Mean turbulent flow in the wake in the wake of a perforated plate equipped with non-thermal plasma

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The mixing of scalar flow component is important for a large number of practical and fundamental situations. Mixing by passively forced turbulence is already used in a variety of engineering phenomena, including combustion, injection cooling, industrial mixing and pollution transport. The present experimental contribution interests in the flow field developing downstream of a plate perforated by 121 holes with 1.8-mm inner diameter. The original aspects of this research is that the holes are all surrounded by plasma discharges (see Figure 1 below) that can actively impose periodic perturbations to the flow developing in the wake of the plate. The objective is to develop a new type of multi-jet injector including an active flow control device. The research presented during this conference focus on the experimental characterization of the mean turbulent flow conditions developing downstream of the perforated plate without and with flow manipulation by non-thermal surface plasma discharge.

Optical flow diagnostics such as smoke flow visualizations and time-resolved particle image velocimetry have been conducted. The velocity of the airflow passing one of the holes is fixed at 20 m.s⁻¹. It is observed that the multi-jet flow quickly form a single jet with an axial velocity that is reduced accordingly to the grid solidity ratio (15 m.s⁻¹). By conducting a parametric study by smoke flow visualization, it is shown that the jet core length of the jet can be reduced by 30% by operating the plasma discharge in a mode imposing perturbations at a Strouhal number equal to 0.3 (see Figure 2). This excitation mode matches with the jet preferred mode of instability many times observed in typical single axisymmetric air jet. The PIV measurements give further information regarding the capability of the plasma actuation to promote an earlier production of turbulence and to impose the formation of coherent flow structures with a shedding frequency matching with the electrical one applied to the actuator (Figure 3).

The present contribution is the first step of a vast investigation on plasma actuator used in context of grid-generated turbulence and multi-jet flows.