Computational Fluid Dynamics Approach to Evaluate Electrostatic Precipitator Performance

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Introduction: Particle deposition studies revealed that airborne pollutants and fine particles can cause serious health problems such as respiratory disease [1-2]. Thus, an efficient particle removing method for exhaust gases treatment is crucial. Electrostatic precipitator (ESP) are commonly used in filtration systems to collect the dust particles from air stream [3]. In such systems, particles are subjected to strong electric field and then settle on collecting electrode.

In this presentation, the effect of applying voltage on particle collection efficiency is shown and analyzed.

Model and Computational Domain:

Figure 1 shows the simulation model for this study. Figure 1,a gives the 2D simulation domain for better understanding. The diameter for particles is 0.3 µm. Three different voltages (6 KV, 12 KV and 18 KV) applied to the discharge electrode. The re-entrainment and rebound factors for particles are excluded in this simulation.

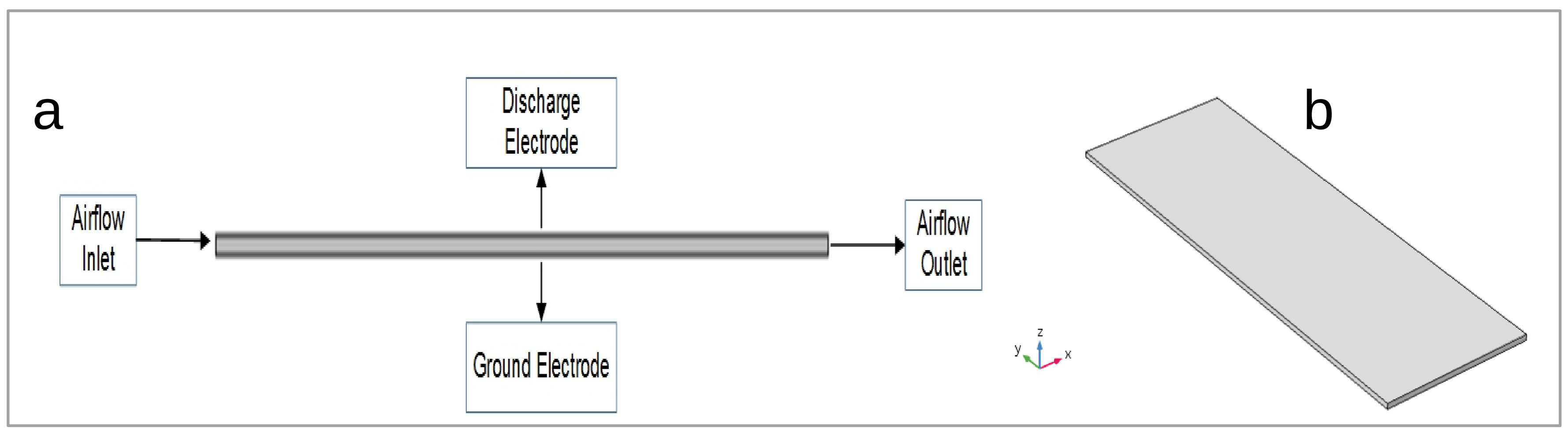

Figure 1. Numerical Model.

- The "Turbulent Flow, K-ε" approach is used to simulate the velocity field.
- "Electrostatics" module is used to simulate the electric field which is solved by Poisson's equation.
- In addition, the particles are subjected to drag and electric forces, coming from the results of "Turbulent" and "Electrostatic" modules respectively. "Particle Tracing for Fluid Flow" is used to trace the particle trajectories.

Details of the boundary conditions are listed in Table 1:

Table 1. Boundary Conditions.

	Flow field	Electric field	Particle transport
Inlet	U_x = 0 m/s U_y = 2 m/s U_z = 0 m/s		2000 Particles
Outlet	0 Pa		Freeze
Wall	No slip		Freeze
Discharge electrode	No slip	6/12/18 KV	
Collecting electrode	No slip	Ground	

Results:

1) Flow

The velocity profile of fluid flow between two electrodes is illustrated in Figure 2 .The velocity is assumed to be 2m/s and the result of this section is required to evaluate the particle trajectory.

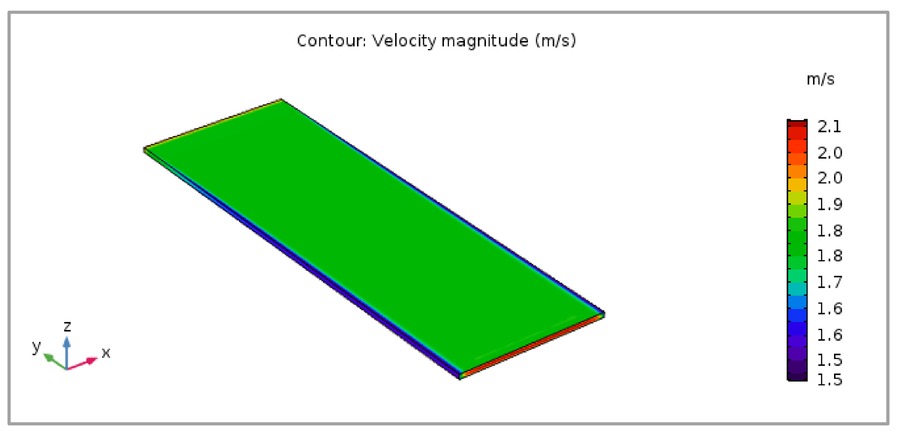

Figure 2. Velocity Field.

