Flow field features of the near-wake of jets with fractal inserts

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An experimental investigation of the flow field features in the near wake of a round jet equipped with a fractal grid insert (see Figure 1) is carried out by means of 2D-2C Particle Image Velocimetry (PIV). The experiments are run in a water tank facility (see Cafiero et al 2014a), at a Reynolds number equal to 28,000. This choice is motivated by the will of comparing the flow field results with those obtained in an application of fractal grids in the heat transfer enhancement (see Cafiero et al 2014b).

Fig. 1 Sketch of the fractal insert

The average and fluctuating flow fields are presented. In particular, the effect of the presence of the fractal grid on the turbulence intensity distribution and on the planar component of the Reynolds stress is analyzed. Some differences between the location of the maximum in the turbulence intensity profile (see Figure 2) and the data reported in the literature (Mazellier&Vassilicos 2010) are found. A possible interaction process between the wakes of the grids and the growing shear layer of the jet might be responsible of this discrepancy.

Fig. 2 Turbulence intensity profile

The coherent structures which characterize the elongated production region of the turbulence intensity profile are underlined and discussed. The application of the Proper Orthogonal Decomposition (POD, Sirovich 1987) reveals that a large amount of the modal energy (about 70%) is associated to the shedding of an intermittent wake from the largest bars of the fractal grid (see Figure 3): the first two modes are associated to the asymmetric whilst the third one to the symmetric shedding of the vortices.

Fig. 3 POD modal energy of the first 100 modes

The conditional average is calculated using the Linear Stochastic Estimation technique (Adrian 1979); it is obtained by imposing a positive value of the fluctuating vorticity vector $\omega^f_2$ in a precise point of the domain where the shedding phenomenon is evident. The results underline a phase locking between the wakes shed from the two largest bars of the fractal insert (Figure 4).

Fig. 4 Conditional average calculated imposing the fluctuating vorticity vector $\omega^f_2 > 0$ at $X/d = 0.3$.