Predicted Flow Characteristics of a Wire-nonparallel Plate Type Electrohydrodynamic Gas Pump Using the Finite Element Method

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***Abstract*— When a voltage above the corona onset level is applied between two electrodes, ions travel from the high voltage electrode toward the grounded electrode(s) due to the Coulomb force. These ions collide with gas molecules and exchange momentum. The phenomenon of inducing the fluid motion by corona discharge is known as the electric wind, corona wind or electrohydrodynamic (EHD) flow. In the wire-to-plate configuration, it is possible to produce a net flow in one direction by changing the position of the ground plates and forming a tilted system. By using this type of configuration an asymmetrical electric field distribution is formed downstream and upstream of the corona electrode, hence unidirectional gas flow may occur. This type of pump has widespread applications in fluid transport, chemical transport and cooling of electronic circuits. Compared to conventional gas pumps, EHD has some advantages such as no moving components, simple construction, noise free operation, continuous control on gas flow and the ability to reduce the pump size. However, low efficiency of electrokinetic conversion and generation of Ozone are major drawbacks of the EHD pumps. The EHD gas pumps have already been developed by many investigators. Published articles are based either on experimental investigations of prototypes or simplified numerical techniques. However, several problems, such as the determination of the optimum wall angle based on mass flow rate, velocity vs. pressure characteristics of the pump, effect of the voltage level on the maximum capacity of the pump, and relation between the maximum velocity and pressure still need to be investigated. The aim of this paper is to numerically investigate the interaction between the electrostatic field and the fluid flow in a wire non-parallel plate configuration. The governing equations; Poisson equation for electric field, continuity equation for charge transport and the momentum equation for flow pattern using k-ε turbulent model; were solved by using the Finite Element Method (FEM) with a highly non-uniform mesh distribution. The main outcome of this study is the prediction of velocity vs. pressure characteristics of the pump, which provides very useful information to predict the pump behavior and for control purposes. Moreover, the optimum wall angle was predicted for this configuration. The numerical results show that the higher level of voltage leads to greater velocity and the greater pressure: the gas velocity is a linear function of voltage and pressure is proportional to the square of voltage. It was also found that there is an optimum wall angle of the configuration, which is about 4°. At this angle the mass flow rate from the outlet of the pump reaches the maximum value.**