Observation of Particle Trajectories in a Two-Stage Electrostatic Air Filter

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Traditional two-stage electrostatic precipitators (ESPs) installed in ventilation ducts usually consist of an ionizer stage in the upstream and a collector stage in the downstream of the air flow. When particles enter the system, they are first charged in the ionizer, and then move towards the collector. The collector has a strong electric field between the repelling (high electrical potential) electrodes and the collecting (usually grounded) electrodes. Charged particles are subjected to electric and aerodynamic forces and travel toward the collecting electrodes, where they eventually settle. The collection efficiency of ESPs is a function of numerous parameters, including particle size, electrode geometry, applied voltage, and airflow velocity. In the linear portion of the operating regime, ESP's collection efficiency is roughly proportional to the electric potential of the corona electrodes and repelling electrodes, and inversely proportional to airflow velocity. The collection efficiency of an ESP is also affected by such phenomena as air turbulence and vibrations.

Here we describe several aspects of operation of a novel collecting electrode, covered with porous foam. Particles that are collected in the pores of the foam have a lower chance of returning to the air stream, because the effects of vibrations and air movement inside the pores are much weaker than they are on the flat and bare collecting electrodes.

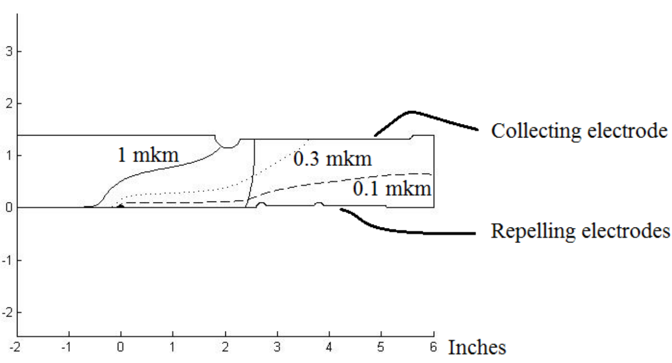

Figure 1. Conceptual representation of particles trajectories in an ESP cell.

Most previously developed computer models published in the past assume that that the collecting electrodes are solid plates with a smooth surface, as shown in Figure 1. However, foam-covered electrodes introduce air vortexes and irregular movement that is hard to model. With that in mind, direct observation of actual particle distribution inside the filter, i.e. between the collecting and repelling electrodes, is especially valuable.

Foam covered collecting electrodes are located between the plate-like repelling electrodes (see Figure 2). The potential difference between the collecting and repelling electrodes varies from 5 kV to 12 kV.

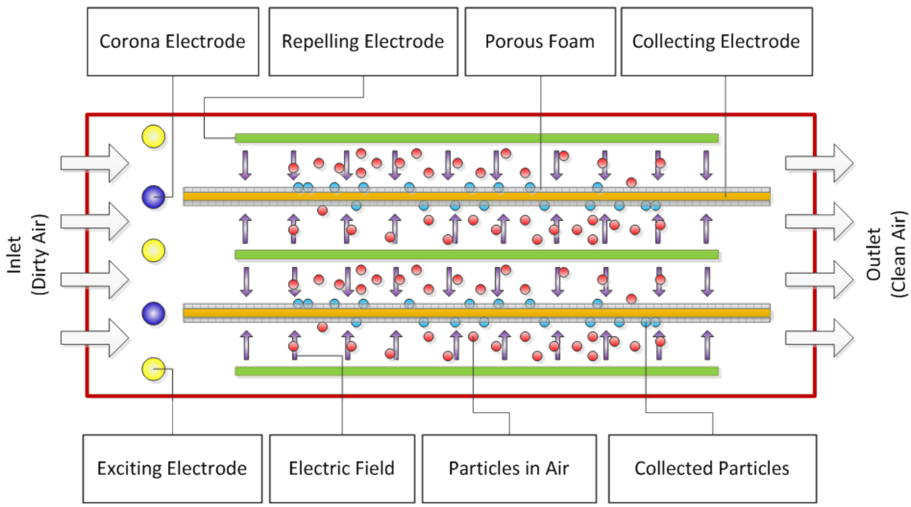

Figure 2. A diagram of the foam-covered ESP, with porous foam attached to the collecting electrodes.

The experimental set up consists of the open from the above structure that allows to look inside the collecting-repelling electrodes area. In the upstream area, dust or smoke generator is placed. Laser beam is directed parallel to the collecting plates (see Figure 3). In a dark room laser beam is visible as long as it reflects particles. In the case of solid smoke the beam looks like a lit bar with a diameter about 1 mm.

