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應用計算機流體力學模擬微粒於靜電場中之運動軌跡

The Study of Particle Motion in Electric Fields by Using Computational Fluid Dynamics

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Research Focus

This research try to focus on the numerical simulation of particle motion on the electrical field by using computational fluid dynamic (CFD). The model combine the effect of electric kinetics, Newton's force, and stokes' force within different particle size and electrostatic precipitator (ESP) types. The objective of this work try to build a better numerical simulation of complex mechanisms with electrostatic field and fluid dynamics that affect transportation and deposition of particle migration by using the commercial CFD tool.

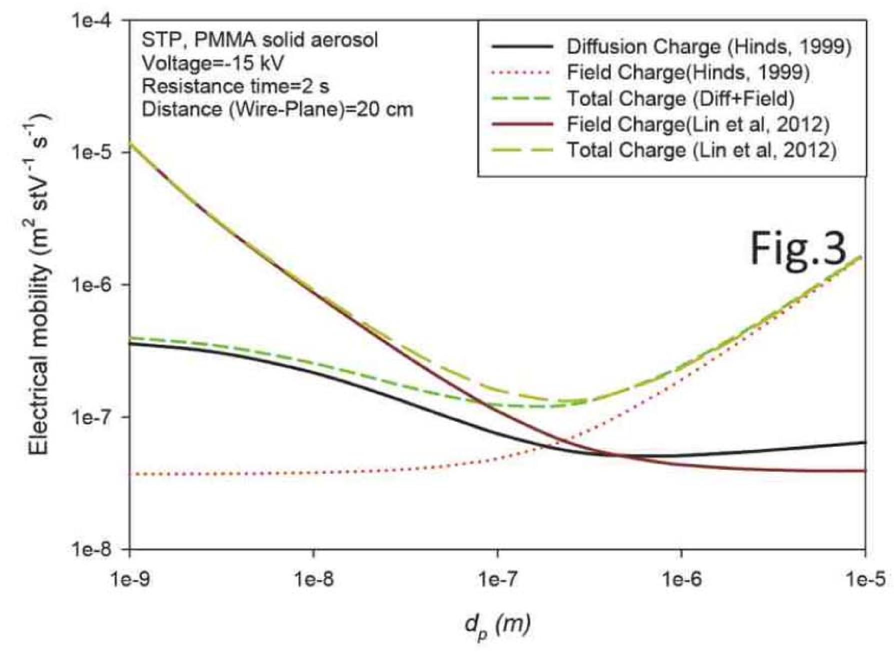

Fig.3

Research Methods and Results

In this work, a wire-plane ESP was set up as the Fig.1. The geometric size is 20 cm (*l*)×5 cm (*w*)×10 cm (*h*), and the wire diameter is 0.03 cm (*d*) , besides, this ESP have three wires and space between wires are 5 cm. The supply voltage of wire surface is -15 kV. As the principal theory of electrodynamics Maxwell's equation, the electric potential in this field was distributed as Fig.2. Besides, according to Lin et al., (2012), the charge number of particle by diffusion need to be regulated as the following equation. Therefore, the relationship between diffusion charge, field charge, and total charge with particle size are redrawn as shown in Fig.3.

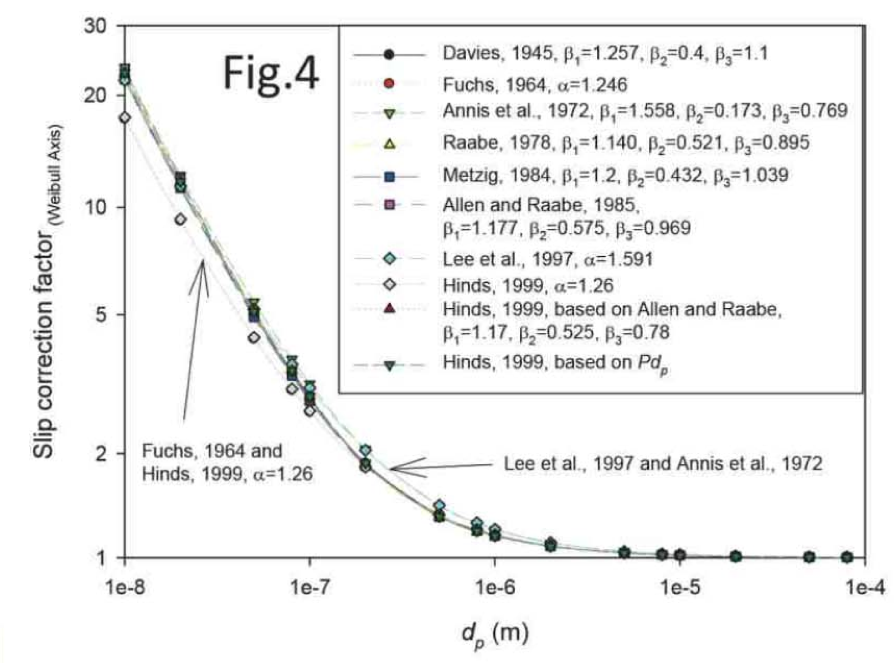

Fig.4

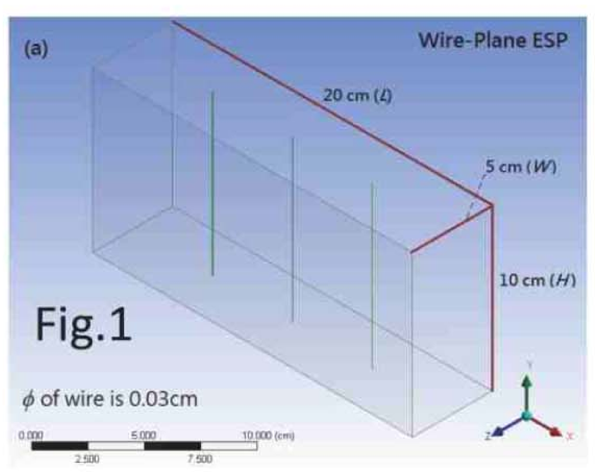

Fig.1

$$n_{e,\text{diff.}}(t)=\frac{d_p k_B T}{2k_e e^2}\ln\left(1+\frac{\pi k_e d_p \bar{c_i} e^2 C_i t}{2k_B T}\right)$$

$$n_{e,field}(t)=\left(\frac{3\varepsilon_r}{\varepsilon_r+2}\right)\left(\frac{E d_p^2}{4k_e e}\right)\left(\frac{\pi k_e e Z_i C_i t}{1+2k_B T}\right)$$

