Electrostatic precipitation of fine particles from coal-fired power plants

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Abstract This paper discusses ESP performance via the so-called ESP index value. Particle emission, ESP sizing and power condition can be evaluated simultaneously. A cost-effective ESP can be designed when the index value of each field is around 200-260 $(kV/cm)^2m^2/m^3/s$, which gives a grade collection efficiency of higher than 95% for PM2.5 collection.

Introduction

Almost all industrial electrostatic precipitators (ESP) and their collection efficiency have been designed according to the revised Deutsch equation:

$$\eta = 1 - \exp(-\sqrt{\omega \cdot s}) \qquad (1)$$

where ω and s are particle migration velocity (cm/s) and specific collection area $(m^2/m^3/s)$, respectively. Its effectiveness for sizing ESP, predicating fine particle collection and upgrading power sources, however, can’t be easily achieved for Chinese ESPs when switching coal or achieving an new emission limit.

Results and Discussions

Based on our more than 50 ESP upgrading experiences with 200-600 MW coal-fired power plants, this paper discusses ESP performance in terms of the so-called ESP index value, i.e. $E_a \cdot E_p \cdot s$, where, E_a and E_p are average and peak electric fields (kV/cm), respectively. The collection efficiency and outlet mass emission can be well approximated as:

$$\log m = -\alpha \cdot E_a \cdot E_p \cdot s + \log(\beta \cdot M_0) \qquad (2)$$

where m and M_0, α and β are outlet and inlet particle concentrations, and system coefficients, respectively. For achieving 10-20mg/m^3 emission, the index value need to be around 1000-1400 $(kV/cm)^2(m^2/m^3/s)$ for matching up to 40% ash composition. The proposed formula can be used for single-phase, three-phase, switch mode and pulsed power sources, and also various kinds of coal in China [1,2]. Figure 1 gives a summary of the emission of Chinese-coal fired power plants via the index value. All industrial measurements can be very well approximated by the equation (2). In fact, the equation (2) has been used for upgrading more than 50 industrial ESPs.

For coals with upto 40% of ash, the relationship is close to the top line L3. For coals with 10% of ash, it is the lower line L1. For most of power plants, it can be well approximated by using the middle line L2. In order to keep low emission, we suggest that Chinese power plants need to design their ESP with a minimum index value of 1300 $(kV/cm)^2(m^2/m^3/s)$.

The equation (2) can also be used for evaluating fine particle grade collection efficiencies [3]. For each field, the grade collection efficiency greatly depends on the index value. To achieve a efficiency of larger than 95% in-between rapping, the index value needs to be larger than 260$(kV/cm)^2(m^2/m^3/s)$ as shown in Fig.2. Experiments were performed with an industrial ESP under a gas flow rate of 20000-40000m^3/h at 384K.

Conclusion

A new empirical relationship between particle emission, ESP size and power source has been widely applied in China for sizing and upgrading ESPs.

Acknowledgement

We think Chinese 863 fund for their support.

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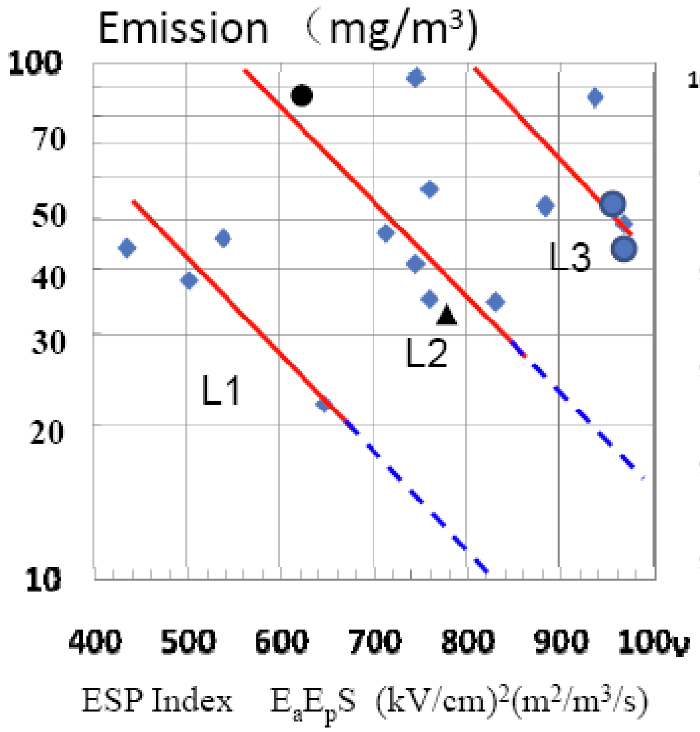