2) Electric Field

In Figure 3, the electric field is demonstrated by directional arrows. As it can be seen, the discharge electrode voltage apparently changes the magnitude of electric field strength. As expected, the highest electric field strength is for Figure 3,c where the applying voltage is 18 KV.

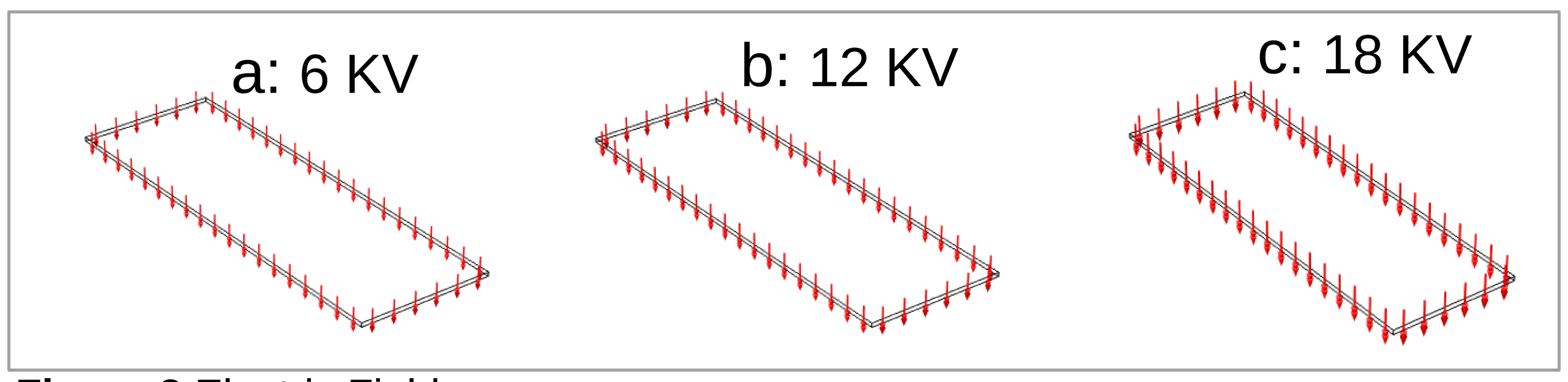

Figure 3 Electric Field.

3) Particle Deposition

Figure 4 gives the particle trajectories with different applying voltages where the color represents the resultant velocity of particles. Airflow direction and electrostatic force cause the particles settle down on the collecting electrode. Additionally, when the discharge electrode voltage increases, particles subjected to stronger electrostatic forces and collected farther before the outlet.

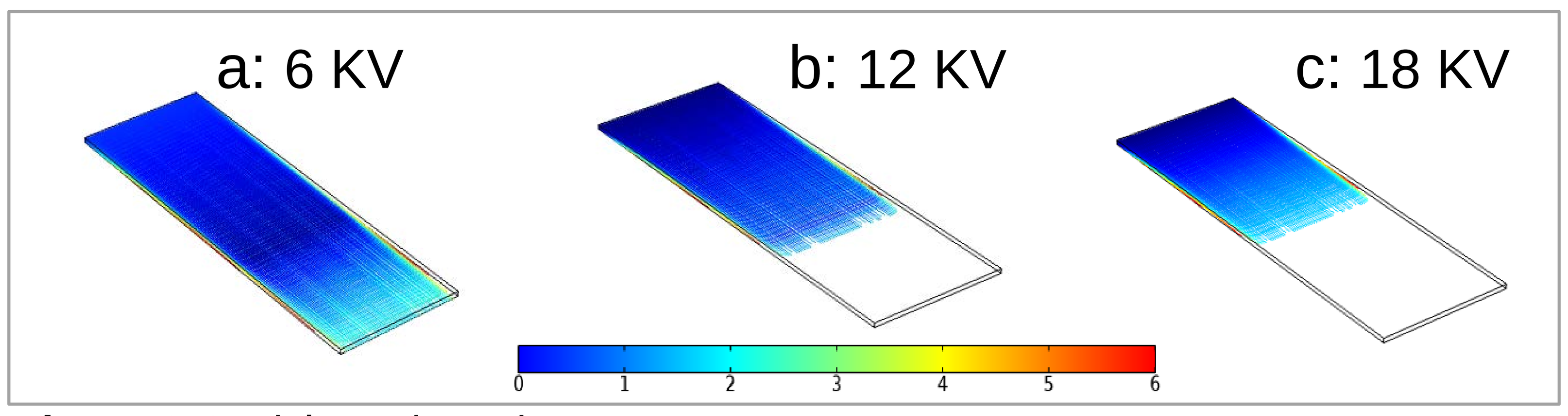

Figure 4 Particle Trajectories.

Conclusions: As it can be seen in the results, the particle deposition increase with an increase of in the magnitude of applied voltage for emitting electrode. Furthermore, the results confirmed the effectiveness of ESP for particulate matter collection. For future studies, further analysis can be done with different particle diameters and airflow velocities.

References:

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