Modeling of submicron particles motion in planar dielectric barrier discharge type electrostatic precipitator

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Two major actors are responsible for air pollution: toxic gases and airborne particles. The suspended particles in the air have a harmful effect on nature and human health. One of the most effective methods for airborne particles removal is electrostatic precipitators (ESP) (Chang *et al*, 1995). Even though the high total particle collection efficiency of conventional ESPs which can reach 99.9 % and their low energy cost, there is still a problem with the collection efficiency of submicron particles in the range from 0.2 to 2 µm (Chang *et al*, 1995). Furthermore, the use of dc corona discharge to charge a particle presents some risks due to arc transition. Recently, many research works have been carried out on dielectric barrier discharge (DBD) to produce ions and charge particles inside the ESP rather than the conventional corona discharge (Zouzou *et al*, 2011).

In this paper, a theoretical model is presented to assess the trajectory, and the collection efficiency of submicron particles with different diameters (ranging from 0.18 to 1 µm) in a plane-to-plane DBD electrostatic precipitator (air gap = 1 mm, dielectric thickness = 180 µm).

The model is based on particles field-diffusion charging theory, classical movement equations and simplifying assumptions. In order to evaluate the charge, the velocity, the trajectory, and the collection efficiency of particles, two kind of forces are taken into account: the first one is the electric force applied by the electric field on charged particles and the second one is the drag force which represent the resistance of the air to particle movement.

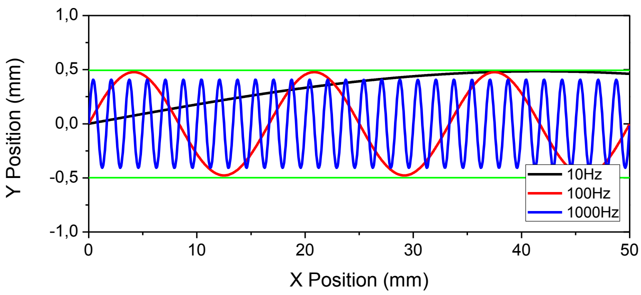

Figure 1. The effect of the frequency on the particles motion. Conditions: V_0=5 kV, dp=0.305 µm

Fig. 1 shows the effect of the frequency on the particles motion. The amplitude of oscillations decreases with the frequency. For this reason, higher frequencies are more appropriate for particles charging applications. At low frequencies, the amplitude is big but there is no enough time for the particles to oscillate, that cause a diminution of the particles collection efficiency.

Fig. 2 shows modeling and experimental results of the frequency effect on the collection efficiency. We can see that the modeling and the experimental results are similar which confirm our assumptions. The collection efficiency decreases at low frequency. By analyzing modeling results, the diminution is due to the low charge of aerosol particles. In fact, between two successive half-cycles, the discharge turns off during a time-interval, that is longer than the residence time of the particles inside the plasma reactor. At high frequency, the decrease of efficiency is caused by the fast oscillation of the particles between the electrodes.

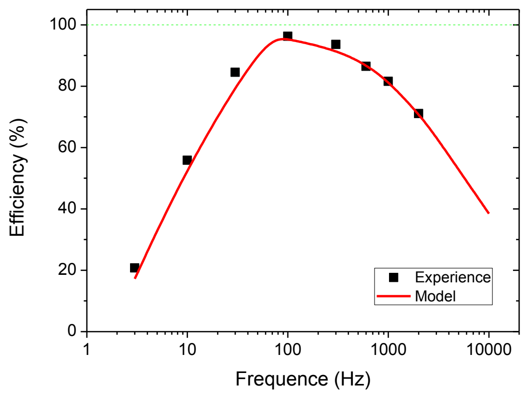

Figure 2. Collection efficiency versus the frequency. Conditions: V_0=5 kV, dp=0.305 µm.

As a conclusion, filamentary DBD can be considered as an efficient way to charge particles inside the ESP. The particles have an oscillating motion which highly affects their collection. The amplitude of particle trajectory oscillations depends on electrical parameters such as the applied voltage and the frequency, and particles characteristics such as their size.

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