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Investigation of the performance of bipolar transverse plate ESP in the sintering flue control

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ABSTRACT

In order to improve the particle collection efficiency of the electrostatic precipitator (ESP), a transverse plate ESP with bipolar discharge electrodes is proposed. The simulations of the velocity distribution have shown that when the inlet velocity is 1 m/s, within the range of 40 mm from electrode plate, the average velocities of windward side and leeward side are less than 0.7 m/s and 0.3 m/s respectively. It is clear that the velocity near the collection electrode plate of this bipolar ESP is much lower than that of the ordinary ESP at the same inlet velocity. This low velocity can lead to higher efficiency for fine dust collection due to the less dust re-entrainment in ESP. It is also found that the average velocities are getting lower when the distance between plates electrodes are greater than 150 mm in accordance with the simulations. The voltage current characteristics of the bipolar ESP are superior to the ordinary ESP. The pressure drop of the bipolar ESP is about 30% higher than that of the ordinary one. The dust penetration of the bipolar ESP is about 54% less than that of the ordinary ESP when the sintering dust with 25.405 μm mass median diameter is used as the test particulate under the condition of the electric field from 2.1 kV/cm to 3.2 kV/cm and the velocity from 1.0 m/s to 1.5 m/s.

Introduction

Ministry of environmental protection in China has issued that the emission concentration of all the head of sinters must less than 40 mg/Nm^3 in the special control area after January 1, 2015 [1]. But now most of the sinters of the iron and steel companies in China do not satisfy this emission standard. Therefore, it is an urgent task to improve the collection performance of the ESPs in the sintering flue gas control.

Actually, there are some difficulties to control particulate pollutant generated from the head of sinter. For instance, the wet ESP cannot be used because the sintering flue gas contains CaO, salt of Na, K and Mg, SO_2, NO_x, which lead to corrosion and scaling in wet ESP. Furthermore, the bag filters are not suitable for the pollution control in the head of sinter either since the bags can easily be plugged by very sticky dust due to quite high humidity of the flue [2]. In the case of the sintering pollution control, therefore, electrodes reforming could be the only way to improve the collection performance of the ESPs.

There are three typical electrode reforming technologies. First, the bipolar ESP, using bipolar charged particle agglomeration to improve ESP performance, was first developed by Ellasson (1987) [3]. Till 2000, a kind of bipolar ESP with Size Selective Mixing System was invented by Indigo [4]. Indigo agglomerator has been used in several power plants in china. However, Indigo agglomerator has not been used in sinters. The main disadvantage of Indigo is that the larger space is needed. The second electrode reforming technology is the transverse Plate ESP. The aerodynamic separation effect is made use of to enhance the collection Performances. Masuda studied the transverse plate ESP in 1976 [5]. Later, many kinds of the transverse plate ESP had been developed, such as double fluted plate (Zou yongping, 1985) [6], C plate (Zhang Guoquan, 1990) [7], ω plate (Pan Yuliang, 2004) [8], double C plate (Yi Chengwu, 2007) [9]. Some of the transverse plate ESPs have been used in kilns, cement factories, and crushers. However, there is no application in the head of sinters. The third one is moving collecting electrode ESP was invented by Hitachi (1993) [10]. The moving electrodes just like the rolling curtains. The collected particles are dislodged from the moving electrodes by brushes instead of by rappers. One of the biggest advantages of the moving collecting electrode ESP is the less dust re-entrainment. Therefore, higher collection efficiency can be achieved. Moving collecting electrode

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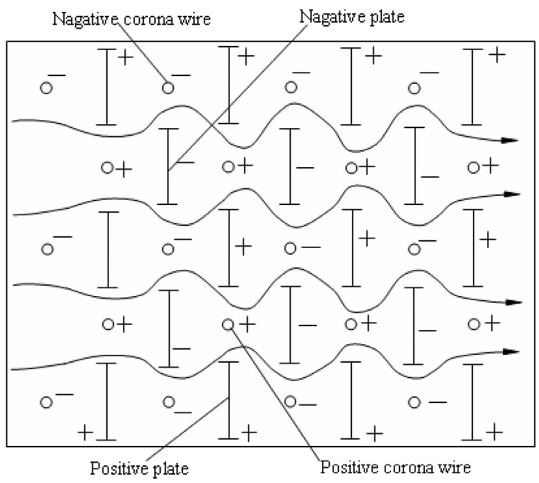

Fig. 1. Arrangement of bipolar transverse plate ESP electrodes.

