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Numerical Models in Simulating Surface DBD Plasma Actuators

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Abstract:

Among different applications of electrohydrodynamics (EHD) potentially the most important are the EHD flow actuators. While in the early period, the corona discharge actuators were considered, for some time the dielectric barrier discharge (DBD) actuators have dominated, as they prevent the corona to arc transition and can produce more intensive discharge. In these actuators, a high alternating voltage is supplied to the discharge electrode, so the gas near the discharge electrode is ionized. The formed ions are accelerated by electric field and they transfer their momentum to the neutral molecules. This generates the surface air jet and modifies the pressure and velocity distribution.

Numerous research teams have presented the results of investigations of the DBD actuators at different voltage waveforms, cross-flow velocities and system configurations. However, for most applications the achieved velocity levels are not sufficient and research efforts concentrate on increasing them by optimizing the actuator geometry and operating conditions. As in many other areas of science and engineering, the experimental investigations are supplemented with numerical simulation. The numerical tools are not only faster and less expensive, but can also provide a better understanding of the process details.

The presented talk will discuss different numerical approaches to predict the characteristics of DBD plasma actuators. The earliest phenomenological models used physically incorrect assumptions that nevertheless yield useful results. However, they needed calibration with experimental data. The Suzen-Huang model was based on apparently correct approach, but the space charge density was described by a formula taken for hot-plasma physics.

A complete physics of the discharge is very complex and it cannot be included in the numerical model due to limitations of the computing equipment. Simplified plasma models are usually considered with the most important ionic species and reactions only. Different authors proposed different idealizations and different numerical algorithms. The problem of accurately modeling DBD actuators is far from being solved, but the progress achieved over the last three decades is remarkable.

Keywords: dielectric barrier discharge, plasma actuator, electrohydrodynamics, mean DBD model, voltage waveform

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