Three-dimensional flow and turbulence structure in electrostatic precipitator

Stereo PIV is employed to study the three-dimensional velocity and turbulence fields in a laboratory model of a negative corona, barbed-wire, smooth-plate, electrostatic precipitator (figure 1). The study is focused on determining the parametric effects of axial development, mean current density \( J_m \) and bulk velocity \( U_0 \) on secondary flows and turbulence levels and structures due to the action of the three-dimensional electrostatic field on the charged gas. At constant bulk velocity \( U_0 = 1 \text{ m/s} \) and current density \( J_m = 0.4 \text{ mA/m}^2 \), secondary flows in the form of rolls of axial vorticity with swirl numbers up to \( S = 0.3-0.4 \) are found to level off after 4-5 electrodes, being most regular in the central unit cells defined by the periodic geometry of pin-electrodes. The corresponding image-mean turbulence intensity increases to about 20% from the 1st to the 7th electrode with a consistent anisotropy of normal Reynolds stresses. The effects of \( U_0 \) and \( J_m \) on \( S \) and \( Tu \) (at fixed position between 6th and 7th electrode) are reasonably correlated by the electrohydrodynamic modulus \( NEHD = (Jm/bi)ly/(½rU_0^2) \), where \( bi \) denotes the ion mobility and \( ly \) the electrode-plate distance.

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