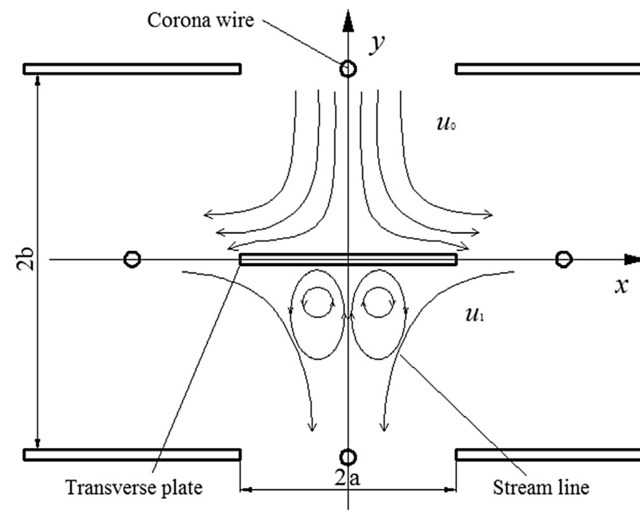

Fig. 3. Schematic diagram of flow field around the plate.

ESP has been used in Tangshan and Henan iron and steel companies in China to control the particulate pollutant generated from the head of sinters. There are several drawbacks of the moving collecting electrode ESP either, such as the high cost, complex structure, and inconvenient maintenance due to the moving parts.

In order to improve the particle collection efficiency of the ESP, a bipolar transverse plate ESP is developed. In this bipolar ESP, there are some combination advantages, such as the effects of aerodynamic separation, less dust re-entrainment, and bipolar charged particle agglomeration. Then, the particle collection performances of this bipolar transverse plate ESP are discussed to confirm the applicability in sintering pollution control.

Configuration

The bipolar transverse plate ESP is different from other ESPs, as schematically illustrated in Fig. 1.

The bipolar transverse plate ESP not only has the negative corona wires and the positive plates, but also has the positive corona wires and the negative plates. However, other ESPs just have the negative corona wires and the positive plates. In the bipolar transverse plate ESP, just only one high voltage supply is needed for bipolar discharging and particle collecting. But in the traditional bipolar ESP, at least, three high voltage supplies have to be used [3,11,12].

The principle of the bipolar transverse plate ESP is shown in Fig. 2. The negative corona wires are located between the positive plates. The positive corona wires are located between the negative plates. In the field between the positive plates, the particles are negatively charged and attracted to the positive plates by electric force. At same time, in the field between the negative plates, the particles are positively charged by the positive corona wires and driven to the negative plates by electric force either. That is, the particles can be collected by both positive plates and negative plates. In addition, if some fine particles are not collected by positive plates and negative plates, because the polarity of these escaped particles in gas is different, the bipolar charged particles will be attracted together to become the bigger particles. These agglomerated particles are then possibly collected by the next plates in series.

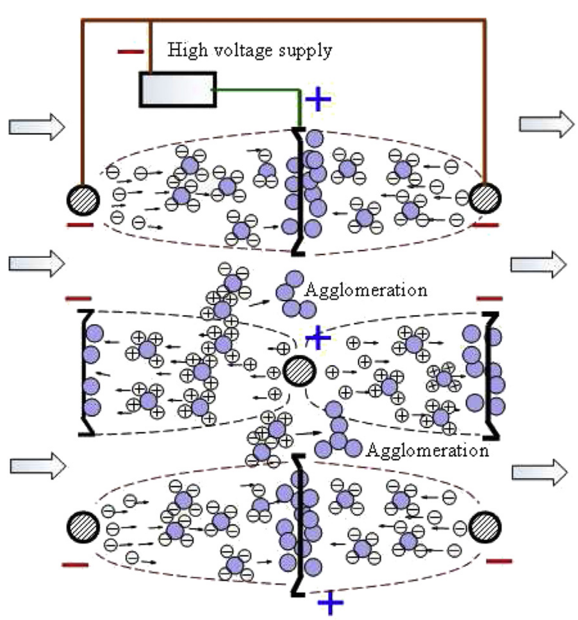

Fig. 2. Principle of bipolar transverse plate ESP.

Gas velocity distribution

It is important to know the gas velocity distribution in the bipolar transverse plate ESP because it is useful to explain the particles transportation and separation behavior. Furthermore, the gas

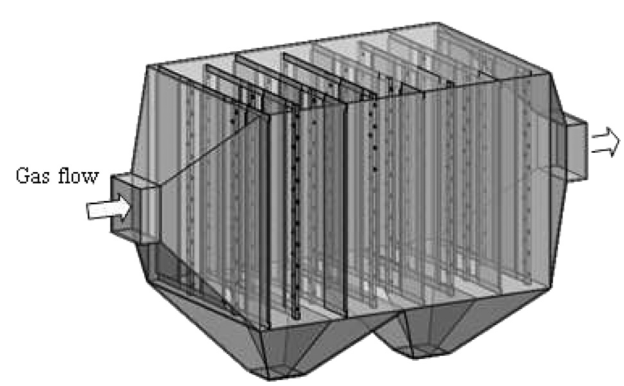

Fig. 4. Bipolar transverse plate ESP model for numerical simulation.