Electrostatic Precipitators - Modeling and Analytical Verification Concept

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Abstract

Electrostatic precipitators (ESP) are a reliable technology to control emissions of airborne particles in a series of applications such as coal-fired power plants, cement plants or even for domestic fireplaces. Numerical calculations allow further development of electrostatic precipitators avoiding expensive test stands and field tests.

The numerical model in this work is based on Navier-Stokes and Maxwell's equations. The connection between Fluid Dynamics and Electrostatics is established through the forces exerted on charged particles, namely Drag- and Coulomb-forces.

The simulations are carried out using the Turbulent Flow SST, Electrostatics, Mathematics, and Particle Tracing for Fluid Flow physics interfaces in COMSOL Multiphysics® software. The air ionization by corona discharge is described by coupling Poisson's equation with the continuity equation for space charge density.

The charge-dependent case is implemented by a custom partial differential equation in coefficient form. The corresponding boundary condition for the emitting electrode relates the electric field to the space charge density. This analysis provides a robust and computational time efficient approach for calculating the initial space charge density on the electrode using the current density as fitting parameter.

Results obtained are compared to experimental data; the latter prove to be delicate to obtain, though, due to the lack of accuracy of measurement devices.

Results for the electric field and the space charge density have been analytically verified for the case of a wire-tube ESP.

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Figures used in the abstract

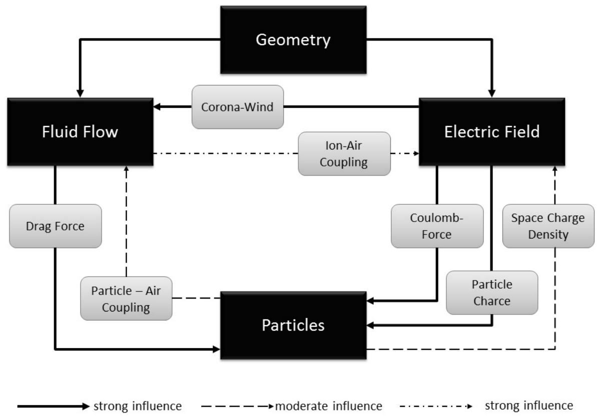

Figure 1: There are several physical effects involved and interacting in an electrostatic precipitator, which can be conveniently modelled with COMSOL Multiphysics.

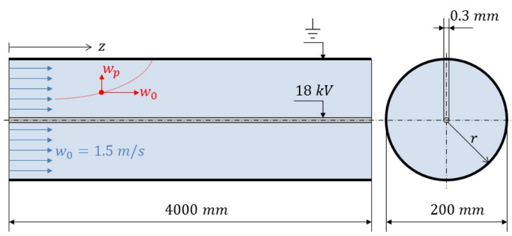

Figure 2: This wire-tube geometry represents the test case setup for analytical verification of the space charge density and the electric field. The geometry has been defined as 2D-axissymmetric component.

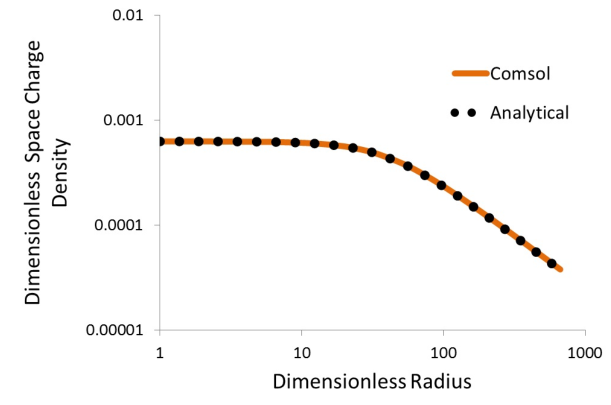

Figure 3: Analytical verification of the electric space charge density.

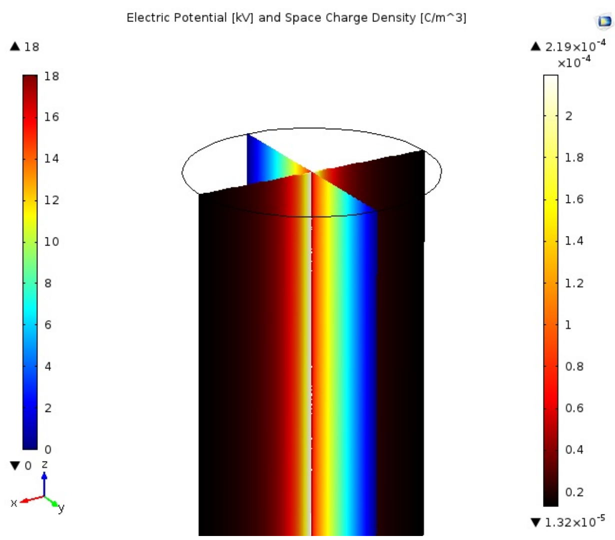

Figure 4: Multislice plot of the main dependent variables of the ESP-model which happen to be the most numerically challenging.