Simulation analysis of the flow on Hole-type Electrostatic Precipitator

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Electrostatic precipitator (ESP) for exhaust gas treatment of marine diesel engines has been attracting attention. When the heavy oil is used as fuel of diesel engine, due to the high particle concentration and low electrical resistance in the exhaust gas, a technique for suppression of re-entrainment phenomenon (once collected particle are scattered) is required. The authors have proposed a hole-type ESP as to suppress the re-entrainment phenomenon (Y. Ehara, 2014). It is composed of charging zone and collecting zone, and the electric field of the collecting zone is zero. Therefore, suppression of re-entrainment can be expected, due to collect the particle in collecting zone pass through the hole. This paper reports the simulation analysis results on hole-type ESP.

This study was used COMSOL Multiphysics® (simulation software based Finite Element Method). By coupling of Poisson's equation and the positive ion continuous, it was analyzed electric field and space charge density. Further, by calculating the Coulomb force as an external force term of the Navier-Stokes equation, it was fluid analysis affected by the ionic wind. Simulation model was designed as shown in Fig. 1 for the purpose of comparison with experimental data.

Fig. 2 shows the analysis results of the fluid affected by the ionic wind. (a) is no primary flow conditions (primary flow velocity of 0m/s), (b) is primary flow velocity of 0.15m/s (same as the experimental conditions), (c) is 0.7m/s. Primary flow is flowed from the left, both are the result of 1.0s after the voltage applied. In (a), ionic wind blows from the discharge electrode toward the hole, blow up on the grounded electrode, and create a Karman vortex on the upstream of the discharge electrode. In addition, the fluid brown into the hole also create a vortex, flow the collecting zone to the downstream. The flow velocity of the ionic wind was around 1m/s at just below the needle. In (b), to make a Karman vortex on the downstream of the discharge electrode, fluid that flows into the holes are generated. Without flowing too much to the downstream, a lot of the primary flow induce into the hole. In (c), the flow entering the hole is small and it flows toward the downstream since very fast the primary flow velocity compared to the ionic wind. In the simulation model, with primary flow of around 0.15m/s, it can be expected to induce the particles into the hole. In addition, it was verified the validity of this simulation and investigated model design to improve the collecting efficiency by analysis of particle behavior and comparison of these results with experimental results

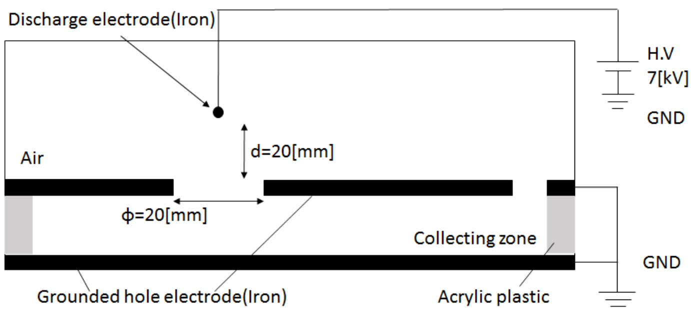
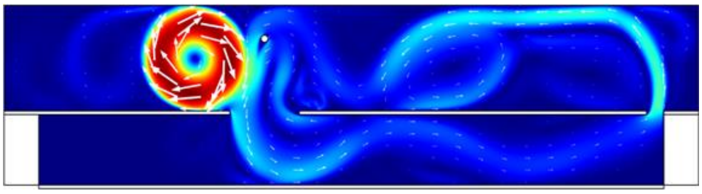
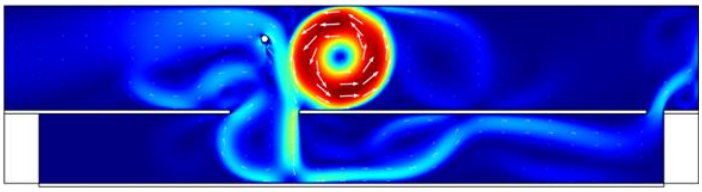


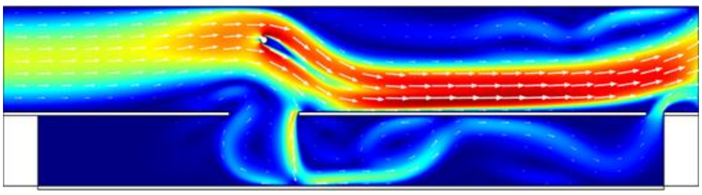
Figure 1. Simulation model



(a) Primary flow velocity 0m/s



(b) Primary flow velocity 0.15m/s



(c) Primary flow velocity 0.7m/s

Figure 2. Fluid analysis (t=1.0s)

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