Fig.1. Industrial ESP Emission via their ESP index for 200-600MW coal-fired generator

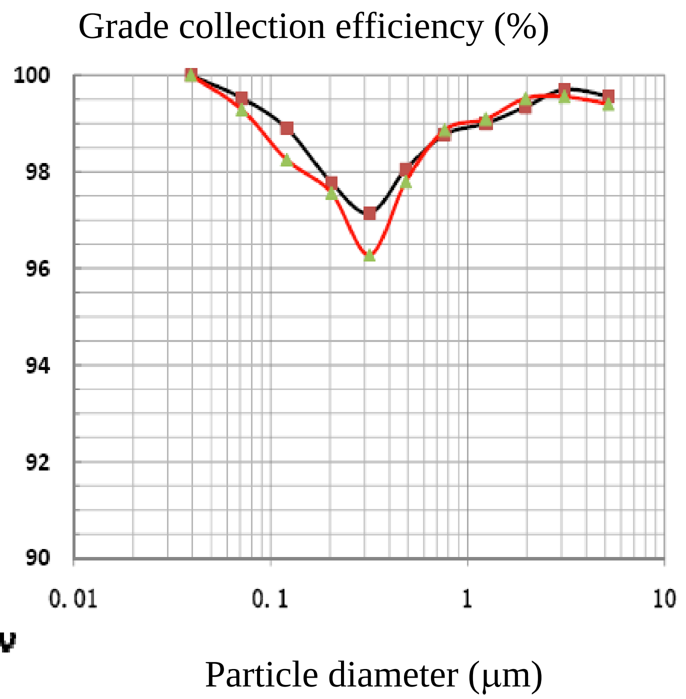

Fig.2. grade collection efficiency when the index value is around 200-260 $(kV/cm)^2(m^2/m^3/s)$.

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Almost all industrial electrostatic precipitators (ESP) and their collection efficiency have been designed according to the revised Deutsch equation:

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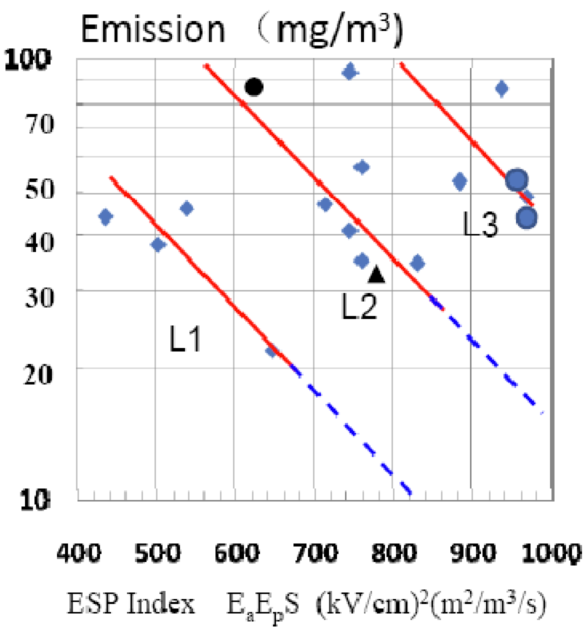

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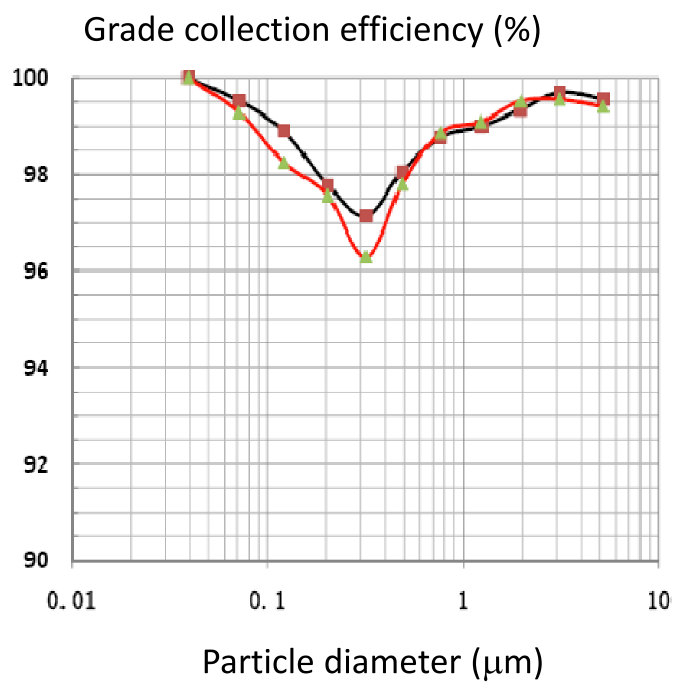

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