Tomographic PIV and planar Time-resolved PIV measurements in a turbulent slot jet

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A jet in a narrow or slot channel has a number of features that significantly distinguish it from free jets and flows in channels. The presence of the bounding surfaces leads to different characteristic scales: small-scale three-dimensional flow with a maximum scale of the order of the channel depth \( h \) and quasi-two-dimensional large-scale flow with the characteristic scales greater than \( h \). The structure of a quasi-two-dimensional turbulent jet in a narrow channel was investigated experimentally in this work. 3D flow structure in the near field of the jet was studied by Tomographic PIV. A study of a spatial-temporal flow structure was produced by the Time-resolved PIV technique.

Low speed Tomo-PIV measurements were carried out in three successive overlapping volumes with the size \( 4d < 3.4d < 0.43d \) (see Figure 1) and a correlation domain size per vector \( 1.3 \times 3.3 \times 0.6 \) mm. High speed PIV measurements were performed at three different sections through the channel depth: \( z = 0 \) (corresponds to the central plane), \( z = 0.25h \) and \( z = 0.4h \). Thickness of the laser sheet is ranged from 0.3 to 0.5 mm. A maximum frame rate was equal to 1.2kHz. Spatial resolution per velocity vector corresponded to 4.15-4.38 mm. The data were acquired for two Reynolds numbers: \( Re = \{10000, 20000\} \) for both techniques.

Secondary flows were found during an analysis of three-component velocity fields in the shear layer of the jet. They are a pair of longitudinal vortices with vorticity of an opposite sign. The nature of the secondary flow in the flow depends significantly on the Reynolds number and the length of its influence may reach six calibers, see Figure 3.

The flow in the far zone is characterized by steady quasi-two-dimensional large-scale vortex structures. The temporal spectrum in Figure 4 shows that with the development of large-scale vortex structures in the downstream direction, the maximum of the turbulent kinetic energy in the spectrum is shifted to longer wavelengths with a characteristic quasi-two-dimensional slope \(-3\).

![Fig. 1 Scheme of the experimental setup for Tomo-PIV measurements in a turbulent slot jet, \( d = 10 \) mm, \( h = 4 \) mm.](image)

![Fig. 2 Comparison of the normalized mean velocity profiles obtained by planar TR-PIV (line 1), Tomo-PIV (line 2, 3) for axial, radial and normal components at \( Re = 10000 \).](image)

![Fig. 3 Secondary flows in the near field by isosurfaces of the streamwise vorticity component calculated for mean velocity field, sections correspond to the mean velocity magnitude. Tomo-PIV measurements at \( Re = 10000 \).](image)

![Fig. 4 Power spectrum of \( u' \) component for planar TR-PIV measurements at different distances from the nozzle, \( Re = 20000 \).](image)