Chapter 7

Design and Operation of Electrostatic Precipitators

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1. Introduction

Dust particles are removed from a gas stream in electrostatic precipitators due to the action of electrostatic forces. Between a positive and a negative electrode an electric field is established in which the charged dust particles are forced to move in the direction of the collecting electrode on the surface of which a very porous layer of dust builds up with time. The dust layer has to be removed periodically, for instance by rapping of the collecting electrode. The dislodged dust falls into a hopper at the base of the precipitator.

Electrostatic precipitators are not only used for the purpose of dust separation but also for the separation of mist from a gas stream. The liquid particles coalesce on the collection electrode so that a liquid film is established that flows downwards due to gravity forces and drains into a sump at the bottom of the precipitators.

The basis of electrostatic precipitation is Coulomb's law that relates electric attraction and repulsion of bodies with the distance between these bodies. According to Coulomb's law the strength of the electric forces decreases with the square of the distance. Coulomb, 1736 to 1806, was a French scientist who...
devoted some of his scientific investigations to the study of magnetic and electric attraction. The unit of electric charge is named, in his honour, the Coulomb. The industrial application of Coulomb's law in dust and mist separation processes is due to the American engineer Frederick G. Cottrell who developed the “Cottrell precipitator” around 1910. The work of Cottrell was initiated directly by environmental protection considerations. An interesting summary of investigations on the nature of electrostatic forces and engineering development of electrostatic precipitators was included in the book by White [1].

The characteristic properties of the electrostatic precipitator are:

1. low pressure drop, of the order of 100 to 1,000 N/m²;
2. high gas capacity, $10^5$ or $10^6$ m³/h are quite common;
3. low energy demand, about 0.1 to 0.8 kWh/1,000 m³;
4. very high collection efficiency in the small diameter range of dust particles, better than 99%.

But there are serious drawbacks in the application of electrostatic precipitators which are primarily related to the electric properties of the dust. However, over many decades, the electrostatic precipitator has been the backbone in the field of fine dust collection and has been successfully applied in all relevant branches of industry.

2. Examples of Industrial Applications of Electrostatic Precipitators

Fig. 1 describes the steam boiler of a lignite power plant with a two-zone electric precipitator (design Walther-France). For power stations, electrical precipitators are designed for a gas flow rate of a million m³/h and more. Most of the power stations in operation today are still equipped with an electrostatic precipitator (EP). Some of the properties of the precipitators have been summarized in Table 1 [2].

The installation costs for an electrostatic precipitator amount to about 2 to 6 % of the overall cost of a power plant.

The collection efficiency of electrostatic precipitators is in many cases higher than 99 %. This means that less than 1 % of the mass of the dust entering the precipitator will not be separated from the gas stream and will be emitted to the environment. But this 1 % of the mass of the dust may be the most dangerous part to the environment: to man, flora, fauna, and buildings. Besides the mass of a pollutant, it is the particle size of a dust that is the most important property. It is therefore necessary to gain information on the particle size distribution of the emitted dust. Fig. 2 shows particle size distribution curves of dust in the flue gas determined behind the electrostatic precipitators of power stations in the USA and Berlin. These data have been collected by Jüntgen [3]. Although the effect of dust precipitation in power stations situated in Berlin seems to be more pronounced than in power stations located in USA, the trend of the curves is the same. There is obviously no influence of the types of coal used in the power stations on particle distribution curves. Surprising, however, is the fact that for