Characteristics of lead smelting fume and its potential treatment technology

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Abstract. Fine particles emitted from lead smelting furnaces contains a variety of heavy metals and oxidized condensates, which are characterized by complex composition and great harm. In this paper, dust samples from lead smelter were collected, and particle size analysis, composition analysis, phase analysis and specific resistance test were carried out in the laboratory. According to the properties of the lead dust, the experiment flow of electric coagulation was designed to verify the effect of using electric coagulation to condense fine particles in lead dust.

1. Introduction
In the process of lead smelting, many processes have flue gas production, such as sintering, blast furnace smelting or direct smelting, crude lead fire refining etc. The flue gas mainly includes dust, smoke and flue gas. The main pollutants of dust are lead, zinc, arsenic, cadmium, indium, mercury and other heavy metals and their oxides.

The composition of smoke and dust from drying, baking and sintering processes is like that of raw materials. The dust in smelting process is enriched with volatile metal oxides, and the dust produced by fuming furnaces and volatilizing kilns mainly consists of volatile metal oxides [1]. The highest amount of lead dust is found in soot because lead produces a large amount of lead vapor when it is heated and melted. Lead oxide particles can be formed in the air, so lead dust is not only a characteristic pollutant in the atmosphere of lead smelters, but also SO₂. In addition, the toxicity of lead to human body, biology and environment is very big, so it should be of special concern. Studies showed that the gasification of inorganic minerals and the concomitant condensation are two important processes in the formation of fine particles.

2. Properties of the lead dust

2.1. Lead dust production
The raw material used in the smelting process of lead metal is mainly lead concentrate, whose main component is lead sulfide, which is converted into crude lead in the smelting process, which produces smelting fume containing SO₂ and smoke. After dust removal, the smelting fume enters the acid production system to produce sulfuric acid, and the tail gas of acid production reaches the standard, please refer to figure 1.
There are many kinds of lead smelting process, the traditional one is sinter-blast crude lead production process. The process flow of lead smelting can be summarized as Table 1.

![Figure 1. Lead smelting process](image)

The experiment dust was collected from bag dust collecting equipment of Shaoguan smelting plant, which USES the sintering airtight blast furnace smelting process (ISP) [1].

2.2. **Phase analysis of lead dust**

Phase analysis shows that the grade of lead is 37.02%, among which lead sulfate, lead oxide, lead sulfide, metallic lead, iron ore coated lead and other mineral coated lead account for 18.46%, 6.02%, 6.20%, 0.04%, 5.94% and 0.36%, respectively, as shown in Table 1 below. The sample also contains a large amount of copper.

**Table 1. Grade of different form of lead among lead smelting dust**

| Ingredient | Lead sulfate | Lead oxide | Lead sulfide | Metallic lead | Iron ore coated lead |
|------------|--------------|------------|--------------|---------------|----------------------|
| Proportion (%) | 18.46 | 6.02 | 6.2 | 0.04 | 5.94 |

2.3. **Specific resistance of lead dust**

Dust resistivity of electric dust collector has a great influence on dust collecting performance. It is generally thought that the application scope of dust ratio resistance is $10^4 \Omega \cdot \text{cm} - 10^{11} \Omega \cdot \text{cm}$[2]. If the dust has small specific resistance and good electrical conductivity, the charged dust can release charge quickly. If the specific resistance of dust is large and the electrical conductivity is poor, the charged dust releases charge slowly.
In this paper, the dr-3 type high-pressure dust specific resistance test bench was used for testing. The ambient humidity was 63%, the test voltage was 4.0kV, and the specific resistance measured was shown in figure 2. The resistance increased with the increase of temperature, peaked at 120 °C after \(2.78 \times 10^{12} \Omega \cdot \text{cm}\) and presented down trend. Tested dust resistivity is relatively high. A large number of studies have shown that the measured specific resistance is 1 to 3 orders of magnitude higher than that under operating conditions, thus the electric coagulation treatment method can be used [3].

![Graph showing specific resistance vs temperature](image)

**Figure 2.** Specific resistance of lead dust

2.4. Size distribution of lead dust

Laser analyzer of particle size showed that PM_{10}, PM_{2.5} and PM_{1.0} account for 60%, 13% and 0.47% of the total weight (Figure 3).

![Graph showing particle size distribution](image)

**Figure 3.** Size distribution of collected lead dust

3. Electrostatic agglomeration

At room temperature, the electrostatic agglomeration adopts a high-voltage dc power supply, the voltage of the high-voltage dc discharge equipment increases from 0 kV to 50 kV step by step, the dust concentration is 6.0g/m³, the fan frequency is 50Hz, and the air volume is 800m³. Under different voltage and current parameters, the size of the voltage and current is changed step by step, and the particle size of the dust is measured by the Marvin laser particle size analyzer.

As can be seen from figure 4, for particles in the range of 0-11.0um, the mass fraction of particles with a particle size larger than 11.0um decreases on the whole after electrocoagulation by DC voltage, while the volume fraction of particles with a particle size larger than 11.0um increases, that is, particles...
with a smaller particle size condense into particles with a larger particle size. Especially, for PM$_{1.0}$, PM$_{1.0-3.0}$ and PM$_{3.0-11.0}$, the coagulation effect is obvious, and the mass fraction was reduced from 0.39%, 18.66% and 58.28% to 0.21%, 8.62% and 41.78% in a 42 kV, 0.3 mA electrical condition.

\[ \text{Figure 4. Particle size distribution of soot under dc voltage} \]

4. Conclusion

In this paper, dust samples from lead smelter were collected, and particle size analysis, composition analysis, phase analysis and specific resistance test were carried out in the laboratory. According to the properties of the lead dust, the experiment flow of electric coagulation was designed to verify the effect of using electric coagulation to condense fine particles in lead dust. Results showed that for the particles in the range of 0-11.0 μm, after electrocoagulation with high voltage, the fine particles showed obvious coagulation effect.

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