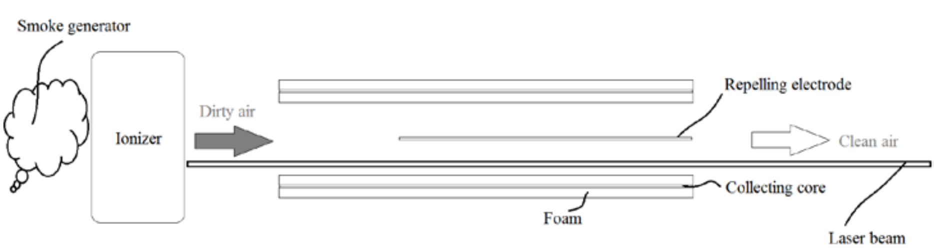

Figure 3. Experimental setup diagram.

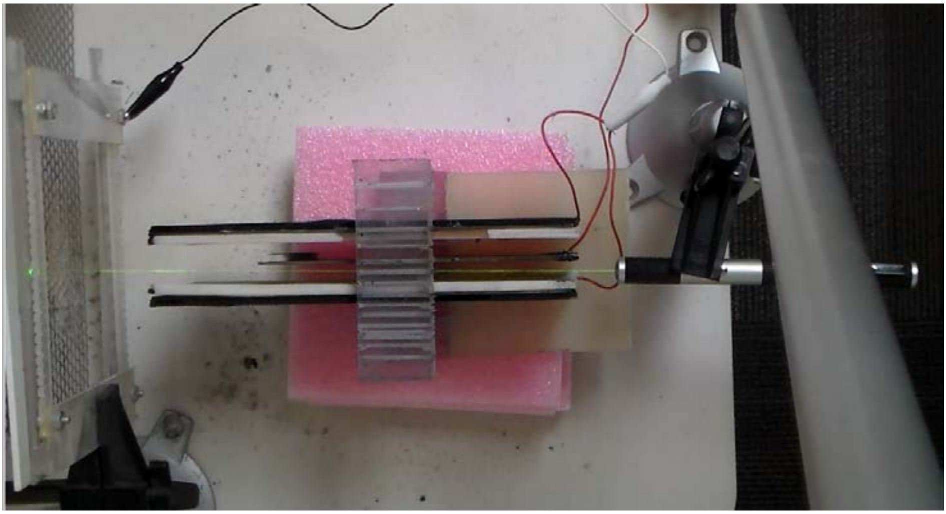

Figure 4. Experimental set up.

Shifting laser location with respect to the proximity to the collecting electrode allows direct observation of particles trajectories. In Figure 5, the ionizer is powered down and particles are not charged. Despite the electric potential applied to repelling electrodes, no smoke particle collection takes place.

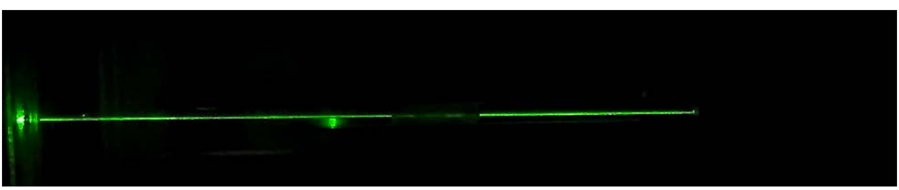

Figure 5. Ionizer is OFF.

In the Figure 6 the ionizer is powered ON, and smoke is no longer present at the very entrance to the collecting plate, which is indicated by the absence of the diffused laser beam in the photograph.

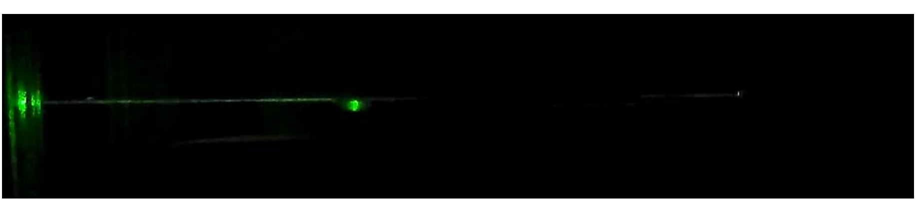

Figure 6. Ionizer is ON.

A number of studies were conducted with different electrodes geometries, voltages and air velocities using this technique and are currently used for verification of numerical simulation models. The presented method allows for rapid visualization of the electrostatic filters operation with the purpose of design optimization.