment is very poor, equipment downtime will also directly cause economic losses. At the same time, the purification effect of high-voltage electric field is the best when the exhaust gas is below 60°[5].

At the same time, due to the high temperature in summer in recent years, the volume and quantity of the heat exchanger in the cooling part have been increasing. "TLL" added a water spray device on the collection pipe before the exhaust gas of the stenter enters the cooling part, and the structure is shown in Figure 3.

![Figure 3. Structure diagram of spray tower](image)

1.Air inlet 2.Water vapor separator 3.Tower body 4.Spiral nozzle 5.Oil baffle

Figure 3. Structure diagram of spray tower

The pressure water pump, through the spiral spray nozzle in the spray tower, sprays out in the form of water mist to remove the flocs in the waste gas of the stenter, which improves the safety factor of the oil fume purification equipment. At the same time of filtering the flocs, the exhaust gas is cooled for the first time to reduce the load of the rear cooling part. The lower the temperature, the better the purification effect of the fume purification equipment on the exhaust gas.

It has been proved that the filter screen in the cooling part of the oil fume purification equipment with spray tower hardly needs to be cleaned, and the heat dissipation area of the exchanger in the cooling part has been reduced by 33% compared with that before, and the intake temperature of the exhaust gas entering the electric field has been reduced from 60 °C to 50 °C.

3.2. Air intake mode
The exhaust gas of the stenter of the original equipment enters the high-voltage electrostatic field in the middle part of the tower body, enters the lower space of the tower body through the hole on the lower separator plate of the tower body, and then enters the circular pipe electric field from the lower space of the tower body for purification, as shown in Figure 4.
The waste gas of the improved stenter enters the high-voltage electrostatic field at the bottom of the tower body and directly enters the electric field of the circular tube for purification, as shown in Figure 5.

Through comparison, it is found that the middle intake has a 180° rotation movement more than the bottom intake. Assuming that the rotation movement is carried out in a circular tube, the pressure loss formula is used:
\[ \Delta P = \frac{\lambda l}{d} \frac{\rho V^2}{2} \]  

(1)

Where: \( \Delta P \) is the pressure loss, \( \lambda \) is the friction coefficient of the pipe wall, \( l \) is the rotation distance, \( d \) is the diameter of the upper hole of the lower diaphragm, \( \rho \) is the tail gas density of the stenter, \( V \) is the tail gas speed of the stenter (in the tower).

Taking "TLL02" as an example, there are 144 electric fields in the tower, and the pressure loss is found to be 11% by formula (1).

\[ \Delta P_{\text{total}} = n \Delta P \]  

(2)

Where: \( n \) is the number of electric field tubes

The practice shows that after the exhaust gas of the stenter enters the tower body from the middle to the bottom, the exhaust fan changes from 27kw to 22kw, which greatly saves the operation cost of the oil fume purification equipment and reduces the energy consumption.

3.3. Pipe arrangement in electric field

Calculation formula of effective treatment area of high voltage electrostatic field of oil fume purification equipment,

\[ S = nL(\pi D) \]  

(3)

Where: \( S \) is the treatment area, \( L \) is the length of electric field pipe, \( D \) is the diameter of electric field pipe.

After the oil fume purification equipment changes the intake mode of the exhaust gas of the stenter, the round pipe of the high-voltage electrostatic field is changed from the square uniform arrangement to the diamond arrangement, as shown in Figure 6.

![Figure 6. Schematic diagram of pipe arrangement in electric field](image)

(a) Square layout  (b) diamond layout

The change of the electric field arrangement of the tube greatly improves the utilization of the effective area of the electric field. Taking "tll02" as an example, the part size of electrostatic field is 3300mm × 3300mm, the number of square tubes is 144, the number of diamond tubes is 161, and the effective treatment area of high-voltage electrostatic field is increased by 11.8%.

4. Conclusion

The high-temperature exhaust gas is mainly treated by cooling condensation and electrostatic adsorption. In this paper, the structure of oil fume purification equipment is optimized from three aspects: adding spray device, improving air intake mode and optimizing the layout of round pipes in the electric field. The practice shows that the optimized equipment has improved the purification effect and energy saving, which provides reference for the structural design of the equipment in the future.

Acknowledgment

The optimization of the structure of fume purification equipment can not be separated from the hard work of the designer, but more thanks to the support and trust of the product users. Here, I hope that
through the analysis of our company's products, the majority of colleagues can design products with higher purification effect on this basis.

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