Flow Distribution Measurement in Wire-nonparallel Plate Type Electrohydrodynamic Gas Pump by a Particle Image Velocimetry

Marek Kocik, Janusz Podliński, Jerzy Mizeraczyk
Centre for Plasma and Laser Engineering,
The Szewalski Institute of Fluid Flow Machinery,
Polish Academy of Sciences,
Fiszera 14, 80-952 Gdańsk, Poland

Kuniko Urashima and **Jen-Shih Chang**
McIARS & Department of Engineering Physics,
McMaster University,
Hamilton, Ontario, L8S 4M1, Canada

ABSTRACT

2D Particle Image Velocimetry (PIV) measurements were performed in a wire-nonparallel plates type electrohydrodynamic (EHD) gas pump. The effect of electrode configuration and polarity of the active electrode on the flow pattern inside the pump was studied. One can deduce from the obtained flow patterns that the flow generated inside the EHD pump is three dimensional. The vortices formed inside the EHD gas pump have negative effect on pumping capabilities of the pump since the vortices may block and suppress the generated flow. The PIV results will be compared with a numerical modelling of the flow, based on k-E model.

Index Terms — Particle image velocimetry, PIV, electrohydrodynamic pump, EHD, corona discharges, non-thermal plasmas.

1 INTRODUCTION

WHEN a high electric field is applied between high voltage and grounded electrodes in a gas medium, a corona discharge is formed by an ionization of the gas molecules. Thus ion flux along the electric field transfers its momentum to the weakly dipole neutral molecules. This results in the so-called ionic wind or an electrohydrodynamically induced gas flow [1-10]. When the electrode configuration forms an unsymmetrical electric field distribution, the unidirectional gas flow can be generated, i.e. the EHD gas pumping [5]. Several electrode geometries have been studied for EHD gas pumps, such as needle-to-mesh, needle-to-ring, wire-to-rod, wire-nonparallel plates etc. [1-10], however, sharp edge electrode such as needle ore blade usually become unstable due to transition from corona to spark discharge [5].

In this work, the potential three-dimensional flow structure of a wire-non-parallel plate push fan (PF) type EHD gas pump is measured by Particle Image Velocimetry (PIV). The dimensions of the EHD gas pump as well as the electrode configuration are similar to those presented by Tsubone et al [10], where the flow characteristics (pressure drop and flow velocity profiles at the pump exit) of the EHD gas pump were given. These flow characteristics allow only general conclusions regarding the generated flow at exit section of pump without understanding flow structure such as turbulent or re-circulating laminar inside pump.

Therefore, to understand the flow behavior in the EHD gas pump it is necessary to investigate in detail the velocity flow patterns near the flow driven electrodes. On the other hand, EHD flow vector maps in the central plane of EHD gas pump, was investigated by Kocik et al [11] using PIV by assuming flow is 2-dimensional. Kocik et al indicated that the generated flow patterns are turbulent and with distinct vortices. The vortices decrease with increasing operating voltage. The vortices formed inside the EHD gas pump have negative effect on pumping capabilities of the pump since the vortices may block and suppress the generated uni-directional flow. The effective pumping (24 L/min) was observed for PF-A type EHD pump at 14-15 kV, when the downstream or upstream vortices were scattered in the flow [11]. In order to study the vortices more detailed, the PIV measurement in the plane close to the side-wall of the EHD gas pump was performed in this work and compared with 2-dimentional numerical simulations.

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