The effects of inflow conditions on a precessing jet using Tomographic PIV

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HIGHLIGHTS

- The flow field investigation of a self-excited precessing jet for two inflow conditions at \( \text{Re}_D=42,500 \) is carried out with tomographic Particle Image Velocimetry.
- The large scale precessing motion is statistically dominant for both the inflow configurations.
- Helical coherent structures are detected within the first 3 diameters from the jet exit.

ABSTRACT

Self-excited fluidic precessing jets PJs generated by a 5:1 expansion of a circular jet issuing at \( \text{Re}_D=42,500 \) in a short coaxial cylindrical chamber (Fig. 1a) has been investigated by means of tomographic Particle Image Velocimetry. Two inflow conditions by using either simply a short-pipe nozzle JWG (Fig. 1b) or placing a regular grid RG at a short pipe exit (Fig. 1c) have been considered. A statistical analysis conducted for both configurations has revealed that the entrainment region extends along the entire length of the cylindrical chamber; for the RG case a residual azimuthal velocity component has been detected. A three-dimensional modal analysis using proper orthogonal decomposition POD conducted in the sudden expansion region SER at the basis of the chamber highlights the dominance of the large scale precessing motion for both configurations. It is found for the JWG case that the instantaneous organization of the large-scale coherent structures in the SER is influenced by the entrainment process during the precessing motion. Under the influence of the entrainment process and the induced swirling motion, helical coherent structures are detected within the first 3 diameters from the circular jet exit (Fig. 1d). At the exit of the cylindrical chamber, the entrainment process is sustained by both a bulk of fluid coming from the external ambient and from the emerging jet; this leads to a formation of a weak recirculation region.

Fig. 1 Details of the fluidic precessing nozzle (a); jet without grid JWG (b) and regular grid RG (c) placed at the nozzle exit. Visualization of helical vortices in SER for JWG case identified by the iso-surfaces of \( \lambda_2 D/V_1 =-30 \) (blue) and \( V/V_1=1.10 \) (red). Iso-contour of \( \omega_D/V_1 \) with in-plane velocity vectors (d).