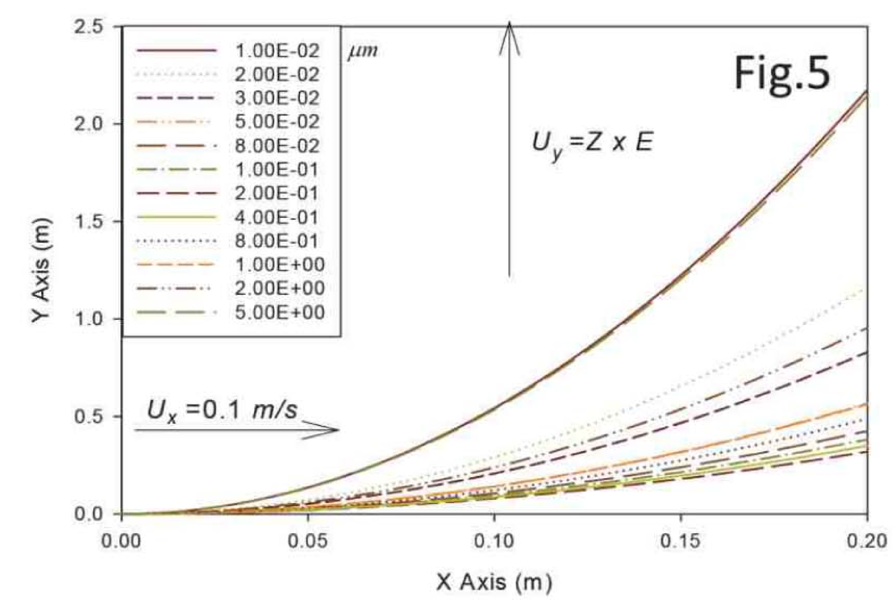

Fig.5

$$n'_e(t)=n_{e,\text{diff.}}(t)\times e^{\left[1.91588\times\left(n_{e,\text{diff.}}(t)\right)^{-0.1425}+1.296\times10^{-5}\times n_{e,\text{diff.}}(t)-1.2671\right]}+n_{e,field}(t)$$

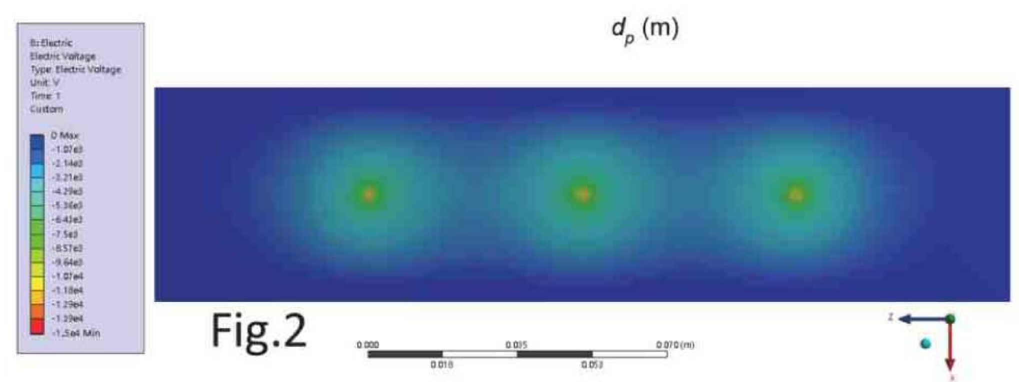

Fig.2

In addition, difference force theories of particle motion also described here, including slip correction factor, Newton's drag force, stokes' force, electrostatic force, etc. Thus the following governing equations are rebuilding foe CFD simulation.

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=\text{div}U=0$$

Mass conservation

$$\frac{\partial(\rho\vec{U})}{\partial t}+\text{div}(\rho\vec{U}U)=-\frac{\partial P}{\partial t}+\text{div}(\eta\ \text{grad}\vec{U})+S_{M\vec{U}}+F_{emag}+\rho f$$

Momentum conservation

$$\frac{\partial(\rho h)}{\partial t}-\frac{\partial p}{\partial t}+\text{div}(\rho hU)=\text{div}(\Gamma\ \text{grad}\ h)+S_E$$

Energy conservation

Research Experience and Acknowledgements

在數值模擬的研究中，數值條件繁多，過程中不斷重複的輸入、確認、定義，對於晉源是很大的挑戰，執行這項研究不僅讓我由熟悉理論到實踐模擬，獲益良多。本次獲獎首先要感謝北科大環境所林文印教授對晉源的指導，以及台大陳志傑教授、韓國Hyuksang Chang教授、台大黃盛修博士對研究的協助，使得晉源於氣膠及空污相關研究上取得成果。更感謝家人的支持，使我無後顧之憂地學習與研究。也感謝研究室大家的激勵。最後，感謝中技社的幫助，未來希望能繼續精進，對社會有所貢獻。