Time-resolved analysis of circular and chevron jets transition by tomo-PIV

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The dynamical phenomena occurring in the near region of a jet at $Re = 5,000$ issued from a circular nozzle and a 6-chevron exit jets are investigated. Experiments are conducted by time-resolved tomographic particle image velocimetry in a tailored water jet facility. The acquisition frequency of 1 kHz allows a high temporal resolution of the vortex shedding phenomenon occurring at 29 Hz and of the subsequent instabilities like vortex pairing and growth of three-dimensional waves. An advanced cross-correlation analysis is performed making use of the correlation signal averaging concept, which leads to use the redundant temporal information and significantly decrease the measurement error.

The coherent structures encountered in the chevron jet do not correspond to any of those exhibited by the circular one. The ensemble averaged flow pattern shows a system of axial rollers fed by the chevron system, with maximum inward radial flow corresponding to the valleys of the chevrons.

The analysis of the unsteady 3D flow behavior for the circular jet reveals the growth of azimuthal waves at the end of the pairing process and the presence of vortex filaments inclined with respect to the axis in the region of second pairing. First and second pairing induce intense fluctuations of the axial flow velocity at the inner side of the paired vortex ring. The chevron jet exhibit no azimuthal coherence the most visible coherent structures produced in the shear layer are C-shaped rollers generated inside each chevron cell show no phase correlation with respect to those in the neighboring cells.

The lower azimuthal coherence brings also comparatively smaller axial velocity fluctuations and a less energetic core breakup downstream.

Fig. 1 Experimental configuration of the jet tomography facility.

Fig. 2 Visualization of jet flow. Left: circular exit. Right: 6-chevron exit. Velocity vector slice in the axial plane. (blue) Iso-surface of axial velocity ($V = 1.05 \, V_{exit}$). (red) Iso-surface of vortex cores by Q-criterion.